DEVELOPING A FRAMEWORK TO PROMOTE THE ADOPTION OF ELECTRIC VEHICLES IN SOUTH AFRICA

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DECLARATION

By submitting this dissertation, I, Simon Mabushi Mohubedu, declare that the work presented herein is, in its entirety, my own original work; that the work is based on my own research (except where stated otherwise); that I am the sole author; and that I have not previously submitted the work, in part or in full, to any other institution of higher learning to obtain any academic qualification.

Signature Date 09.09.2021

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ABSTRACT

Increasing greenhouse gas (GHG) emissions are considered as the major challenge for climate change, global warming and air quality in cities and South Africa has pledged a reduction of its GHG emissions to peak at 398 to 614 Mt CO_2-eq for the period 2025 to 2030 as part of the Paris Agreement on climate change. The government has also noted that as a means to reduce GHG emissions, the domestic electric vehicle (EV) market needs to grow significantly as the road transport sector is responsible for over two-thirds of transport-related carbon dioxide emissions. While many developed nations globally are beginning to adopt EVs as a strategy to moderate GHG emissions, South Africa is falling short in this regard and still lacks a policy on the electrification of vehicles.

A qualitative research design was used to investigate and identify factors that have potential to stimulate the adoption of EVs in South Africa. A conceptual framework of public policies for innovation diffusion was also used to provide structure to the study. Additionally, the conceptual framework was further expanded with a view to developing and proposing a framework to policymakers for the promotion of the adoption and uptake of EVs in South Africa.

Some of the major findings from the study were that the high purchase price of EVs, the availability of charging infrastructure and the lack of customer education and awareness were the biggest impediments to the uptake of the domestic EV market. Inversely, these were equally the main factors that have potential to stimulate the uptake of the EV market in South Africa. Amongst the recommendations from the proposed framework were that policymakers should be cognisant of these and other demand-side barriers together with existing advantages such as the presence of a successful automotive policy framework in South Africa and should devise policies aimed at removing the barriers to the adoption of EVs in the local market. Furthermore, the proposed framework also highlights the significant role that government needs to play by being involved in driving the demand for EVs in South Africa through relevant interventions, notably, through the provision of policy incentives.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS AND ACRONYMS

AAAM	African Association of Automotive Manufacturers
APDP	Automotive Production Development Programme
BEV	Battery-Electric Vehicle
CO_2	Carbon Dioxide
CSIR	Council for Scientific and Industrial Research
DEA	Department of Environmental Affairs
DoE	Department of Energy
DoT	Department of Transport
DTI	Department of Trade and Industry
DTIC	Department of Trade, Industry & Competition
EC	Eastern Cape
EHAVC	Electric, Hybrid and Alternative Vehicle Committee
EV	Electric Vehicle
FCEV	Fuel Cell Electric Vehicle
GDP	Gross Domestic Product
GHG	Greenhouse Gas Emissions
Gt	Billion metric tonnes
GTS	Green Transport Strategy
HEV	Hybrid Electric Vehicle
ICE	Internal Combustion Engine
IDC	Industrial Development Corporation
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency
MIDP	Motor Industry Development Programme
NAACAM	National Association of Automotive Component & Allied Manufacturers
NAAMSA	National Association of Automobile Manufacturers of South Africa
NDC	Nationally Determined Contribution
OEM	Original Equipment Manufacturers
OIES	Oxford Institute for Energy Studies

OPEC	Organisation of the Petroleum Exporting Countries
PEV	Plug-in Electric Vehicle
PHEV	Plug-In Hybrid Electric Vehicle
RMI	Retail Motor Industry Organisation
TIA	Technology Innovation Agency
USA	United States of America
WEF	World Economic Forum

CHAPTER 1:

INTRODUCTION

1.1 Introduction

This introductory chapter consists of the general overview of the study. It provides the background of the study and identifies the research problem. It further states the aims; research questions; research objectives; significance as well as the scope of the study. Thereafter, it presents an overview of the conceptual framework used in the study and, lastly, outlines the structure of the dissertation.

1.2 Background of the Study

Greenhouse gas (GHG) emissions, which result in warming of the climate system could lead to concerns such as increased frequency and intensity of weather systems, e.g., intense droughts, intense rainfall and extreme temperatures (South Africa, the Department of Environmental Affairs (DEA) 2011: 9), which could have adverse effects on human health (Franchini and Manucci 2014: 1). Sierzchula, Bakker, Maat and Van Wee (2014: 183) warned that GHG emissions therefore pose a serious danger to the economic and physical livelihoods of individuals around the globe as well as putting plant and animal species at high risk of extinction.

To mitigate GHG emissions, global trends in the automotive industry aim at transitioning from vehicles with the internal combustion engine (ICE) technology to “green energy” vehicles such as electric vehicles (EVs) as the transport sector has been identified as one of the leading contributors to GHG emissions (The Intergovernmental Panel on Climate Change (IPCC) 2014: 603). As its Nationally Determined Contribution (NDC) to the global effort to limit GHG emissions, South Africa pledged an emission target of 398 to 614 Mt carbon dioxide (CO_2)-eq for the period 2025 to 2030 (South Africa, DEA 2011: 27). While a number of first-world nations are beginning to adopt the EVs as a strategy to curb GHG emissions, South Africa is falling short in this regard (Hancock 2019: 1). The South African transport sector’s dependence on fossil fuels has been identified as

one of the core factors contributing to the non-achievement of South Africa's emission targets (Vanderschuren, Jobanputra and Lane 2017: 47).

Furthermore, studies (Gajjar and Mondol 2016: 586) have suggested that as a means to reduce GHG emissions, the EV market needs to grow. Previous studies (Bakker 2012; Grant 2014) predicted a small but optimistic market penetration for EVs in South Africa to the year 2020. However, current data suggests that the adoption of EVs in South Africa is not progressing at the anticipated pace (South Africa, the Department of Transport (DoT) 2019: 39). Although the government is considering a number of measures to stimulate the adoption of EVs in the country, South Africa has not yet developed a clear policy framework on electrification of vehicles (Malinga 2019a: 2).

Against this background, the study sought to identify factors that are critical for promoting the adoption of EVs in South Africa. To achieve this aim, the study adopted a qualitative approach wherein data was collected from prominent stakeholders within the South African automobile industry (i.e., vehicle manufacturers, including importers of assembled vehicles). It is further hoped that the study will be of value to policymakers either in the development of new policies or to enhance existing policies on vehicles electrification.

1.3 Research Problem

The automotive industry is the largest manufacturing sector in South Africa contributing about 7% of the country's gross domestic product (GDP) (South Africa, the Department of Trade and Industry (the dti) 2019: 22). The IPCC (2014: 603) points out that it is also the road transport sector which is the biggest contributor to transport-related GHG emissions, and hence a sector that must be prioritised to enable South Africa to achieve its emission target through electrification of vehicles. According to studies (Dane 2014: 20; uYilo 2018: 5), lack of policy direction is seen as one of the central reasons hampering the stimulation of the EV market in South Africa. Therefore, lack of policies that enable EV market penetration or deployment of ineffective policies could have a negative impact on this important sector and subsequently South Africa's economy.

To address the research problem, the researcher investigated those factors that are critical for promoting the adoption of EVs in South Africa. Sperling (2018: 11) found that countries that have been successful in the electrification of vehicles as a strategy to mitigate GHG emissions have aggressively incentivised their markets. Thus, the application of incentives as a policy instrument is investigated along with potential barriers and drivers to stimulate adoption of EVs in the South African context.

1.4 Research Questions

The research questions are:

- What are the factors that have potential to stimulate/drive the adoption of EVs in South Africa?
- What policy initiatives in the form of incentives will have a positive effect on the stimulation of adoption of EVs in South Africa?
- What are the pre-existing or possible future barriers to the adoption and uptake of EVs in South Africa?
- How can the barriers to the adoption and uptake of EVs in South Africa be overcome?

1.5 Aim and Objectives of the Study

The aim of the study was to develop a framework that has the potential to promote the adoption of EVs in South Africa.

The objectives of the study are to:

- Investigate factors that have potential to promote the adoption of EVs in South Africa;
- Identify existing or possible future barriers to the adoption and uptake of EVs in South Africa;
- Ascertain whether policy interventions in the form of incentives will have a potentially positive effect to drive the adoption of EVs in South Africa and identify those policy incentives;
- Propose a framework to stimulate the adoption of EVs in South Africa.

1.6 Conceptual Framework

The conceptual framework used in the study was based on the 'general framework of public policies for innovation diffusion' developed by Caiazza (2015: 1410). Innovation refers to the process of bringing new goods and services to the market (Seaden and Manseau 2010: 185) or "anything new that is actually used" (Slaughter 1993 cited in Seaden and Manseau 2010: 186). Likewise, innovation diffusion and adoption has been defined by Roggers (2003 cited in Caiazza 2015: 1407) as "the spread of new products, values, policies or processes beyond the locus of their original success".

For the most part, the framework contends that without the diffusion of innovations there will be no economic success at either firm or country level. Furthermore, the framework emphasises the importance of the role that policymakers must play in pursuing and deploying a wide variety of policy measures to promote or accelerate the diffusion of innovation. In addition, Rogers (2003), Zahra and Nielsen (2002) and Hall and Khan (2003) cited in Caiazza (2015: 1409) asserted that diffusion of innovation is often impacted by a series of factors or barriers, namely, institutional (general) factors; barriers relating to an innovator's ability to push their innovation to the market as well as those concerning the user's capability to adopt the innovation. In addition, Caiazza's (2015: 1410) general framework of public policies for innovation diffusion advocates for the use of incentives by policymakers as a tool to accelerate the diffusion of innovation.

Therefore, the researcher deemed the aforementioned framework appropriate to adapt as a conceptual framework for the study as it has all the variables relevant to the study objectives. Additionally, the diffusion of innovation model has been used before as a conceptual framework in other studies (Noel, de Rubens, Sovacool and Kester 2019; Peters and Dütschke 2014; Seign and Bogenberger 2013) researching the adoption of EVs.

Lastly, to address the last research objective, Caiazza's (2015: 1410) framework will be expanded or modified to develop and propose a framework/model to stimulate the adoption of EVs in South Africa.

1.7 Significance of the Study

Reports and industry experts (Hancock 2019: 1; South Africa, DoT 2019: 39) have noted that South Africa is lagging behind developed nations in the global drive to convert the road transport sector to “zero-emission” mobility as a strategy to curtail GHG emissions to committed targets. Additionally, there is little evidence that South Africa has defined or deployed a clear policy framework to promote the adoption of EVs in the country (uYilo 2018: 5).

Therefore, the study focuses on collecting data from key people in the automotive industry to investigate those factors that are critical for the promotion of adoption of EVs in South Africa. It is intended that the study culminates in proposing a policy framework or model to promote the adoption of EVs in South Africa. It is further anticipated that the outputs of the study would thus be helpful to policymakers when developing new policies or amending existing ones to promote the uptake of EVs in South Africa. In addition, the study is important as it will provide a base for future studies by other researchers and hence add value to the body of knowledge in the field.

1.8 Scope of the Study

The study was confined to the vehicle manufacturing companies in South Africa, inclusive of the importers of assembled vehicles. Since the automotive industry is the largest manufacturing sector in South Africa, other associated organisations within the automotive value chain were excluded from the study.

1.9 Structure of Dissertation

The dissertation is organised into seven chapters as outlined below:

Chapter 1: Overview of the study

Chapter 1 provides a general overview to the study. It also clarifies the background to the study and identifies the research problem. It further states the aims and objectives of the study; significance of the study and the limitations of the study. Thereafter, it

provides an overview of the theoretical framework underpinning the study, and briefly outlines the structure of the dissertation.

Chapter 2: Literature review

In Chapter 2, a critical review of the relevant literature regarding electrification of vehicles in line with the study's aim and objectives is undertaken. It also discusses in detail the conceptual framework that guides the research.

Chapter 3: Research methodology

This chapter focuses on the research methodology for the study. It discusses the philosophical approaches and the design of the study, which includes the target population and sample size. It also explains the sampling method used; data collection and data analysis methods; pretesting technique for the interview questions for the study and the key ethical considerations undertaken during data collection.

Chapter 4: Data analysis and results

This chapter presents analysis of the data collected through the semi-structured interviews with participants purposefully selected within the automotive industry to participate in the study.

Chapter 5: Proposed framework

Chapter 5 presents the proposed framework/model for the promotion of the adoption of EVs in South Africa to achieve the fourth research objective. The chapter is also an extension of the literature review undertaken in Chapter 2. It focuses on discussing the key components of the conceptual framework and expanding on it to propose a framework/model for the stimulation of the adoption of EVs in South Africa and then explaining each section of the proposed model to substantiate their relevance in the model.

Chapter 6: Discussion of the results

Chapter 6 focuses on the analysis of the research data collected through interviews and the interpretation of this data. Further analysis of the data is made by linking the analysis to the relevant literature reviewed in Chapter 2 and Chapter 5.

Chapter 7: Conclusions and recommendations

The bulk of this chapter is comprised of the summary of the main findings of the study. Most importantly, a recommendation to policymakers on policy options and recommendations for the promotion of the adoption and uptake of EVs in South Africa are presented in this final chapter.

CHAPTER 2:

LITERATURE REVIEW

2.1 Introduction

This chapter discusses the existing literature relating to the adoption of electric vehicles (EVs). It starts by briefly reviewing the history of the EV and highlights some of the important aspects relevant to the research objectives. It then moves on to discuss the automotive industry in South Africa and its regulatory framework, and how the current framework relates to the promotion of the adoption of EVs in South Africa. Consistent with the variables of the conceptual framework that underpin the study, the chapter also examines literature relating to barriers to the adoption of EVs as well as specific aspects such as the significance of the use of policy incentives to stimulate the uptake of EVs. Thereafter, a framework for promoting the adoption of EVs in South Africa is proposed.

2.2 Definition of Electric Vehicle

The term “electric vehicle”, or EV for short, typically refers to a vehicle with an electric drive or electric motor propulsion system that can be plugged in to recharge the batteries that provide some of the energy storage on the vehicle (International Renewable Energy Agency (IRENA) 2017: 8). According to Bjerkan, Nørbech and Nordtømme (2016: 169), “electric vehicles (EVs) are vehicles that are partly or fully powered by electric motors”. Faiz, Weaver and Walsh (1996: 227) also defined an EV as an automobile that is propelled by one or more electric motors. However, Faiz, Weaver and Walsh (1996: 227) stated that an EV may be powered through a collector system by electricity (from external sources), or may be self-contained with a battery, solar panels, fuel cells or with an electric generator to convert fuel into electricity for propulsion.

Furthermore, there are two main types of EVs, namely, battery EVs and plug-in hybrid electric vehicles (IRENA 2017: 8). These can be further classified into four categories

(Un-Noor, Padmanabas, Mihet-Poppa, Mollah and Hossain 2017: 3) as explained below;-

- **An all-Electric or Plug-in Electric Vehicle (PEV)**: Often called a battery-electric vehicle or BEV, an EV is a vehicle that gets its energy for propulsion exclusively from its battery and must be plugged in to be recharged (United States of America (USA), Department of Energy (DoE) 2014: 17).
- **Hybrid Electric Vehicle (HEV)**: A vehicle that can run on just the ICE, just the batteries or a combination of both technologies (Momoh and Omoigui 2009: 1288) and has no provision to charge its batteries from an external energy source (Eberhard and Tarpenning 2006: 2).
- **Plug-In Hybrid Electric Vehicle (PHEV)**: PHEV is an HEV but with the ability to recharge its energy storage system with electricity supplied from an external energy source (USA, DoE 2014: 17).
- **Fuel Cell Electric Vehicle (FCEV)**: Like a BEV, an FCEV solely uses an electric motor for propulsion; however, an FCEV uses hydrogen as a source of fuel for generating electric energy (Tanç, Arat, Baltacıoğlu and Aydın 2019: 10121).

For simplification, the abbreviation EV in this work refers to all the four categories of electric vehicles defined, namely, plug-in electric vehicle (PEV/BEV or EV), hybrid electric vehicle (HEV), plug-in hybrid electric vehicle (PHEV) and fuel cell electric vehicle (FCEV) except when a specific reference is made to any of the categories.

2.2.1 History of electric vehicles

The history of the EV dates back to the early 1900s (Santini 2011: 36). In the USA, EVs for personal use existed alongside gasoline-powered ICE cars in the most densely developed regions such as New York, Chicago and Boston in the 1890s and early 1900s and, in actual fact, EVs outnumbered gasoline cars in 1899 by two to one in the major metro areas (Santini 2011: 36). However, EVs ceased to be a viable commercial product by about 1920 (Chan 2013: 210) and development and production in the USA came to an end as personal transportation after ICE took over in 1935 (Situ 2009: 2).

Stimulated by the adoption of new transportation emissions regulations in the USA, EVs made a come-back in the early 1990s (USA, DoE 2014: 13). This resulted in a number of EVs being manufactured by several automakers such as those produced by the likes of Ford, Toyota and Honda and offered for sale in the USA between 1996 and 2003 (Savagian 2017: 74). Launched in Japan in 1997 and selling in excess of 18000 units in its first year of production, the Toyota Prius was the first commercial and highly successful HEV – with Nissan Leaf, Chevrolet Volt, and Tesla Model S along with some Chinese vehicles being some of the examples dominating the EV market today (Un-Noor et al. 2017: 2).

According to uYilo (2017: 3), in South Africa, interest in EVs was sparked by the first oil crises in the 1970s. This saw the then South Africa's Department of Minerals and Energy Affairs in collaboration with the Council for Scientific and Industrial Research (CSIR) researching and demonstrating the use of EVs as an alternative to cars requiring imported oil. Subsequently, a few vehicles were converted to electric propulsion though they had a low driving range and were very slow. The focus on EVs rapidly died out as the oil crisis subsided only to be revived by yet another round of high oil prices about a decade later. Between the late 1980's and the early 2000's, various vehicles were piloted and demonstrated with technologies equalling those of ICE cars with such examples as the electric game viewer used at the Kruger National Park, two Volkswagen shuttle buses and a hybrid electric combat vehicle developed by the state-owned entity, Denel. When oil prices dropped, the EV programmes were halted again (uYilo 2017: 3).

Another important example of South Africa's past contribution to electric mobility is the development of a BEV family car – the Joule. The zero-emission vehicle was developed and built by a Cape Town-based transport solution company called Optimal Energy (Davenport 2008: 1). The Joule was developed with the vision to, amongst other objectives, address concerns around the urban transport sector's dependence on fossil fuels, continued increases in oil prices and issues of increasing levels of air pollution and climate change (Barry 2008; Davenport 2008: 2). According to Cokayne (2012) and Hussain (2019a), the Joule project received funding from the South African Department

of Science and Technology's Technology Innovation Agency (TIA) and received substantial financial assistance from the state-owned financier, the Industrial Development Corporation (IDC) of South Africa. After having been unable to secure the necessary funding from government and the private sector for further development and industrialisation of the electric car, work on the project ceased in April 2012 and subsequently the company closed down in June of the same year (Cokayne 2012: 1). This resulted in the Joule EV ending up as a concept car that was never released commercially.

Many different reasons were cited to explain the failure of the Joule project. Dane (2014: 19) noted that there were also broad disagreements regarding the reasons thereof. According to Dane (2014:19), amongst the reasons cited were:

- There was a lack of clarity around the roles of different stakeholders (public versus private), which contributed to the failure of the programme.
- The vehicle had been developed in isolation in that no investment in charging infrastructure had been made and consequently no one was interested in purchasing the vehicle.
- The commercial risk was too high.

Whether the Joule project's failure was due to the reasons discussed or some other institutional (e.g., political) factors or due to general barriers to new market entry, the Joule project presented South Africa with a rare opportunity to establish a domestic EV industry and even possibly to becoming a global supplier of EVs. Amongst other benefits, this would have had a positive impact on the adoption of EVs in South Africa to help reduce its transport sector's contribution to GHG emissions. The Joule case thus leads to a proposition that to improve the EV market in the country, barriers that can impede the adoption of EVs in the South African context need to be understood from the outset in order to institute effective measures to overcome them.

Driven by the need to reduce GHG emissions from the transport sector to moderate effects of global warming, the global EV market (including South Africa) needs to grow

(Gajjar and Mondol 2016: 586) and high EV market penetration rates have been forecast for the near future. As an illustration, the Organisation of the Petroleum Exporting Countries (OPEC) (2017: 20) estimated that the EV market will increase to 80 million units sold annually by 2040 and the International Energy Agency (IEA) (2017: 27) predicted that there will be 40 to 70 million EVs by 2025 reaching 200 million by 2030. Global enthusiasm for EV market growth is also evident in the announcements of plans by some leading nations and automakers to phase out fossil fuel vehicles and shift to e-mobility, for example:

- Norway's announcement to ban fossil fuel cars in 2016 and prohibit the sale of all petrol and diesel cars (i.e., move to 100% EV sales) by 2025 (Dugdale 2018: 2);
- China's government anticipating that sales of 'New-Energy Vehicles' will reach 20% of total car market demand by 2025 (Oxford Institute for Energy Studies (OIES) 2018: 12);
- The United Kingdom seeking to ban the sale of new petrol, diesel and hybrid vehicles from 2035 (Venter 2020a: 1);
- In Germany, Mercedes-Benz working towards a 2030 deadline to build only PHEVs or fully electric cars (Furlonger 2019: 1); and
- Volvo Cars announcing that every vehicle it launches from 2019 onwards will have some form of electrified powertrain (Roberts 2017: 1).

The apparent absence of South Africa in these examples points to the lack of a target or commitment by government to help drive the transition of its transportation sector from ICE cars to EVs, or more specifically the absence of an EV policy.

2.3 Investigating factors that have potential to promote the adoption of EVs in South Africa

Sierzchula et al. (2014: 183) argued that EV adoption is seen as being very limited without stimulation from external factors such as rising fuel prices, financial incentives or strict emissions regulations. According to Miller and Façanha (2014: 6), the global transport sector was responsible for nearly a quarter of all anthropogenic CO_2

emissions in 2010, which contributes to global warming and climate change. Of these emissions, on-road vehicles accounted for three-quarters or 6.5 billion metric tonnes (Gt) CO_2 resulting in the release of 8.8 $GtCO_2$ into the atmosphere. By 2030, transport-related emissions are expected to increase by approximately two-thirds to 15 $GtCO_2$ (Miller and Façanha 2014: 6). Therefore, as Bryden, Hilton, Cruden and Holton (2018: 322) advised, the use of EVs could play a major role in the efforts to combat climate change and providing health benefits to the general population by reducing air pollution, especially in cities as EVs could significantly reduce the transport sector's contribution to CO_2 emissions.

Accordingly, the Paris Declaration on Electro-Mobility and Climate Change, for instance, calls for the worldwide deployment of 100 million EVs across all market segments by 2030 (IEA 2016: 20). The Paris Declaration is thus driving many nations, including South Africa, to make national commitments to contribute to the global call to reduce GHG emissions through the adoption of EVs. As an example, the Chinese government "prompted by the urgency of reducing greenhouse gas emissions in the transport sector" has set ambitious targets for the uptake of EVs in China (Li, Yang and Sandu 2018: 1). However, recent EV stock figures have only reached about 7.2 million cars worldwide, according to the IEA (2020a: 40) which indicates the need for substantial market growth.

Although South Africa has made a commitment through its NDC pledge to the Paris Agreement to limit GHG emissions (South Africa, DEA 2011: 27), it is yet to follow the lead of other nations and announce a target for EV uptake as well as deploying relevant EV policies to drive the domestic adoption of EVs. However, the OIES (2018: 13) cautioned that emerging markets will need to account for issues of social equity in their EV targets. For instance, tax revenues from transport fuels make up a large percentage of government finances in emerging markets (OIES 2018: 13). Hence, the OIES (2018: 13) advised that emerging markets should proactively develop an industrial policy as the key driver to achieve EV targets, as opposed to simply reacting to environmental pressures; e.g., China is one example of an emerging market that has explicitly adopted EVs as part of its industrial strategy (OIES 2018: 13). Fortunately, South Africa's

automotive industry has a successful policy framework, with the Automotive Production Development Programme (APDP), which incentivises the assembly of ICE cars locally being the highlight of government's industrial policy (Bischof-Niemz 2019: 1) and one which government could leverage to promote the adoption of EVs in the local market.

2.3.1 South Africa's automotive industry

The South African automotive industry is an important factor that can aid the country in its quest to promote the adoption of EVs. According to Lamprecht (2019: 5), the South African automotive industry owes its success to the partnership between the automotive sector and government to develop the sector, and is a reflection of the power of combining foreign investment with good industrial policy. The automotive industry is crucial for job creation and makes a significant contribution to the broad South African economy in terms of capital investment, exports, compensation, employment, government revenue and GDP. As the largest manufacturing sector in South Africa's economy, vehicle and components production accounted for 29,9% of South Africa's manufacturing output in 2018, the sector employed a total of 110 000 people directly. The contribution of the broader automotive industry to the country's GDP stood at 6,8% (i.e., 4,3% manufacturing plus 2,5% retail). Furthermore, exports of automotive products reached a record value of R178,8 billion, equating to 14,3% of South Africa's 2018 total exports. In addition, investments by the seven major Original Equipment Manufacturers (OEMs) in South Africa amounted to a further R7,2 billion along with an investment amount of R3,5 billion by the automotive component suppliers, equating to a total investment of R10.7 billion (Lamprecht 2019: 5).

At 610 854 units, South Africa's automotive industry was responsible for 0.64% of the world's vehicle production in 2018 (Furlonger 2019: 1) with about 58% of the vehicles being exported to more than 155 countries globally (Malinga 2019b: 1).

Lamprecht (2019: 8) further elaborated that South Africa's pro-automotive government policy programme, public-private partnerships, industry associations and favourable trade agreements had created an attractive environment for international OEMs and

automotive component suppliers to manufacture products in South Africa. Automotive industry bodies in the retail and manufacturing sectors of the industry include the Retail Motor Industry Organisation (RMI), the National Association of Automobile Manufacturers of South Africa (NAAMSA) and the National Association of Automotive Component and Allied Manufacturers (NAACAM). The major OEMs in South Africa, as well as NAACAM, are also affiliated to the independent organisation - African Association of Automotive Manufacturers (AAAM) (Lamprecht 2019: 8).

Specifically, South Africa has three key automotive or vehicle manufacturing hubs located in three provinces, i.e., the Eastern Cape (EC), Gauteng and KwaZulu-Natal (Kumalo 2019: 10) as depicted in Figure 2.1.

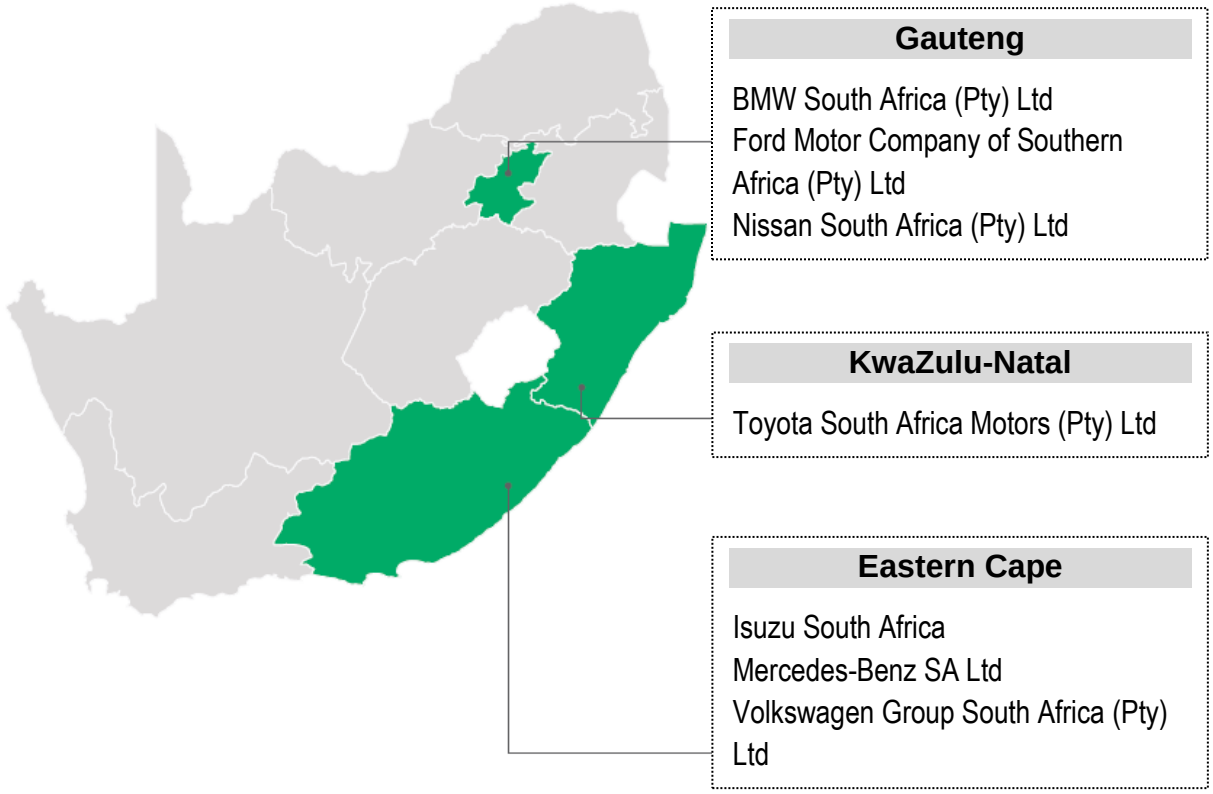

Figure 2.1: OEM hubs and their geographic locations in South Africa

Source: Adapted from Raw and Radmore (2020: 12).

At the beginning of August 2018, BAIC, China's fifth-largest vehicle manufacturer, opened a vehicle assembly plant in Port Elizabeth, EC (Du Venage 2019: 4) adding to the list of international OEMs that have invested and manufacture vehicles in South Africa.

Kumalo (2019: 10) further highlighted that since the stabilisation of the automotive industry in the post-apartheid era, the South African automotive market has expanded to include all leading global brands, with several big brands also manufacturing locally. Table 2.1 lists the multinational OEM's represented in South Africa and Table 2.2 presents the list of known importers and distributors of light motor vehicles in South Africa.

Table 2.1: Multinational OEM representation in South Africa.

BMW South Africa (Pty) Ltd
Ford Motor Company of Southern Africa (Pty) Ltd
Isuzu South Africa
Mercedes-Benz SA Ltd
Nissan South Africa (Pty) Ltd
Toyota South Africa Motors (Pty) Ltd
Volkswagen Group South Africa (Pty) Ltd

Source: Adapted from NAAMSA.

Table 2.2: Importers and distributors of light motor vehicles in South Africa.

Audi (VW Group)
European Automotive Imports South Africa (EAISA) (Pty) Ltd (Maserati)
FCA South Africa (Pty) Ltd (Fiat Chrysler Automobiles Group)
HAVAL Motors South Africa (Pty) Ltd (HMSA)
Honda
Hyundai Auto South Africa Pty Ltd (MOTUS Group)
KIA Motors South Africa (Pty) Ltd
Jaguar Land Rover
Mahindra & Mahindra South Africa (Pty) Ltd
Mazda Southern Africa (Pty) Ltd
Mini South Africa
Mitsubishi Motors South Africa (MMSA)
Peugeot SA (Pty) Ltd
Porsche
Renault South Africa (Pty) Ltd
Subaru
Suzuki Auto South Africa
TATA Motors South Africa
Volvo Car South Africa

Source: Adapted from Kumalo (2019: 11).

At the end of 2019, South Africa had a vehicle parc (i.e., number of registered vehicles) of 12,7 million, of which 7,49 million (or 59,0%), comprised passenger vehicles (Lamprecht 2020: 16). With over 46 brands (and 2 507 model derivatives) of passenger vehicles and 28 brands with 526 model derivatives of light commercial vehicles to choose from in 2019, Lamprecht (2020: 16) maintained that car buyers in South Africa were afforded the widest choice to market-size ratio than anywhere else in the world.

Because of its pro-automotive government policy, public-private partnerships and favourable trade agreements, amongst other attributes, South Africa therefore

possesses an auspicious automotive environment on which it could capitalise by building a policy framework that supports and promotes the adoption of EVs in the country. Additionally, South Africa would most likely want to avoid undesirable economic consequences such as those that could arise from disruptive market changes due to deepening of the uptake of EVs elsewhere in international markets without South Africa having been able to align its automotive sector to international market trends.

2.3.2 Policy framework regulating South Africa's automotive industry

The South African government has recognised the significance of well-designed automotive incentives and provided a high degree of support to the industry through consecutive industry incentive programmes (Deloitte 2019: 1). Government support was executed through the deployment of the automotive industry development policy in the form of the Motor Industry Development Programme (MIDP), which ran from 1995 to 2012 followed by the APDP (Barnes and Black 2019: 2). The MIDP provided the automotive industry with export benefits through a duty rebate system that then permitted the discounted importation of components and fully assembled vehicles, with these gradually reduced over time (Barnes and Black 2019: 2). Currently, the regulatory framework for transport is governed by South Africa's DoT and the policies that are relevant to the automotive industry, in addition to the APDP, include the South African Automotive Masterplan (SAAM) (2021 – 2035) as well as the Green Transport Strategy (GTS) (2018 – 2050) (Kumalo 2019: 24) as outlined below. The GTS (2018 – 2050) is discussed in section 2.3.5 that follows.

- APDP: as one of the policies that govern the automotive industry, the APDP was implemented in 2013 and is due to expire in 2020, according to Kumalo (2019: 24). The policy outlines rebate mechanisms, taxes, and incentives in the local traditional automotive industry dominated by the ICE vehicles (Kumalo 2019: 24). By making the necessary amendments to correct shortfalls identified within the APDP framework, a second version of the APDP will take effect from 2021 to 2035 to provide policy direction for the South African automotive industry (NAACAM 2019: 16). As noted by Kumalo (2019: 24), the APDP does not,

however, make direct or specific provision for EV manufacturing. This shortcoming could perhaps be rectified by, for instance, making amendments to the extended version of the APDP to address the need to grow the domestic EV market and incorporate supportive measures.

- SAAM: completed on 11 November 2016 and released for public comments on 7 July 2017, the SAAM is the South African automotive industry's long-term development strategy plan that places local value-addition at the core of any future support for the industry. It is also a strategy framework within which the second version of the APDP will now operate (Barnes, Black, Comrie and Hartogh 2018: 6). Likewise, amendments to the SAAM could be made for this framework to provide long-term strategic development of the EV market in South Africa.

Also, more importantly, South Africa's automotive incentive scheme through the APDP subsequently enabled international OEMs to set up streamlined vehicle assembly plants in the country to focus on specific models intended for their customers globally while, simultaneously, being able to import a wide range of models to suit customers' needs in the local market (Du Venage 2019: 3). For instance, BMW South Africa uses its plant in Rosslyn, Pretoria, to build its super utility vehicle (the BMW X3), which it exports globally, including to Germany, while, at the same time, it is able to sell approximately 50 different models in South Africa which it imports from its international manufacturing plants (Du Venage 2019: 3). Equally, this scenario positions South Africa in an environment where it could, with a supportive EV policy, see a large number of EVs being imported by OEMs into the country for local consumers enabling the local EV market to grow.

2.3.3 Policy and regulatory framework promoting the adoption of electric vehicles in South Africa

The South African DoT's GTS (2018 – 2050) is the first national policy document that sets out government's vision to promote the adoption of EVs in South Africa, according to Bulbulia (2019: 14). Launched and signed into law in 2018 (Makwitting 2018: 1), the

GTS (2018 – 2050) is a strategic document that informs and sets out the environmental directive of the DoT of South Africa (DoT 2014). The GTS (2018 – 2050) is comprised of five implementation themes and ten strategic pillars and it is strategic pillar eight, as Bulbulia (2019: 14) observed, that is of particular significance as it relates to the promotion of EVs in South Africa. Explicitly, strategic pillar eight states that government aims to "promote electric and hybrid electric vehicles". Precisely, the South African DoT (2019: 39) stated that "in order to radically grow the uptake of EVs in South Africa DoT, in conjunction with DTI and National Treasury, the DoT will:

- offer producers of EV vehicle manufacturing incentives to both produce and sell affordable EVs in South Africa, for both the local and export markets.
- work with local research institutions to conduct research on EV batteries.
- work with national, provincial and local government departments and authorities and the automobile industry to set annual targets for the uptake of EVs and hybrid electric vehicles in the government vehicle fleet, as well as monitoring the local content of the manufacturing of cars locally, in line with the Industrial Policy Action Plan.
- introduce the conversion of old technology vehicles with higher emission factors to be retrofitted with EV technology.
- consider providing incentives related to the beneficiation of using local resources in the manufacturing of key machineries and or components (e.g. fuel cells).
- assist in establishing and developing local EV OEMs".

Also, according to Parmar (2018: 22), one of the strategic initiatives within the GTS (2018 – 2050) of the national DoT that promotes introduction of EVs is an entity called the national uYilo e-Mobility Technology Innovation Programme established in 2013 to serve as a collaborative, multi-stakeholder programme. Its activities include industry engagement, capacity development, pilot projects, government lobbying and enterprise development (Parmar 2018: 22). Government could thus align policies governing the South African automotive industry such as the APDP and the SAAM with this "EV-friendly" strategic policy to avoid a disjointedness within government departments with regard to South Africa's EV objectives and a probable subsequent ineffectiveness of the

GTS (2018 – 2050) policy. Furthermore, value could be realised from setting clear EV targets with clearly defined deadlines in these policies. Using two examples, China, the leading nation in EV market size has set a target of 5 million EVs by 2030 and 40–50% EV sales by 2030, while Norway, the world leader in terms EV market share, has set a target of 100% EV sales by 2025 (Chen, Zarazua de Rubens, Noel, Kester and Sovacool 2020: 2). South Africa's GTS (2018 – 2050) policy, on the other hand, aims to achieve a 5% reduction of transport-related emissions by 2050; shifting 30% of freight transport from road to rail; 20% of passenger transport from private cars to public and ecomobility transport by 2022 (South Africa, DoT 2019: 25). However, no specific EV targets are mentioned. By contrast, South Africa estimated, as part of its commitment to the Paris Agreement, that the country would have more than 2.9 million EVs on the road by 2050 (Calitz 2019: 14). But there is currently no evidence of similar commitment having been made within the national government policy document (the GTS (2018 – 2050) that supports or is meant to support the adoption of EVs in South Africa.

Furthermore, the South African DTI's Electric Vehicle Industry Road Map, launched in 2013 (the DTI 2013: 1), proposed that government develop policies to ensure that 5% of total annual fleet requirements by both the state and state-owned entities be comprised of EVs and increasing these by 5% each year thereafter until 2020 (Montmasson-Clair, Dane, and Moshikaro 2020: 44). Although this was a specific and perhaps a more practical EV target, Montmasson-Clair, Dane and Moshikaro (2020: 44) reported that the 2013 Electric Vehicle Industry Road Map was never formally adopted. There is, therefore, a need for the South African government to also ensure that EV policies that are developed are also adopted and, most importantly, implemented in order to reap the full benefits of such policies. Furthermore, the fact that an 'Electric Vehicles Industry Road Map' was developed in the recent past but never adopted or implemented could point to the existence of policy implementation problems within government, an issue which a future EV study could look at.

2.3.4 Emission issues as drivers for the adoption of electric vehicles in South Africa.

According to reports (Miller and Façanha 2014: 6; Degirmenci and Breitner 2018: 250), increasing GHG emissions are considered as the major challenge for global warming, climate change and air quality especially in cities. In 2010, as represented in Figure 2.2, transport accounted for approximately one-quarter (23%) of global CO_2 emissions which are the main ingredient of GHGs that contribute to global warming, and over 70% of these emissions are generated by road transport (Miller and Façanha 2014: 6; Degirmenci and Breitner 2018: 250).

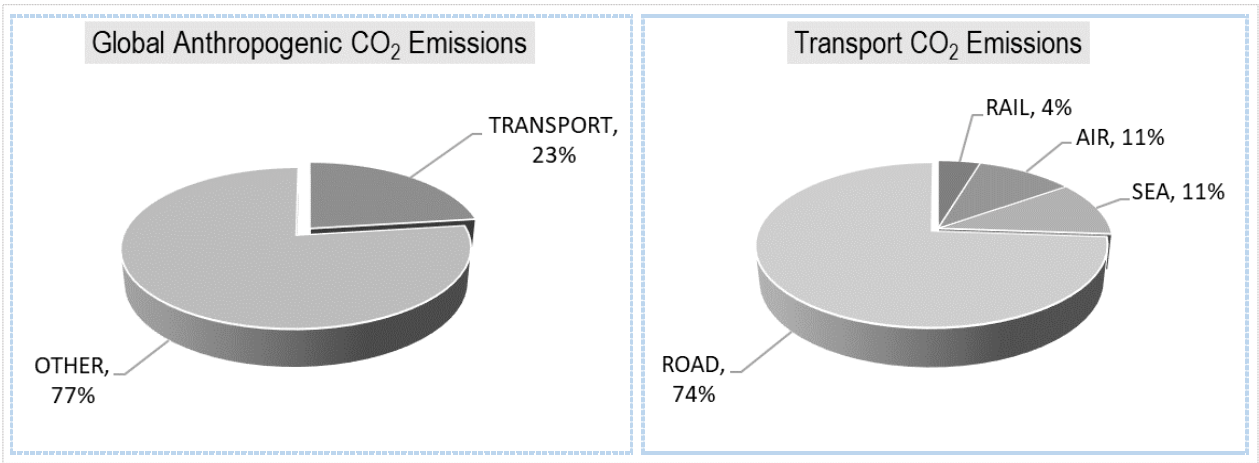

Figure 2.2: Global transport sector carbon dioxide emissions, 2010.

Source: Adapted from Miller and Façanha (2014: 6).

In this context, EVs are considered to have the potential to reduce GHG emissions significantly, provided that the electricity to charge them is produced from renewable sources of energy (Degirmenci and Breitner 2018: 250) and South Africa`s government have also realised the potential of EVs in reducing GHG emissions.

As a result, to reduce transport-related emissions that contribute to global warming and climate change, sustainable mobility plans of many governments worldwide, including South Africa, include the need for a significant shift towards the use of ultra-low or zero carbon emission vehicles such as EVs (Miller and Façanha 2014: 6).

South Africa has the highest CO_2 emission intensity in the G-20 group (the premier forum for international economic cooperation) of industrialised and developing countries (Booysen and Apperley 2020: 2). Globally, South Africa is the world's 14th largest emitter of GHGs (McSweeney and Timperley 2018: 1). This threatens South Africa's commitment to help slow global warming. Critically, the transport sector contributes to the problem in that its contribution to the national energy-related CO_2 emissions in South Africa is estimated to be approximately 14%, with the road transport sector being responsible for 90% (~13%) of transport emissions (Ahjum, Godinho, Burton, McCall and Marquard 2020: 2). To reach its targets, South Africa must reduce emissions by 32% in the next decade alone (Booysen and Apperley 2020: 2).

In addition, average annual temperatures in South Africa over the past five decades have increased by at least one and a half times the observed global average of 0.65°C (Ziervogel, New, Archer van Garderen, Midgley, Taylor, Hamann, Stuart-Hill, Myers and Warburton 2014: 605) as a result of global warming caused by CO_2 emissions. Minimum and maximum daily temperatures have been increasing in nearly all seasons and regions, and rainfall patterns show a tendency towards a decline in the number of rainy days in virtually all regions, with severe rainfall events having increased in frequency, particularly in spring and summer (McSweeney and Timperley 2018: 20). Furthermore, Ziervogel et al. (2014: 606) warned that climate change subsequently poses a major threat to South Africa's infrastructure, water resources, health, food security, and its ecosystem services and biodiversity. Worst still, Climate Action Tracker (an independent scientific analysis produced by three research organisations tracking climate action), rated South Africa's NDC as "highly insufficient" (McSweeney and Timperley 2018: 5). Climate Action Tracker added that this means South Africa's pledge is outside a "fair share" of the emissions reductions required to meet the goals of the Paris Agreement, and "not at all" consistent with limiting global warming to less than 2°C or 1.5°C (McSweeney and Timperley 2018: 5).

There is therefore an urgent need for South Africa to curtail its CO_2 emissions to stymie the advances of climate change. The adoption and uptake of EVs present one of the possible means to address these environmental concerns.

A study conducted by Buresh, Apperley and Booysen (2020: 139) in the South African context claimed that indirect carbon emissions from charging plug-in EVs (BEVs and PHEVs) increase beyond those of an ICE vehicle except when the vehicles are charged exclusively using solar energy. In particular:

> workplace charging of EVs using solar photovoltaic carports, whether it is the sole charging scenario, or if it is combined with home-based charging, has significant benefits, including an overall reduction in total carbon footprint, and an increase in the total number of EVs that can be supported by the grid.

More than 80% of South Africa's electricity demand is currently generated mostly by coal-fired power stations primarily owned and operated by the national power utility, Eskom, which supplies over 95% of the country's total electricity demand (Calitz 2019: 11). Therefore, for South Africa, there appears to be a need to also address the issue of electricity generation from renewable sources to complement the intervention to reduce GHG emissions through electrification of its road transport sector.

2.4 Identifying Existing or Possible Future Barriers to the Adoption and Uptake of EVs in South Africa

In the wider EV literature, studies asserts that the introduction and penetration of EVs worldwide is confronted by several barriers that inhibit a larger market penetration (Egbue and Long 2012: 717; Steinhilber, Wells and Thankappan 2013: 531). The major impediments to EV adoption are listed by Aasness and Odeck (2015: 34), Degirmenci and Breitner (2018: 250), Egbue, Long and Samaranayake (2017: 937), Mersky, Sprei, Samaras and Qian (2016: 56), Neaimeh, Salisbury, Hill, Blythe, Scoffield and Francfort 2017 (2017: 474) as the high purchase price of EVs, charging infrastructure, and limited driving range. Also, in literature, a number of studies (Bonges and Lusk 2016: 63; Rezvani, Jansson and Bodin 2015: 123; She, Qing Sun, Ma and Xie 2017: 38) further pointed out that factors such as perceived limited driving range, long charging times of EV batteries and lack of public infrastructure of charging stations can cause what is known as range anxiety (i.e., the concern that the driving range of EVs may not be

sufficient to meet the driving needs of the user), which is an important obstacle to consumer's purchase of EVs.

According to Anjos, Gendron and Joyce-Moniz (2020: 263), the obstacle to mass adoption of EVs due to the limited range phenomenon is aggravated by the hours-long charging times imposed by the first-generation slow chargers. Also, in the South African context, factors such as the security of electricity supply could impact the public perception of the viability of EVs in South Africa (Labuschagne 2020: 4). Likewise, security of electricity supply in South Africa is thus another factor that could contribute to range anxiety. Availability of EV models for consumers in South Africa is another important factor that could hamper the adoption of EV in the domestic market (Raymond 2019: 3). Furthermore, consumer behaviour is also a concern in developing countries like South Africa since the EV market development is also linked to consumer behaviour and awareness of the relative benefits of EVs, as Isaac (2018: 1) claimed.

2.4.1 High upfront capital cost of electric vehicles

According to Ahjum et al. (2020: 1), the purchase price of an EV is an important barrier to widespread adoption. Newbery (2016: 1) added that the upfront capital cost of EVs is, at present, high in relation to that of their comparable ICE counterparts, largely associated with high cost of the battery. Even so, the costs of batteries declined by 12% to 14% on average per year from 2000 to 2015 (OIES 2018: 6) and are continuing to decline. Additionally, according to Eggert (2019: 2), the price of EVs is forecast (by gold standard technical and economic studies) to reach parity with ICE vehicles by the mid-2020s. In actual fact, "one study finds that when fuel savings are counted, EVs are already at cost parity in some markets and that automakers could reap profits comparable to or greater than gas-powered cars by or before 2025" (Eggert 2019: 2).

In South Africa, adding to the high capital cost of EVs is the import tariff and ad valorem tax as EVs imported into South Africa are taxed at 25%, compared with the 18% import duty for ICE cars (Droppa 2019: 2). EVs in South Africa are also classified as luxury items, hence they are taxed like one (Gosling 2019: 2).

As noted by Hussain (2019b: 3), the EVs currently offered in South Africa by some of the international brands are still premium vehicles with prices that can range from R500 000 to as high as R2 million. Therefore, with possible introduction of less costly base-model EVs to the South African market and the likely imminent price parity between ICEs and EVs, the barrier at hand to the uptake of EVs in the South African context may be perceived as only a short-term and yet important phenomenon. The issue of import duties and ad valorem tax, on the other hand, could be addressed through deployment of targeted policies such as is currently the case with incentivising policies under the APDP framework and related policies that support the local manufacturing of the traditional ICE vehicles in South Africa.

2.4.2 Limited driving range of electric vehicles

Another important factor that continues to be labelled and presented as one of the most pressing barriers to the adoption of EVs is the perceived limited driving range of the EV (Noel et al. 2019: 96), which impacts the consumer's inclination to purchase an EV. Still, research suggests that current EVs satisfy the driving range needs of most car users (Needell, McNerney, Chang and Trancik 2016; Pearre, Kempton, Guensler and Elango 2011 cited in Melliger, van Vliet and Liimatainen 2018: 103). Also, Burger (2019: 23) recorded that the driving range of modern EVs is typically 250 to 550 km, and that this is suitable for most commuters' daily use.

In South Africa, for example, about one third of the estimated 10 million households use a vehicle to travel to work daily, according to a 2018 Statistics South Africa survey cited by De Villiers (2019: 3). Also, in South Africa, "the minibus taxi industry carries roughly 15 million commuter trips every day, with most vehicles operating within a radius of 200 to 300km a day" (George 2020: 2), which is a commuting range seemingly satisfied by the range of most modern EVs (of typically 250 to 550km). Additionally, Bischof-Niemz (2019: 2) comments that daily commuting in provinces such as Gauteng, with its relatively long distances, is perfectly suited for BEVs. Nonetheless, in South Africa, consumers' concerns about such factors as the security of electricity supply could aggravate this barrier to the adoption of EVs.

2.4.3 Security of Electricity supply in South Africa

Currently, South Africa has a well-documented electricity crisis which could undermine the attraction of EVs in South Africa (Furlonger 2019: 3) as it can also give rise to the phenomenon of range anxiety on the consumer. Labuschagne (2020: 4) warned that the state of Eskom and prevalence of load shedding in South Africa could impact public perception about the viability of EVs in that potential customers may be scared off by the likelihood of not being able to charge their vehicle at any given moment.

According to Labuschagne (2020), all three automakers currently offering BEVs in South Africa – Jaguar Land Rover, BMW and Nissan – have in place the following mitigating measures to enable them to provide power during outages:

- Jaguar Land Rover South Africa: about half of Jaguar Land Rover's public charging stations along the Jaguar Powerway network are fed by backup generators;
- BMW South Africa: similarly, most of BMW's ChargeNow public charging stations are supplemented by either electricity from solar panels or generators for backup power. In addition, BMW offers its clients a 24-hour on-call service where a client's vehicle will be transported to the nearest charging facility with power, or any location convenient to the client, should the battery pack be depleted;
- Nissan: is looking at adding alternative power sources (solar energy and batteries) to many of its charging facilities to reduce reliance on Eskom's power grid; and
- Both BMW and Jaguar Land Rover's dealerships in South Africa are equipped with generators for backup power (Labuschagne 2020).

Du Venage (2020: 18) cautioned that South Africa's power utility, Eskom, which supplies nearly all of the country's electricity is strained and struggling with an ageing fleet of coal-fired power generating plants. It has, on several occasions, communicated the difficulties it faces in supplying South Africa with electricity while maintaining and repairing its power generating plants that are in need of revamping (Bavier and Winning

2019: 2). Eskom struggles to meet current electricity demand and has been implementing frequent rolling blackouts during peak times (Buresh, Apperley and Booysen 2020: 132), typically two to four hours at a time since 2008 and has not been able to guarantee a stable and consistent supply of electricity (Samodien 2019: 3). Worse still, the study by Buresh, Apperley and Booysen (2020: 139) added that electrification of vehicles in South Africa will have negative effect on the already struggling national electricity grid. Fortunately, South Africa has abundant sunshine, as Booysen and Apperley (2020: 3) observed. This presents South Africa with a probable solution whereby plug-in EVs could be charged using solar energy to reduce the load on the national grid – a solution which Booysen and Apperley (2020: 3) proposed would ideally require EVs to be charged during the day using solar photovoltaic carports at the workplace or large car parks.

2.4.4 Inadequate availability and visibility of charging infrastructure

Related to perceived limited driving range and security of electricity supply (in South Africa) is the issue of availability and visibility of charging infrastructure for EVs. Bonges and Lusk (2016: 63) cited Krupa, Rizzo, Eppstein, Brad Lanute, Gaalema, Lakkaraju, and Warrender (2014) and Li, Tong, Xing, and Zhou (2015) who showed that the customer's decision to purchase an EV is directly related to the availability of charging stations. Bonges and Lusk (2016: 64) thus advised that to increase the use of EVs, the location, the number and types of chargers need to grow simultaneously to increase chargers availability. Raw and Radmore (2020: 20) recommended that having charging stations in locations that can be easily accessed by commuters is key to the adoption and growth of the EV market.

Nationally, South Africa currently has a charging network comprising of 258 publicly accessible charging stations (Montmasson et al. 2020: 33) as illustrated in Figure 2.3 below. Depending on the vehicle battery size, power capacity and their location, these chargers can provide charge times from as low as 25 minutes to a high of six hours (Parmar 2020: 4).

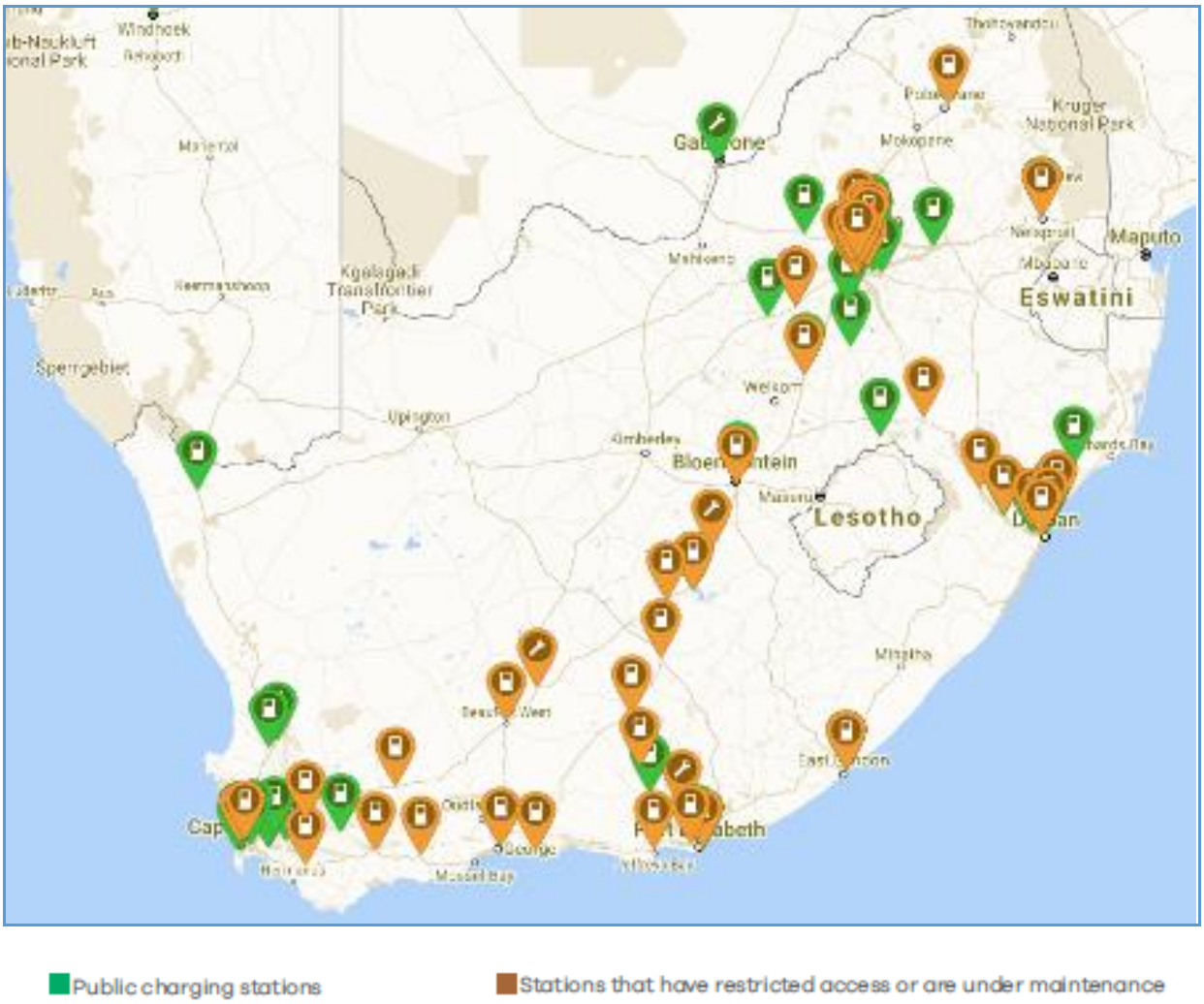

Figure 2.3: Public electric vehicle charging locations in South Africa.

Source: PlugShare, taken from Raw and Radmore (2020: 20).

The charging stations, which are sponsored by both government and the private sector are strategically located in popular locations, shopping malls, airports and along major routes (Pedroncelli 2020: 4). Examples of private sector-sponsored public charging stations includes Jaguar South Africa's Powerway network of public charging stations. These charging facilities (rolled out in late 2018), entail charging stations located along frequently travelled highways – the N1, N2 and N3, and shopping malls along the country's major routes in Bloemfontein, Cape Town, Durban, East London, Johannesburg, Port Elizabeth and Pretoria (Malinga 2019c: 2).

BMW shares some of its ChargeNow charging stations with Nissan because of the two companies' memorandum of understanding signed in 2015 to jointly build a national network of charging facilities for plug-in EVs (Bhana 2019: 3) – a factor that increases the availability of the charge points.

Montmasson-Clair, Dane and Moshikaro (2020: 34) pointed out that South Africa's charging infrastructure which translates to five plug-in EVs per public charge point compares favourably to those of other developed nations. They stated that it is particularly on par with Germany in terms of the ratio of plug-in EVs to charging points. The global norm for charging infrastructure, according to Venter (2020a: 5), stands at 18 to 20 plug-in EVs per public charge point. Montmasson-Clair, Dane and Moshikaro (2020: 34) further highlighted that the coverage and visibility of public charging points in South Africa is, nonetheless, less advanced.

Yet, fast-charging stations located in public places have the benefit of not only facilitating long range drives for EVs but can also enhance the visibility of electro-mobility in the population thereby serving as a means to mitigate range anxiety of the adopter (Melliger, van Vliet and Liimatainen 2018: 114). In conclusion, it would appear that South Africa has an adequate charging infrastructure for EVs. However, visibility of these charge points to consumers and to the general public needs to be ensured and optimised to increase potential customers' interest to purchase EVs. In other words, this will ease consumers' concerns about such issues as limited driving range and long charging times of EVs, and subsequently encourage EV purchases.

2.4.5 Long charging times of electric vehicles batteries

Zhang (2020: 3570) argued that long charging times for lithium-ion batteries used in EVs is an important obstacle for the widespread adoption of EVs, particularly when compared with the rapid refuelling of traditional ICE vehicles. The OIES (2018: 8) pointed out that fast charging (to address range anxiety held by consumers) is one probable technology that could enable faster adoption of EVs but cautioned that, given that the fastest way to 'kill' a battery is to either charge it at high temperatures or

operate it outside its voltage stability windows, charging in seconds is unrealistic. The OIES (2018: 9) further argued that charging times can be reduced significantly from the current figure of six to eight hours, but that the infrastructure needed to bring it down to minutes (i.e., under an hour) is as yet undeveloped at scale.

Owners of plug-in EVs have the option to charge their vehicles at home, workplaces, at fleet facilities, or at the available public charging stations (USA, DoE 2020: 5). Charging times for plug-in EVs vary depending on several factors, namely, how much energy the battery holds (battery capacity); the battery type; how depleted the battery is; and the type of charging equipment. Dependent on these factors, charging times can range from less than 20 minutes (using fast chargers) to 20 hours or more with standard chargers. However, not all plug-in EVs can accept fast charging, nor do all vehicles use the same type of plug for fast charging. Furthermore, fast-charging stations are typically positioned along corridors of heavy traffic and due to cost and electric current requirements, they are usually impractical for home installation (USA, DoE 2020: 5).

For South Africa, consumers' concern relating to slow EVs charging time was highlighted by a recent (2020) survey of South African car buyers conducted by AutoTrader (South Africa's biggest digital automotive marketplace) in partnership with smart mobility solutions provider – Generation.e. In the survey, 61% of respondents cited charging infrastructure as the biggest disadvantage of EVs, while 60% of respondents also believed that 'charging time' is a major disadvantage (Kreetzer 2020: 3), that deter consumers from investing in EVs, thereby limiting the adoption and uptake of EVs in South Africa.

2.4.6 Product availability and limited electric vehicles options for consumers in South Africa

The availability and variety of EV models in South Africa are also significant barriers to the growth of the domestic EV market. According to Parmar (2020: 5), South Africa has a small EV market with a (electric) vehicle parc of 0,009%, which could be attributed to, amongst other factors, the small number of EVs available for consumers to choose

from. In addition to the small number of EVs, South Africa does not manufacture passenger BEVs to supply to the mass market which, in turn, impacts consumer's choice in the switch to EVs (Parmar 2020: 3). Specifically, there is currently only three BEV models, i.e., the BMW i3, Nissan Leaf and the Jaguar I-pace, and ten PHEV models in South Africa. There are 23 HEV models and there are zero FCEVs for South African consumers. Figure 2.4 shows EV sales in South Africa by vehicle model and EV category as of the end of 2019.

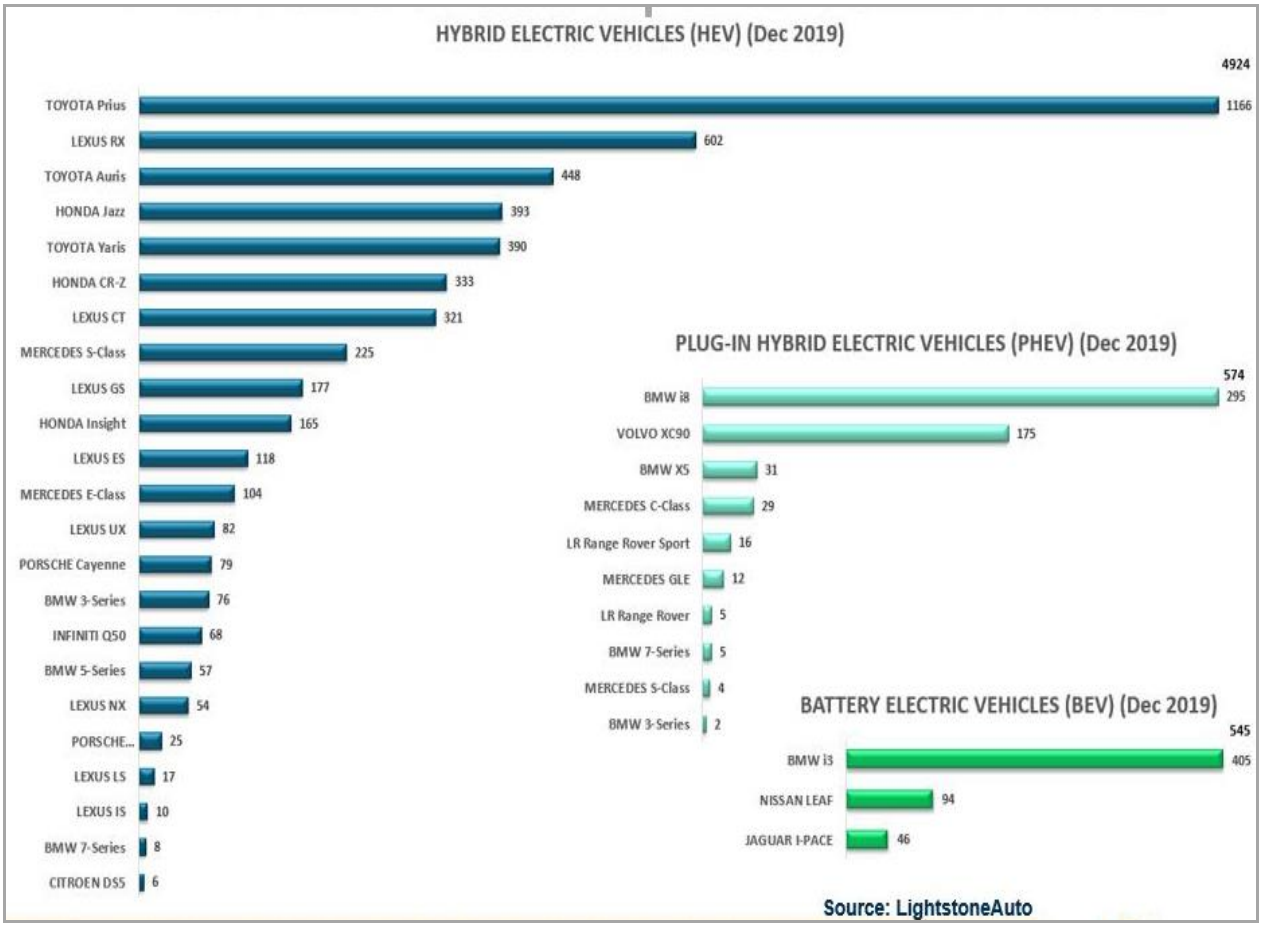

Figure 2.4: Passenger electric vehicle sales in South Africa (as of end 2019).

Source: Kuhudzai (2020: 3).

The sales of EVs by vehicle category for the period 2010 to 2019 are presented in figure 2.5 below.

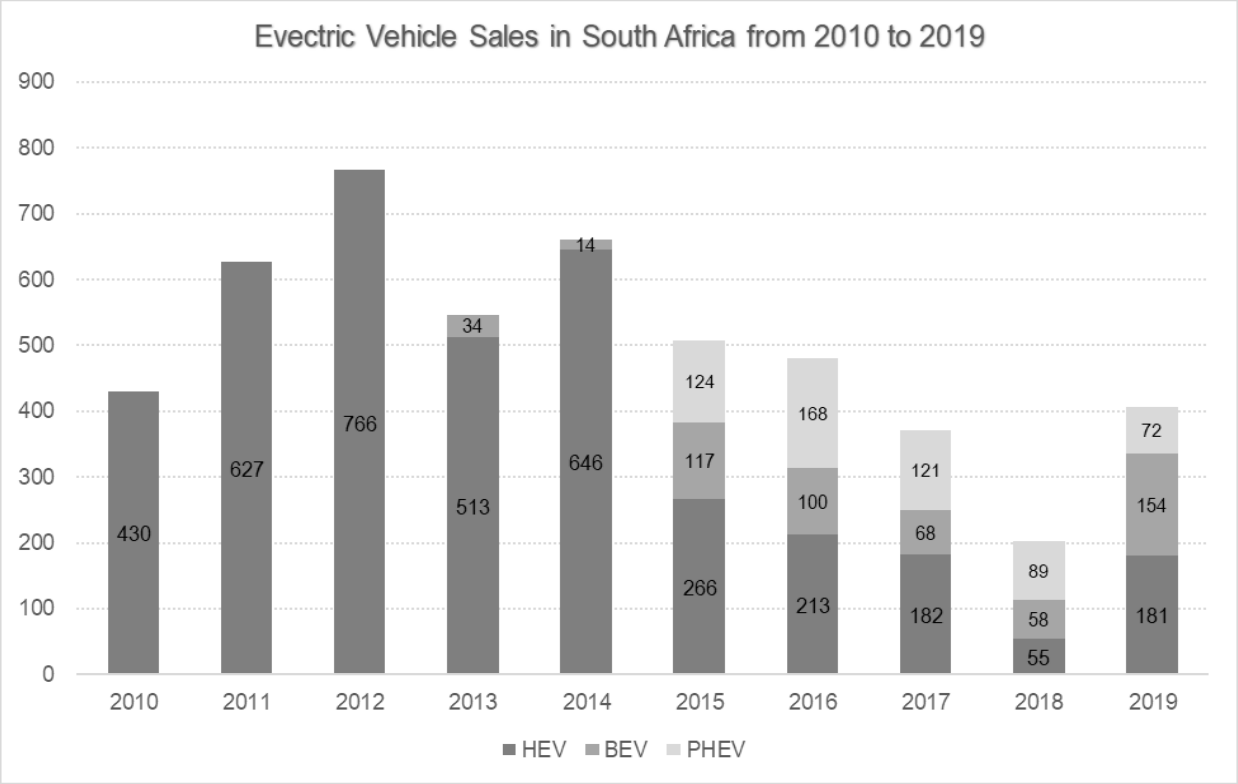

Figure 2.5: Sales of electric vehicles in South Africa for the period 2010 to 2019.

Source: Adapted from Lightstone and obtained from Montmasson-Clair, Dane and Moshikaro (2020: 27).

As Figure 2.5 shows, sales of EVs in South Africa for the period have been rather minimal and sporadic. In total, the number of EVs sold in South Africa stood at 6 043 with HEV dominating the mix at over 80% of the total, which is consistent with the fact that the HEV category had the greatest number of models available (23 HEV models versus 13 models for PHEVs and BEVs combined) for consumers.

In comparison, the number of EV models currently available worldwide was 162 in 2019 and was expected to increase by 100 more models in 2020 (Montmasson-Clair, Dane and Moshikaro 2020: 28). This means the vast majority of EV models that leading brands have released in international markets are not available in South Africa. Additionally, Raymond (2019: 3) regards the limited number of EVs as a key determinant of the uptake of the EV market in South Africa in the future. Government's

intervention by putting measures in place to ensure that more EVs are available for South African consumers to stimulate the local EV market is, therefore, of utmost necessity. Such measures could include, for instance, removing import duties on EVs to encourage importers to bring in more EV models and/or incentivising local OEMs to manufacture EVs.

On the positive side, a small number of BEVs were expected to arrive in South Africa during the course of 2020 and 2021, which would potentially help widen the consumers' choice of EVs to some extent and increase the opportunities for more EV purchases. The additional EVs anticipated in 2020/2021 to add to the lineup of BEVs currently on the local market, according to Kuhudzai (2020: 3), included the Audi e-tron, the Mercedes EQC, the new 40 kWh Nissan Leaf (the first-generation Nissan Leaf was discontinued after a short run in South Africa) and the 62 kWh Nissan Leaf e+, the Opel Corsa-e as well as the new MINI-E.

2.4.7 Lack of consumer awareness about electric vehicles

The primary concerns of consumers inhibiting the sales of more EVs include the high cost of the vehicle, limited driving range, the length of time it takes to recharge the battery and safety concerns whereas secondary concerns relate to the lack of charging infrastructure, both local and long distance (Bryden et al. 2018: 322). Isaac (2018: 1), added that consumer behaviour towards the adoption of EVs, especially within developing nations such as South Africa, are negative because of the concerns consumers have about the aforementioned aspects of EVs despite the advantages that EVs provide. Hence, raising consumer's awareness on EVs could increase the potential adoption of EVs in South Africa.

Kester, Noel, Zarazua de Rubens and Sovacool (2018: 730) also argued that consumer awareness programmes and especially consumer information and awareness campaigns were still left out of most of the public EV support incentives and proposed that public authorities could become "front-runners" themselves. For example, a 2017 survey by Altman Vilandries & Company of more than 2 500 American drivers found

limited awareness of EVs with about 60% of respondents saying they were unaware of electric cars, and 80% had never ridden in or driven one, according to Morris (2017: 1). Remarkably, the survey also found that a clear majority of consumers who have been inside an electric car enjoyed it, suggesting that overlooking consumer information and awareness programmes could create a significant barrier in the transition to electro-mobility. Also, according to a Jaguar Land Rover South Africa representative, as quoted by Labuschagne (2020: 3), "consumer education and the correction of common misconceptions about EVs is key, and with the continuous spread of proper EV education most consumers would likely discover that regular travel by electric vehicle is not only viable but also very appealing".

Possible options, as suggested by Montmasson-Clair, Dane and Moshikaro (2020: 44) to improve consumer's awareness of EVs to address the barriers to EV adoption associated with the consumers' concern about such aspects of EVs as perceived limited driving range; long charging time or availability of charging infrastructure include the following:

- carrying out marketing and education campaigns tailored to raise awareness; and, most importantly, getting customers to experience EVs;
- ensuring availability of adequate and visible charging infrastructure;
- promoting EVs through dedicated dealerships and other channels; and
- increasing visibility of EVs through a targeted campaign to electrify highly visible public or private fleets (possibly with accompanying branding).

Therefore, implementation of these interventions would create general public awareness on EVs and positively influence consumer behaviour towards EVs (i.e., remove associated barriers) leading to improved EV adoption in South Africa.

2.4.8 Lack of clear policy framework supporting the adoption of electric vehicles

As Labuschagne (2020: 2) observed, government policy is one of the biggest barriers to mass adoption of EVs in South Africa. More particularly, South Africa currently lacks a clear policy framework on electrification of cars (Cokayne 2018: 3). Therefore, South

Africa needs to adopt a coherent policy framework consistent with South Africa's domestic context that promotes the adoption of EVs in order to enable government to meet its GHG emission target in keeping with its commitment to the Paris Agreement on climate change. Such a policy could, amongst other objectives, help to overcome the existing barriers and avoid potential future barriers to the uptake of EVs in South Africa. For example, government could provide purchase incentives (e.g., through a rebate system) to reduce the prohibitively high purchase price of EVs in South Africa and motivate more consumers to purchase EVs. Alternatively, it could roll out EV public procurement programmes to increase EV awareness among consumers and evoke the consumers' interest to purchase EVs.

2.5 Policy Incentives Interventions

The current South African government's incentive scheme for the local automotive industry, the APDP has no direct incentives for the production of alternative drivetrain technologies such as BEVs or to support their demand (Venter 2020b: 1). Montmasson-Clair, Dane and Moshikaro (2020: 27) added that that some locations offer free charging, but the benefit is limited and slowly disappearing. As an example, BMW and Nissan, who are also early adopters of EVs in South Africa have so far been offering free fast-charging service at their dealerships to encourage the sales of their EVs, but the practice is believed to be unsustainable especially as the EV market grows (Droppa 2019: 3). Therefore, a government-supported incentives programme to stimulate the adoption of EVs is vital.

In contrast, there are numerous reports in the broader EV literature, e,g., Bjerkan, Nørbech and Nordtømme (2016: 170), Aasness and Odeck (2015: 34), Langbroek, Franklin and Susilo (2016: 94) and Wee, Coffman and La Croix (2018: 1601) attesting to the significance of incentives in increasing the attractiveness of EVs and their subsequent purchases. Hence, many countries have provided packages of incentives to increase the sales of EVs in their local markets.

As an illustration, the global EV market has expanded significantly in the past decade largely owing to aggressive government policies incorporating monetary and non-monetary incentives targeted at stimulating their market growth to achieve set targets IEA (2020a: 86). After entering commercial markets in the first half of the decade, there were only around 17 000 EVs in the world in 2010. But in 2019 alone, the number of light EVs sales globally was 2.1 million units representing a 6% growth from the previous year. In the previous six years however, growth rates were between 46% and 69%. In 2019, the global total number of EVs stood at 7.2 million as shown in Figure 2.6 (IEA 2020a: 40). The substantial growth in the EV market in the global arena is attributed to aggressive policy interventions by governments. Meanwhile, South Africa is yet to determine a target for its EV market uptake or to roll out the necessary policy incentives programme to encourage the adoption of EVs.

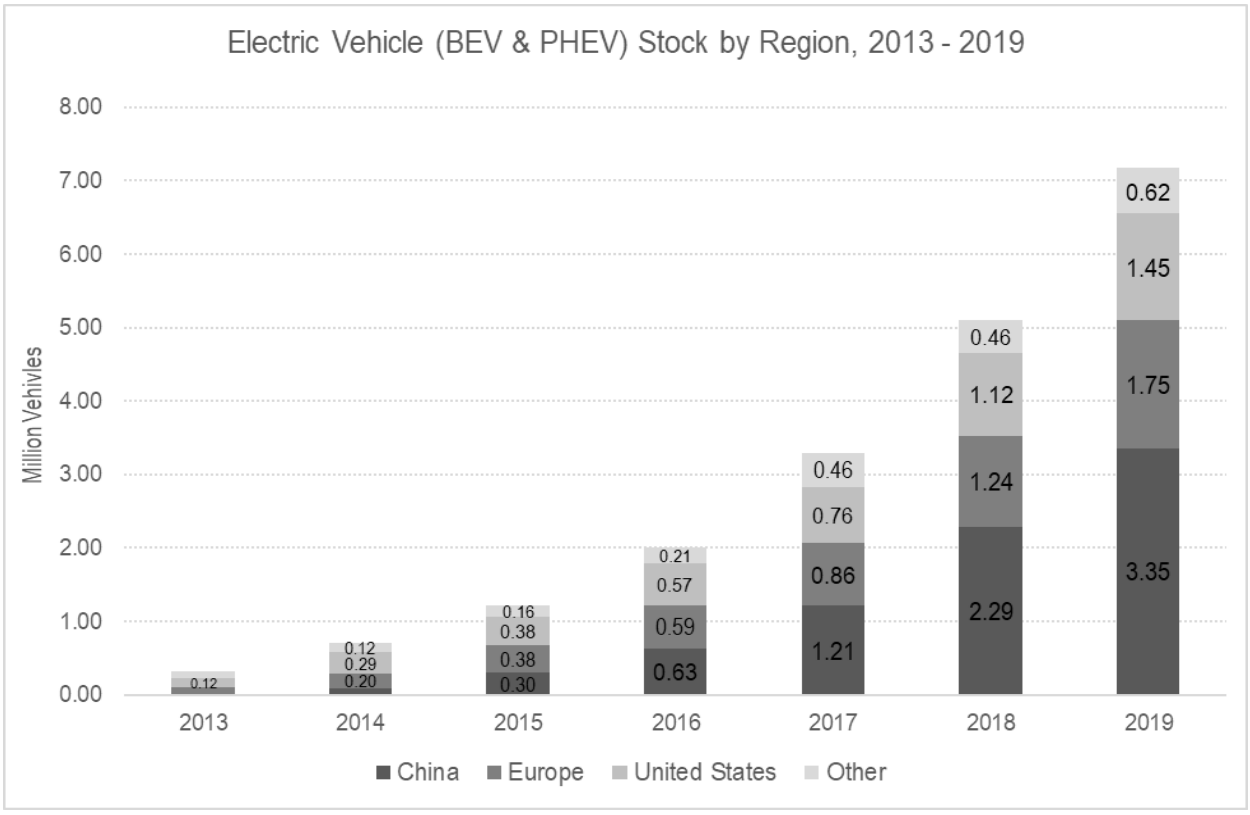

Figure 2.6: Global electric vehicles stock by region from 2013 to 2019

Source: Adapted from the IEA (2020a: 40).

Figure 2.6 shows that China was the largest EV market followed by Europe and the USA. It also shows an exponential growth of the EV market in these countries since the 2010. As shown in Figure 2.7, Norway is the leading nation worldwide in terms of EV market share at 55.93% EVs on the road, followed by Iceland (22.6%) and the Netherland at 15.14% EV market penetration, according to the IEA (2020b: 2).

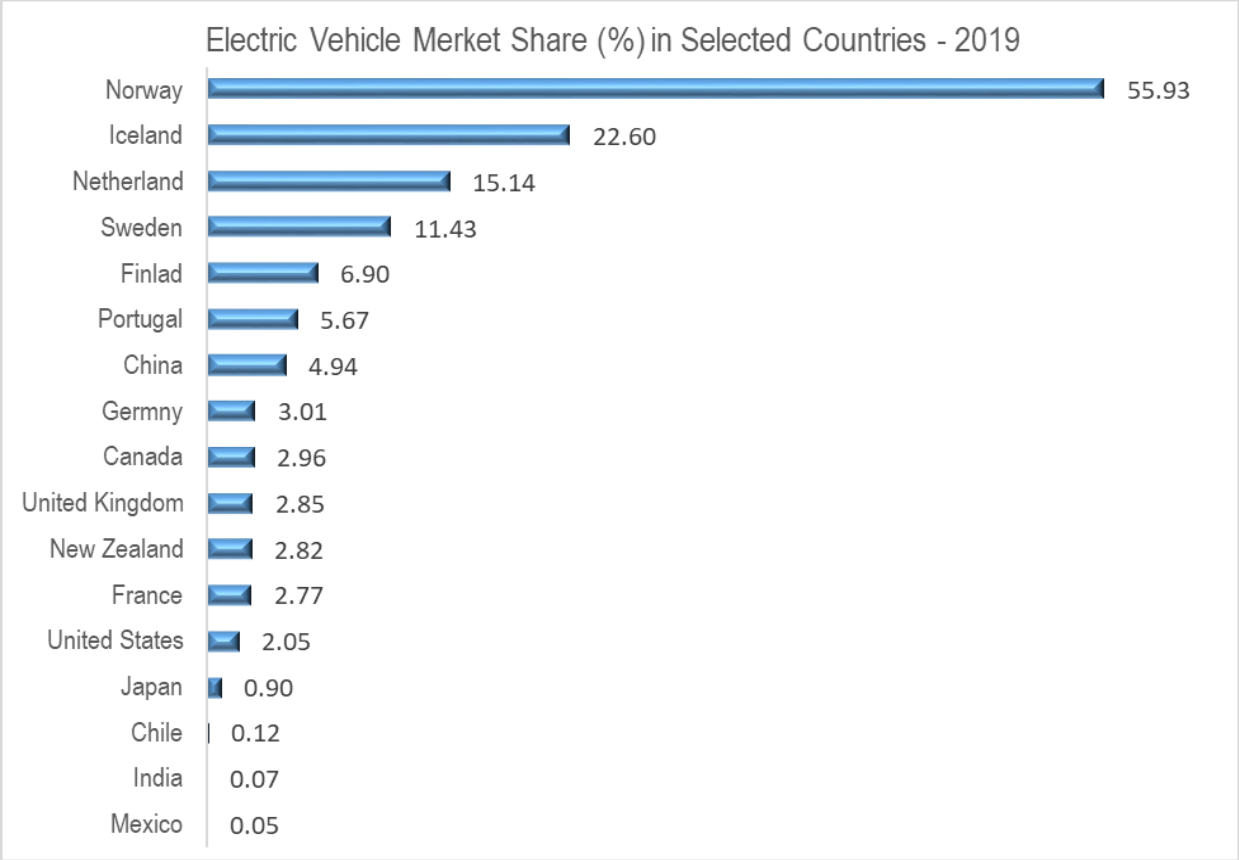

Figure 2.7: Electric vehicle market share in selected countries in 2019

Source: Adapted from the IEA (2020b: 3).

As a global leader by EV market share, Norway presents a special case to make evident the effectiveness of policy incentives to promote EVs adoption. This is discussed in more detail in the section that follows.

2.5.1 Effectiveness of policy incentives on electric vehicles adoption in Norway

Worldwide, the fleet of EVs in Norway is the largest per capita (IEA 2020b) because of multiple economic incentives offered, which encouraged consumers to purchase and use EVs, according to a 2015 study by Aasness and Odeck (2015: 1). The list of implemented incentives in Norway to promote the adoption of EVs is presented in Table 2.3.

Table 2.3. The implemented electric vehicle (BEV & PHEV) incentives in Norway.

Incentive	Trial Period	Permanent Year
Temporary Exemption from on-off registration tax	1990–1995	1996
Exemption from annual vehicle tax	–	1996
Exemption from road tolls	–	1997
Exemption from parking fees on municipal owned parking facilities	–	1999
Reduced company car tax	–	2000
Exemption from VAT		2001
Temporary use of transit lanes	2003–2005	2005
Permanent use of transit lanes	–	2005
Further reduction in company car tax		2009
Exemption from paying car ferry fees	–	2009

Source: Aasness and Odeck (2015: 4).

The list of the Norwegian government's incentives comprises of both financial (e.g., exemption from VAT) as well as non-financial incentives such as the use of dedicated transit lanes, which other countries such as South Africa could also adopt. However, Aasness and Odeck (2015: 1) cautioned that some of the incentives adopted have had negative effects – the most serious of which is the exemption from toll charges, which has resulted in a sizeable loss of toll (fees) revenue to the Norwegian government. Policymakers in countries with nascent EV markets such as in South Africa would therefore need to be prudent in their approach and avoid potential shortcomings by

learning from this European example and devise objective incentive policies that will benefit the country and its EV market.

Aasness and Odeck (2015: 3) further pointed out that the Norwegian EV incentive scheme's overall goal was to bring the purchase and use of EVs in Norway up to or beyond par with that for the equivalent traditional vehicles, and to enable the Norwegian government to achieve a share for the EV fleet of approximately 10% by 2020. As a result of its strong incentives for promoting purchase and ownership of BEVs, Norway became a global leader in the field of electro-mobility and its BEV market share is significantly higher than that of any other country in the world (Bjerkan, Nørbech and Nordtømme 2016: 170). As Mersky et al. (2016: 57) noted, Norway's policy incentive system is unique to those of other countries in that Norway has a nationally uniform policy that includes every major category of incentive: infrastructure usage pricing and access benefits; parking access; charging access benefits; and point of sale pricing benefits, in addition to having the longest continuous national campaign to encourage EV adoption. South Africa could thus take a lesson from Norway by setting national EV targets and adopting a similar nationally uniform policy approach for example in drafting its EV incentive policy, of course, taking into account factors that are unique to South Africa in doing so. Figure 2.8 depicts the accumulated number of registrations of EVs in Norway from 2004 to 2019.

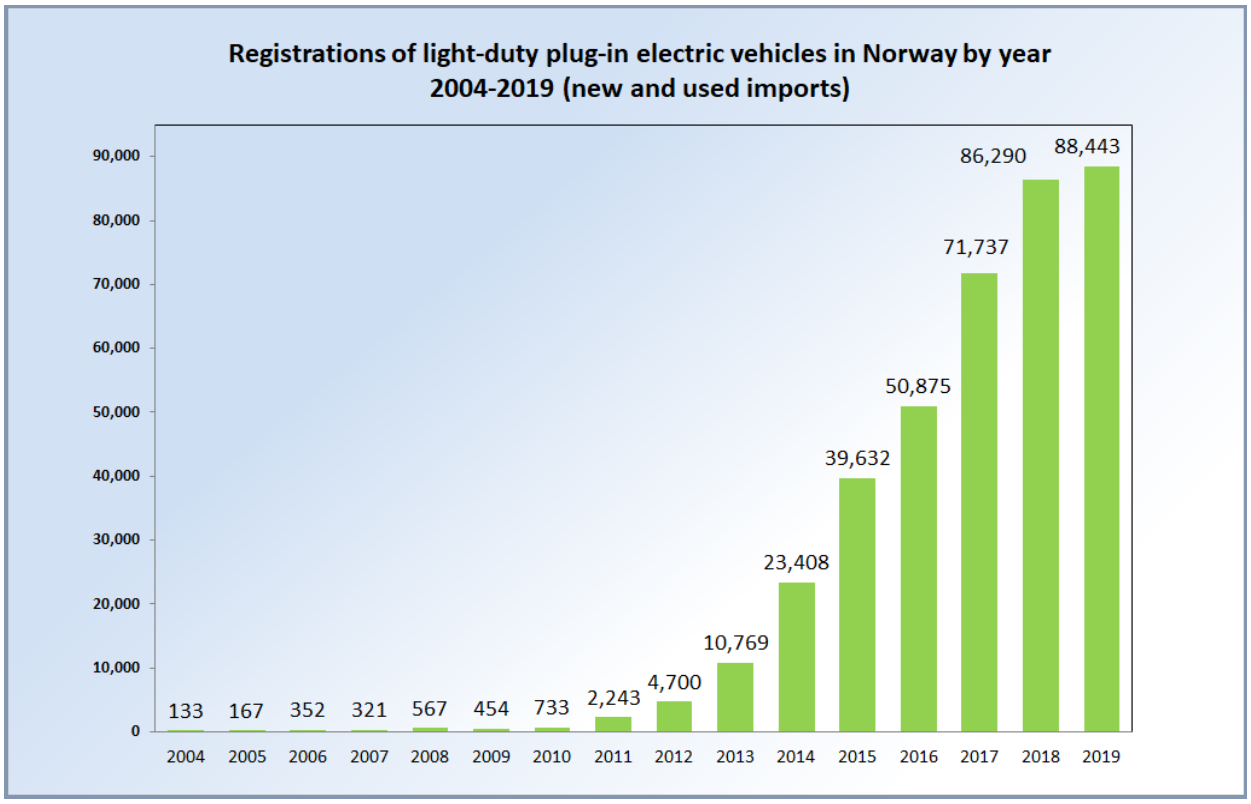

Figure 2.8: Sales of plug-in EVs (BEVS and PHEVs) in Norway from 2002 to 2019

Source: Wikimedia.org.

The chart shows that from a cumulative plug-in EVs fleet of hardly 10 000 registered vehicles in 2012, the fleet had risen to nearly 90 000 in 2019. The Norwegian account therefore demonstrates the usefulness of aggressive and targeted policy incentives in stimulating the adoption of EVs, from which South Africa could take valuable lessons.

As the leader (first) and third positions respectively by EV market size, the contribution of incentives to China and the USA's EV market growths is also discussed in the following sections 2.5.2 and 2.5.3.

2.5.2 Effectiveness of policy incentives on electric vehicles adoption in China

Globally, China is the largest EV market with a PHEV fleet of around 3.3 million units in 2019 (IEA 2020a: 44). To increase the development and adoption of EVs, the Chinese government used a series of policy incentives and especially aggressive incentivising

policies which led to the sales of EVs in China exceeding 500 000 back in 2016 (Wang, Tang and Pan 2017: 211). According to Li, Yang and Sandu (2018: 6), the policy initiatives introduced by the Chinese government aimed at providing both monetary and non-monetary incentives such as the following examples:

- rolling out two programmes in 2009 initially focused on public procurement (of EVs), later extended to include private procurement where financial subsidies were provided to consumers to encourage EV purchases. Salient features of these financial subsidies included: (1) direct payments to approved vehicle manufacturers and (2) subsidy levels based on the rate at which petrol can be saved.
- providing financial assistance for construction and operation of charging facilities, and regulatory provisions such as charging interface standards to streamline charging infrastructure planning processes (Li, Yang and Sandu 2018: 6).

As highlighted in earlier discussion, features such as targeted funding to encourage public and private procurement of EVs has the added advantage of increasing visibility of EVs to create EV awareness to consumers. This is an approach that South Africa could imitate in its undertaking to promote the adoption of EVs as it has significant potential to eradicate many of the barriers relating to consumer behaviour towards the adoption of EVs.

As with the Norwegian case, the Chinese policy incentives were also not without challenges. This is demonstrated by a study conducted by Li, Yang and Sandu (2018) who reviewed China's EV incentives to assess their effectiveness in overcoming existing barriers to the uptake of EVs in China. The study found that there was room to improve the incentives particularly to target the removal of macro-level barriers (e.g., fragmented authority and local protectionism), which could significantly inhibit the uptake of EVs. This example suggests that even the EV incentive programme in China was not perfect, despite it having helped China to grow its EV market to levels that, at present, surpass that of any other country in the world. The inference that could be made from this is, therefore, that the existence of policy incentives (even with some

imperfections) still has the potential to improve the adoption of EVs. South Africa could thus take note and be encouraged that employment of policy incentives is likely to have a positive impact on the uptake of EVs (an observation noted also with the Norway case). Still, South Africa is presented with great opportunity to learn from other nations' shortcomings and could aim to avoid similar errors in designing and developing its own EV policy framework. Another crucial learning for South Africa from the Chinese case is the need to avoid or be vigilant of political interference in the design of the policy incentives and their implementation.

2.5.3 Effectiveness of policy incentives on electric vehicles adoption in the USA

In recognition of the potential social benefits of EVs, the USA government also offered customers a tax credit that is scaled according to the vehicle's battery capacity and capped at $7 500 (Jenn, Springel and Gopal 2018: 351) – an approach which South Africa could adopt. Furthermore, almost half of the American states also offer some kind of purchase-related financial incentive to consumers (Wee, Coffman and La Croix 2018: 1601). Another example is a 2014 study by Jin, Searle and Lutsey (2014) which compared 2013 EVs market share with state-level incentives in the USA. The study found that direct subsidies were the biggest determinant of sales of EVs followed by access to high-occupancy-vehicles lanes (in states with a high density of traffic in carpool lanes). A subsequent 2018 study conducted by Jenn, Springel and Gopal (2018) that reviewed a database of 198 incentives across all 50 (USA) states found that every $1 000 offered as a rebate or tax credit (as is the current most dominant incentive in the USA) increases average sales of EVs by 2.6%. The study also found that high-occupancy-vehicles lane access is a significant contributor to the adoption of EVs.

The foregoing examples are, in conclusion, good examples of objective policy interventions, especially that some form of direct financial incentive has great potential for stimulating EV market penetration in international markets and could do so in South Africa. This inference is supported by the World Economic Forum (WEF) (2018: 5) in its remarks about the state of EVs in sub-Saharan Africa that "international examples have demonstrated that rapid EV adoption requires strong enabling policies, including tax

incentives and subsidies". Similarly, these examples suggest that emerging markets such as South Africa have abundant opportunities to develop context-specific and beneficial policy incentives to promote the adoption and uptake of EVs by learning from examples from international markets.

2.5.4 Policy incentives to promote the adoption of electric vehicles in South Africa

In keeping with the Norwegian, Chinese and USA cases discussed previously, the incentives to promote the adoption of EVs in South Africa need primarily to aim at removing most of the existing or possible barriers to EV adoption in South Africa so that more consumers are encouraged or incentivised to purchase EVs. Subsequently, the incentives proposed for the South African EV landscape also include some of the examples adopted in international markets.

Although it is outside the scope of this work to evaluate the examples of incentives discussed in this chapter to determine the extent of their potential effectiveness in driving the adoption and uptake of EVs in South Africa, the list of incentives as presented in Table 2.4 is drawn from elements identified in the preceding discussions. This excludes those elements that are not applicable to the South African context such as "exemption from paying car ferry fees" since South Africa simply does not have any vehicle ferrying system.

Table 2.4: Policy incentives that can potentially promote the adoption of electric vehicles in South Africa

Financial Incentives	Non-Financial Incentives
• Remove or reduce import duty • Remove or reduce ad valorem tax • Subsidize EV purchases through a purchase rebate system • Provide subsidies for company fleet purchases • Exemption from VAT on EV purchases • Reduce company car Tax • Free or subsidized charging services • Exemption from road toll charges • Exemption from annual vehicle licensing fees • Incentivize local OEMs to build EVs	• Free parking at public places (e.g., shopping malls, airports) • Dedicated parking zones for EVs in public parking facilities - shopping malls, airports, etc. • Dedicated lanes for EVs in cities

Source: Author's own compilation.

Likewise, it will also be noted that elements such as "exemption from toll charges" previously discussed as having resulted in unintended consequences for the Norwegian government are also included in the list of possible beneficial incentives for South Africa. This is because these possible options were not assessed for the magnitude of impact they could have in stimulating the adoption of EVs in South African – an exercise which would lie outside the scope of this work but is perhaps a topic for further research.

2.6 Framework for Promoting the Adoption of Electric Vehicles

The conceptual framework for the study is guided by the 'general framework of public policies for innovation diffusion' developed by Caiazza (2015: 1410). "An innovation is an idea, practice, or object that is perceived as new by an individual or other unit of adoption" (Rogers 1983: 11). Diffusion, as defined by Kee (2017: 1) refers to "the communication process through which an innovation spreads through certain channels from one person, an organisation, or any unit of adoption to another within a social system over time". Wejnert (2002: 297) cites Rogers (1995) to define diffusion of innovations as "the spread of abstract ideas and concepts, technical information and actual practices within a social system, where a spread refers to a flow or movement from a source to an adopter typically via communication and influence".

Caiazza (2015: 1406) asserted that the diffusion of innovation is key both for firms' profitability and countries' economic growth and that policies that aim to reduce the main barriers to innovation diffusion as well as public policies that aim to enhance it should be key considerations for policymakers to ensure effective diffusion of a new technology. Also, policymakers must consequently adopt the right mix of multisector and multidisciplinary policies to overcome barriers to the diffusion of innovation (Caiazza 2015: 1408). Caiazza (2015: 1410)'s 'general framework of public policies for innovation diffusion' is shown in Figure 2.9 and is discussed below.

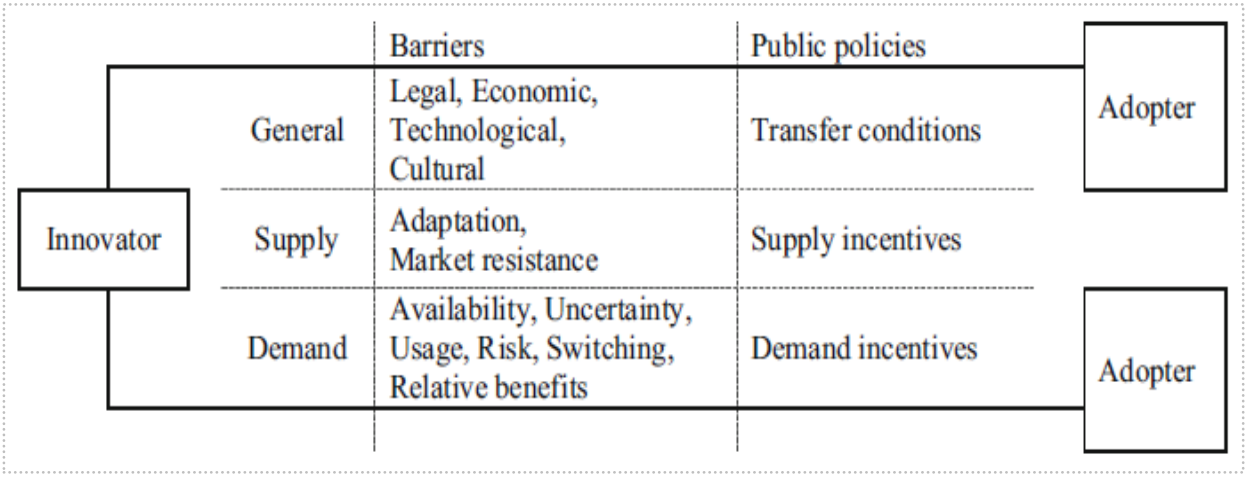

Figure 2.9: Caiazza's general framework of public policies for innovation diffusion

Source: Caiazza (2015: 1410).

The model identifies the barriers that affect the process of innovation diffusions and are relevant for public policymakers. Caiazza (2015: 1408) (citing Rogers 2003; Zahra and Nielsen 2002; and Hall and Khan 2003) stated that the diffusion of innovation is impacted by a series of institutional factors (general), innovators' ability to push their innovations on the market (supply-side) and users' capability to adopt the new technology (demand-side).

- Institutional (general) barriers to innovation diffusion per the model are comprised of legal, economic, technological and cultural obstacles related to the context in which the process of diffusion is realised. Additionally, Caiazza (2015: 1409) pointed out that the primary institutional barriers are those related to uncertainty in intellectual property rights, weaknesses in legal frameworks such as regulatory obstacles and economic frameworks (e.g., fiscal structure, financial mechanisms). One example of institutional barriers – so-called macro-economic barriers in EV policy in South Africa and one which would affect the adoption of EVs – would be misalignment between the different policy documents governing the automotive industry or between government departments with regards to EV policy or objectives.

- Supply-side barriers are shown as those characterised by barriers relating to innovation adaptation and market resistance. That is, they are obstacles that innovators encounter when pushing their innovation to the market (Caiazza 2015: 1409). Concerns about technological aspects and market uncertainty for EVs are said to be examples of factors that influence producer preferences for EVs (Li, Yang and Sandu 2018: 2).
- Demand-side barriers, on the other hand, are reflected in the model as those comprising of obstacles relating to the availability, uncertainty, risk, usage and relative benefits of the innovation. They are described as those that relate to obstacles that users (adopters) face in becoming aware of and adopting an innovation (Caiazza 2015: 1409). According to Li, Yang and Sandu (2018: 3), examples of factors that affect consumer preference for EVs include financial factors, such as high purchase prices and high maintenance costs; technological factors, such as short driving range, short battery life and long recharging time of EVs battery packs; and infrastructure factors, such as limited access to charging facilities.

The model also introduces the issue of public policies and the role that policymakers play in promoting new technology diffusion characterised by transfer factors, supply-side and demand-side incentives. Consequently, Caiazza (2015: 1411) recommended that a government should assume the role of a catalyst in the process of the diffusion of innovation through the definition of policies aimed at providing rules concerning interactions between innovators, adopters and other stakeholders in the interest of the entire economic system.

According to Caiazza (2015: 1411), it is broadly recognised that public innovation policies, like the barriers to innovation diffusion, should have a general, a supply-side and a demand-side nature. He discussed these aspects as follows:

- General policies are those that target to create general conditions for innovation diffusion and adoption. For instance, acting as a regulator, a government can promote the diffusion of innovation through policies aimed at clarifying legal and

economic frameworks, technological elements and cultural behaviours focused on promoting the diffusion of innovations. Thus, public policies can create an institutional framework that facilitates the adoption of an innovation. As an example, government can adopt macro-economic measures, e.g., favourable depreciation schedules and other measures such as financial incentives for entities that invest in the diffusion of a new technology.

- Supply-side policies are key tools that aim to support the diffusion of innovation on the market that provides innovators with technical assistance, funds and political support needed to face market resistance and the adoption of the innovation.
- Demand-side policies are concerned with public measures that increase demand for innovations and enhance conditions for the uptake of innovations. For example, government can act as a sponsor that supports users in facing the risks involved in choosing and adopting the new technology or as an adopter that is the main acquirer of an innovation (Caiazza 2015: 1411).

2.7 Conceptual Framework for the Study

Based on Caiazza's (2015: 1410) 'general framework of public policies for innovation diffusion' discussed in the preceding section, a framework was developed and proposed for the promotion of the adoption of EVs in South Africa. In addition, Moon and Bretschneider's (1997: 60) 'framework for the diffusion of government-sponsored innovation' presented in Figure 2.10 on the next page was employed to corroborate Caiazza's (2015: 1410) framework with regard to the role of government in the diffusion of innovation process.

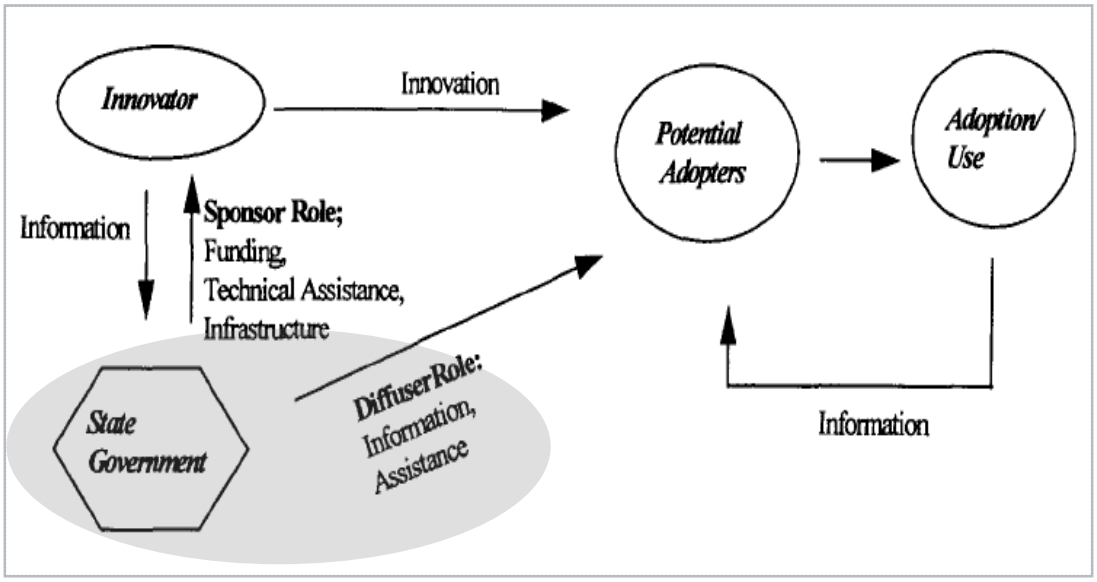

Figure 2.10: Theoretical framework for the diffusion of government-sponsored innovation.

Source: Moon and Bretschneider (1997: 60).

Moon and Bretschneider (1997: 60) presented the 'framework for the diffusion of government-sponsored innovation' which modified the traditional 'communication model for the diffusion of innovation'. In this alternative or extended communication model, the authors argued that the state should assume the role of a catalyst (i.e., assume a diffuser's role) in the diffusion of innovation process as highlighted in the shaded area in Figure 2.10. The model also highlights two aspects of government's role as the diffuser of innovation, comprised of information and assistance. The authors consequently asserted that the extent of government involvement in the diffusion-facilitating process is likely to increase the probability of adoption (Moon and Bretschneider 1997: 62) of the innovation. This could be accomplished by enhancing information flow to potential adopters and providing financial support not only by subsidising innovators but also by funding potential adopters.

Therefore another important dimension of government involvement in the promotion of the adoption of EVs in South Africa, in addition to providing financial assistance, could

be that it takes a leading role in the aspects of customer education and awareness or in the dissemination of information on EVs to influence potential customers' purchase options towards EVs.

Subsequently, it is the desired outcome of the study to propose a model for the promotion of the adoption of electric vehicles in South Africa, in order to effectively contribute to knowledge in the study area. It is therefore anticipated that the study will build the proposed model by incorporating elements such as government involvement as a key factor in catalysing the EV adoption process in South Africa, provided the element is validated by the research findings which would then justify its inclusion in the proposed model.

Meanwhile, the study therefore proposes a conceptual framework to guide the research based on Caiazza's (2015: 1410) 'general framework of public policies for innovation diffusion' and incorporating the elements from Moon and Bretschneider's (1997: 60) 'theoretical framework for the diffusion of government-sponsored innovation'. The conceptual framework is as depicted in Figure 2.11.

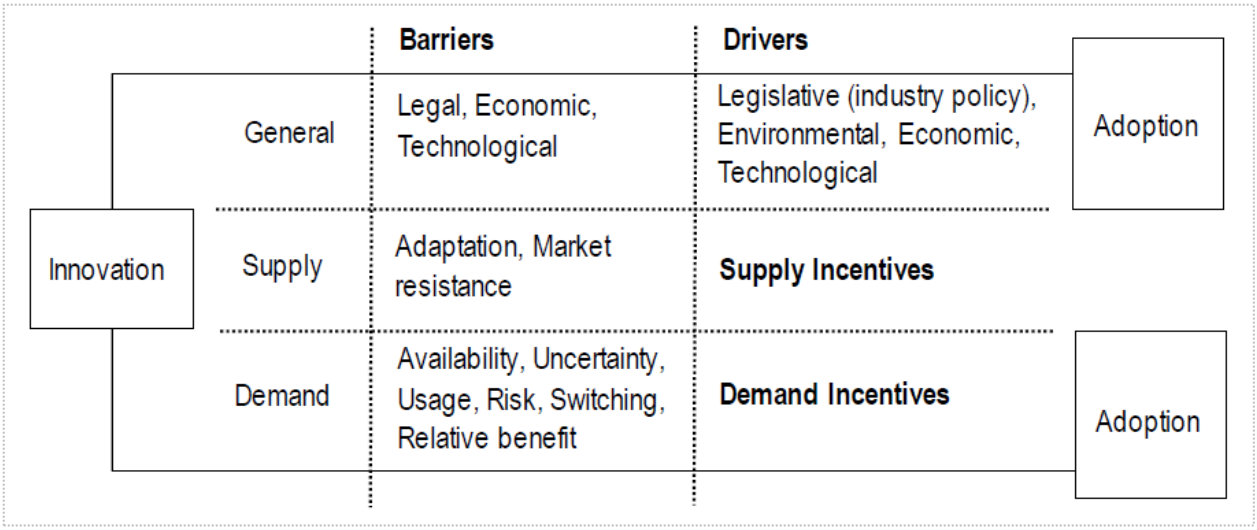

Figure 2.11: Conceptual Framework for the Study

Source: Adapted from Caiazza (2015: 1410).

More specifically, the conceptual framework is an adaptation of Caiazza's (2015: 1410) 'general framework of public policies for innovation diffusion' as it adds the "adoption drivers" variable characterised by elements such as legislative, environmental, economic and technological factors. The legislative aspect, in the South African context, pertains to the policy framework regulating the automotive industry elaborated upon in sections 2.3.2 and 2.3.3, whereas the environmental factor relates to the emissions and air pollution issues also discussed in section 2.3.4.

2.8 Chapter Summary

The chapter discussed the critical aspects relevant to the market penetration of EVs in a global context. Also reviewed was literature applicable to the research objectives of the study relating to drivers and barriers to the adoption of EVs, particularly those in international markets that have experienced significant EV market growth. Specific aspects such as the role of policy incentives in growing the global EV market were discussed, along with identifying potential policy incentives that could stimulate the adoption of EVs in South Africa. While international markets, notably those in China, Europe and the USA are seeing substantial adoption of EVs, South Africa is yet to experience EV market uptake. In order for the EV market in South Africa to grow, factors that have potential to drive the local EV market growth and the barriers that may need to be overcome need to be identified so that the required regulatory framework can be developed and implemented. To this effect, a conceptual framework was developed to guide the study. The next chapter focuses on the research methodology for the study, which entails, amongst other things, the discussion of the methods used to collect data to address the study objectives.

CHAPTER 3:

RESEARCH METHODOLOGY

3.1 Introduction

The current chapter begins by reflecting on the aims and objectives of the study as these were not dealt with when critically reviewing the applicable literature in the preceding chapter two. The chapter then introduces the methodological approach used in investigating the research problem. This includes discussions of the philosophical stance adopted, the research approach, and strategies, the research design, which entails the target population, sampling method, sample size, data collection, pilot study or pretesting (of data collection tool), validity and reliability/trustworthiness, data analysis method and lastly, key ethical considerations for the study.

3.2 Aim and Objectives of the Study

The aim of the study was to develop a framework for the adoption of EVs in South Africa.

The objectives of the study to address the research aim were to;

- Investigate factors that have potential to promote the adoption of EVs in South Africa;
- Identify existing or possible future barriers to the adoption and uptake of EVs in South Africa;
- Ascertain whether policy interventions in the form of incentives have a potentially positive effect to drive the adoption of EVs in South Africa and identify those policy incentives;
- Propose a framework to support the adoption of EVs in South Africa.

3.3 Research Philosophy

Research philosophy refers to a system of beliefs and values that guide the design of a research study and how the data about a phenomenon should be collected and analysed (Saunders, Lewis and Thornhill 2009: 124). There are three commonly known philosophical research paradigms used to guide research methods and analysis

comprising of positivism; interpretivism; and critical theory (Ryan 2018: 14). According to Ryan (2018), these philosophical approaches could be defined as follow;

- Positivism: is a philosophical paradigm commonly associated with experiments and quantitative research and is considered a form of or a progression of so-called rationalism or empiricism – which believes knowledge should be objective and free from any bias arising from the beliefs and values of the researcher.
- Interpretivism: is a philosophical stance which is in opposition to positivism (hence, sometimes known as anti-positivism) and contends that knowledge and truth are subjective, as well as being historically and culturally positioned, based on people's experiences and their understanding of them.
- Critical theory: is a philosophical position which seeks to challenge world views and the fundamental power structures that generate them (Ryan, 2018).

Of these philosophies, this study adopted the interpretivist philosophical stance. Interpretivists view the approach to research through the theoretical lens that makes the assumption that knowledge is gained, or at least filtered, through social constructions such as consciousness, language and shared meanings (Rowlands 2005: 81). And, it is these meanings, experiences and views of research participants, which the interpretivists study to create new and rich understanding of the phenomenon (Saunders, Lewis and Thornhill 2009: 151). For example, interpretive research is defined, from the standpoint of methodology, as an approach that does not predefine dependent or independent variables nor embark on testing hypotheses but aims to produce an understanding of the phenomenon's social context and the process by which the phenomenon influences and is influenced by the social context (Walsham 1995: 75).

Therefore, considering the foregoing definitions, the interpretivist paradigm was considered appropriate for the study as it would enable exploration and in-depth understanding of the phenomenon being investigated through interviewing of participants as the research questions required. As Rowlands (2005: 84) argued,

“interpretive researchers thus attempt to understand phenomena through accessing the meanings that participants assign to them”.

3.4 Research Approach

According to Creswell (2003), there are three research approaches: the quantitative, qualitative and the mixed-method approaches. A quantitative approach is an approach in which the inquirer employs positivist claims for developing knowledge whereas a qualitative approach is one in which the investigator often makes knowledge claims based primarily on constructivism. A mixed-method approach, on the other hand, is an approach in which the inquirer tends to base knowledge claims on pragmatic grounds and entailed data collection methods that involve gathering both textual and numeric information such that the final database represents both qualitative and quantitative information (Creswell 2003).

Additionally, Myers (2009, cited in Goundar 2012: 15) stated that qualitative research involves an in-depth study of social and cultural phenomena and focuses on textual data whereas quantitative research investigates general trends across a population and focuses on numbers. This means that in any type of research, the data gathered will come either in the form of numbers or descriptions; in other words, the researcher will be required to either count objects or converse with people (Macdonald and Headlam 2008: 9). Subsequently, Creswell (2013: 3) advocated that the choice of a research approach be based on the type of phenomenon being investigated and the nature of the data required for the intended study.

For the current study, the exploratory nature of the study objectives necessitates interviewing of prominent stakeholders in the automotive industry to collect data to develop a framework that has the potential to promote the adoption of EVs in South Africa, which lends itself to a qualitative research. “Indeed, the term ‘qualitative methods’ commonly denotes data collection techniques based on various types of conversations between researchers and respondents” (Crouch and McKenzie 2006: 484). Barrett and Twycross (2018: 63) concurred and stated that collecting data through

interviews with participants is a common characteristic of many qualitative studies as interviews give the most direct approach to gathering rich and detailed data regarding a particular phenomenon. Meanwhile, qualitative research has also been defined by Strauss and Corbin (1990: 17) as “any kind of research that produces findings not arrived at by means of statistical procedures or other means of quantification”. Hoepfl (1997: 48) elucidated further that unlike quantitative researchers who seek causal determination, prediction and generalisation of findings, qualitative researchers seek, instead, illumination, understanding and extrapolation. Therefore, the qualitative method is an apposite approach to enable garnering of detailed and rich data required to answer the research questions.

Lastly, the study employed the inductive data analysis approach as a means of finding conclusions in the data collected. According to Ryan (2018: 15), there are two main approaches to theory development that could be adopted for a study and these consist of deductive and inductive reasoning. Deductive reasoning is said to occur when the conclusion is derived logically from a set of premises – the conclusion being true when all the premises are true (Ketokivi and Mantere 2010). By contrast, inductive reasoning starts with making observations and finding patterns in the data, then developing a theory to describe the situation (Ryan 2018: 15). Additionally, inductive reasoning or inductive data analysis is claimed by Koch, Niesz and McCarthy (2014: 137) to be a defining characteristic of qualitative research that involves answering open-ended research questions, such as those in this study.

3.5 Research Strategies

The choice of research strategies in qualitative research includes strategies such as case studies, ethnography, grounded theory, narrative research and phenomenology (Creswell 2003: 15). The qualitative researcher often collects open-ended, emerging data with the primary objective of developing themes from the data (Creswell 2003: 18). Creswell and Poth (2016: 66) advocated that examining the research problem is essential for guiding the choice of which approach (amongst the five) is best suited to addressing one’s research focus, i.e., the study objectives or goal. As an example,

Patton and Appelbaum (2003: 60) defined a case study as an empirical inquiry that investigates a contemporary phenomenon within a real-life context where the boundaries between phenomenon and context are not clearly evident. Also, according to Crowe, Creswell, Robertson, Huby, Avery and Sheikh (2011: 100), the case study approach is particularly useful when there is a need to obtain an in-depth appreciation of an issue, event or phenomenon of interest.

Subsequently, the case study approach was deemed appropriate for this study as it would enable the researcher to attain an in-depth appreciation of the phenomenon being explored and enable the development of a framework to promote the adoption of EVs in the South African context.

3.6 Research Design

Research design is a detailed plan, structure and strategy of investigation designed to obtain answers to research questions or problems validly, objectively, accurately and economically (Kumar 2011: 97). Zikmund (1988: 41) defined research design as “a master plan specifying the methods and procedure for collecting and analyzing the needed information”. In other words, the research design is the conceptual blue print (for the collection, measurement and analysis of data) within which the research is conducted (Akhtar 2014: 1210). Thus, in order to address the research aims and objectives, the study adopted a qualitative case study approach using semi-structured interviews to collect the data needed to answer the research questions. This is because semi-structured interviews (involving the use of pre-determined question) allow for the key elements of the phenomenon being studied to be explicitly asked about by the interviewer (Barrett and Twycross 2018: 63). This, in turn, requires participants to respond in their own words (Doody and Noonan 2013: 28) and thus suited to elicit information from participants to address the research objectives for the study.

However, in defining case studies, Stake (1995) distinguishes amongst three types of case studies: the intrinsic case study, the instrumental and the collective (or multiple-case) case study approach. According to Stake (1995), an intrinsic case study research

focuses on one case and provide an in-depth examination and interpretation to understand that particular case, i.e., investigates or solve the specific problems of an individual case. In an instrumental case study, on the other hand, the researcher selects a small group of subjects in order to examine a certain pattern of behaviour. And lastly, multiple-case study approach involves the use of multiple cases to explore similarities and differences between cases. Also, unlike intrinsic case studies, instrumental and collective case studies may allow for the generalisation of the research findings to a bigger population (Stake 1995).

Hence, the research adopted the intrinsic case study design as this would allow for the examination of the phenomenon being investigated using a single case, being that of the automotive industry, to investigate factors that have potential to stimulate the adoption of EVs in South Africa. Additionally, purposefully selected informants from the automotive industry were regarded as being appropriate and adequate to provide the information required to answer the research questions and to achieve the research objectives. Although not particularly concerned with generalisation of the study findings, the results from this intrinsic case study approach would thus provide a valuable and in-depth context-specific understanding of the phenomenon being investigated.

Lastly, the research was of a cross-sectional nature wherein a single interview was conducted with each selected participant, since it was not necessary to conduct multiple interviews with the participants over a period of time as would have been the case with a longitudinal case study (Draper and Swift 2011: 4).

3.7 Target Population

A population is the entire group of people, events or objects of interest that the researcher wishes to investigate in order to make inferences (Sekaran and Bougie 2016: 236). Fraenkel and Warren (2002) also defined population as the complete set of individuals (participants or events) having common characteristics in which the researcher is interested. For this study, the researcher was interested in interviewing key people within the automotive sector or more specifically OEMs (or vehicle

manufacturing companies) employees and importers (i.e., retailers of imported vehicles). Therefore, the target population for the study was employees of all seven international OEMs represented in South Africa, located in the EC, Gauteng and KwaZulu-Natal as well as importers of assembled vehicles since the study objectives were pertinent to the automotive industry. The researcher was interested in this population because the study centred around the automotive industry and thus people in this sector, especially those in senior positions, were appropriate informants who hold the relevant information required to address the study objectives.

3.8 Sampling Method

"Sampling is the process of selecting or searching for situations, context and/or participants who provide rich data of the phenomenon of interest" (Moser and Korstjens 2018: 10). Zikmund, Babin, Carr and Griffin (2013: 392) classified sampling methods into two distinct types: probability (or random) sampling and non-probability sampling. They clarified that in probability sampling method, every unit, individual or element of a population has an equal chance of being selected, whereas in non-probability sampling method, the probability of any member of the population being chosen is unknown and they are selected based on the discretion of the researcher. According to Sekaran and Bougie (2016: 240), probability sampling designs are often used when the representativeness of the sample is of significance in the interest of wider generalisability of the study findings. Non-probability sampling techniques, on the other hand, are generally used when time and other factors rather than generalisability become critical (Sekaran and Bougie (2016: 240).

A qualitative case study, such as the study at hand, is one such example where the study is not concerned with making generalisations of the findings to the wider population of interest (Dworkin 2012: 1319). Instead, the study is interested in garnering rich information from informants regarding the phenomenon being investigated; hence, it is a study for which the non-probability sampling technique is most relevant.

There is a choice of non-probability sampling techniques in qualitative enquiries that researchers could use to select a sample of subjects/units from a population, the most commonly used being convenience sampling, criterion sampling, theoretical sampling, purposive sampling and snowball sampling (Moser and Korstjens 2018: 10):

- Convenience sampling also known as haphazard sampling or accidental sampling, is a type of non-probability sampling where members of the target population that meet certain practical criteria, such as the willingness to participate, geographical proximity, easy accessibility, or availability at a given time are included for the purpose of the study (Etikan, Musa and Alkassim 2016: 2).
- Criterion sampling refers to the selection of participants who meet pre-determined criteria of importance (Moser and Korstjens 2018: 10).
- Theoretical sampling is the selection of participants based on the emerging findings to ensure adequate representation of a theoretical concept (Moser and Korstjens 2018: 10).
- Purposive sampling also known as judgement sampling, is a sampling technique which allows for a deliberate choice of participants to be made by the researcher on the basis of the qualities, experience or knowledge that the participants possess (Etikan, Musa and Alkassim 2016: 2).
- Snowball sampling is the selection of subjects through referrals by previously selected participants/persons who have access to potential participants (Moser and Korstjens 2018: 10).

Thus, to achieve the objectives of the research, this study employed the non-probability purposive sampling technique. The purposive sampling strategy was considered the most suitable for this study as it allowed for the selection of participants based on the skills and knowledge they possess with regard to the subject of the electrification of vehicles. Additionally, Robinson (2014: 32) argued that “the rationale for employing a purposive strategy is that the researcher assumes, based on their *a-priori* theoretical understanding of the topic being studied, that certain categories of individuals may have a unique, different or important perspective on the phenomenon in question and their

presence in the sample should be ensured". Hence, this study deliberately targeted employees within the automotive sector who were in management positions or higher (in their respective areas of specialisation such as technical services, commercial, marketing and planning). This ensured that participants possessed the relevant experience and knowledge of the automotive industry as well as being knowledgeable about EVs.

To access and recruit the participants, the researcher approached NAAMSA who were kind enough to provide e-mail contact details of senior employees within the automotive sector (OEMs and Importers), who were also members of NAAMSA's Electric, Hybrid and Alternative Vehicle Committee (EHAVC). The latter therefore meant that, in addition to having knowledge of the automotive industry and of EVs, participants also kept abreast of industry trends and new developments, which are attributes that made the participants most suitable to provide the information needed to achieve the study aim and to address the study objectives. Cleary, Horsfall and Hayter (2014: 473) cited Curtis et al. (2000) and Walsh and Downe (2006) who stated that participants in a qualitative study (such as the study at hand) should be selected because they are likely to generate dense, rich and focused information on the research question to allow the investigator to provide a convincing account of the phenomenon being investigated.

3.9 Sample Size

Sample size refers to a segment or subset of the population selected for investigation (Bryman 2012: 187). For this study, the researcher planned to interview one representative participant from each of the 7 OEMs as this was practically feasible given the small number of OEMs, plus five other interviewees (at the most) each representing a vehicle importer to achieve a sample size of 12 (Boddy 2016: 1). A larger sample size than this was not sought for this study given the in-depth interviewing approach and the homogeneous nature and profile of the sample (Boddy 2016: 4) in that all participants represented their respective companies in the same EHAVC committee in addition to the fact that they were all employees within the automotive sector. However, two of the OEMs did not participate as they could not give interviews, citing company policy as the

reason, and another became unavailable closer to the interviews date due to unforeseen circumstances, and this was considered as a limitation for the study. Effectively, 4 OEMs and five vehicle importers participated in the study resulting in a sample size comprised of nine participants. This sample size was considered adequate for the study because the participants, because of their profiles, had the potential to adequately answer all the interview questions to provide the information required to achieve the study objectives – a fact which became evident as the interviews progressed. Additionally, a large sample size was not critical for this research since the study's focus, in keeping with the qualitative approach, was on garnering a deeper understanding of the phenomenon being investigated as opposed to being concerned with making generalisations of findings to the larger population of interest (Dworkin 2012: 1319). The latter would lend itself to a quantitative research approach, whereby a larger sample size would be necessary. Additionally, it is also not uncommon for a small sample size to be encountered in an in-depth interview-based qualitative study such as the study at hand. For example and as Dworkin (2012: 1319) observed, several writers have suggested sample sizes comprising anywhere from as low as five to a high of 50 participants as being adequate for a qualitative study.

3.10 Data Collection

Saunders, Lewis and Thornhill (2009) reiterated that in order to answer the research questions and to address the research objectives, researchers must often collect and use primary data (information that investigators gather first hand) as well as secondary data (information from secondary sources and not directly compiled by the researcher). Therefore, to address the research aim and objectives, the researcher collected both primary and secondary data. To collect primary data, the researcher conducted semi-structured in-depth interviews with participants. An interview guide/schedule comprising of open-ended questions was first e-mailed to potential participants ahead of time allowing up to three weeks for participants to prepare before the interviews were done. According to Doody and Noonan (2013: 30), an interview guide facilitates the collection of similar types of data or information on specific topics from each participant and creates a sense of order during the data collection process.

Interviews were conducted virtually between 20 January and 23 February 2021 using Microsoft Teams, the online video and audio call service. During interviewing, the researcher used the interview guide to ask questions linked to the research objectives as well as asking ad hoc prompting and probing questions in order to elicit as much information from the participants. Informed by the pilot study conducted with the data collection tool (i,e., interview questions), each meeting was scheduled for one hour with each participant. The actual interviews lasted between 45 minutes and just under one hour for the longest interview. Hand notes were taken during the interviews and all interviews were voice-recorded for analysis later.

Lastly, secondary data for the study was collected by conducting thorough literature review using various sources of secondary information on EVs relevant to the research aims and objectives. The secondary sources of information reviewed included journal articles, research reports, conference papers/presentations, news reports/articles, government reports and publications, and the electronic media.

3.11 Pilot Study

Before starting the actual interviews, the interview questions were piloted by interviewing seven colleagues to pre-test and validate the data collection tool. According to Gill, Stewart, Treasure and Chadwick (2008: 292), a pre-test is required to establish if the interview guide/schedule is clear, understandable and capable of answering the research questions, and if, therefore, any changes to the schedule are required. All “pilot” interviewees were able to easily answer all the interview questions and they all specifically confirmed that they understood the questions. Consequently, no major amendments were made to the interview guide. Opinions expressed in the pilot test were not included in the data for the study.

3.12 Validity, Reliability and Trustworthiness

Validity and reliability are important aspects of all research (Brink 1993: 35). This is because validity and reliability (in quantitative terms) or rigour/ or trustworthiness in qualitative terms are ways of establishing trust or confidence in the findings or results of

a study (Thomas and Magilvy 2011: 151). Trustworthiness or rigour of a study refers to the degree of confidence in the data, interpretation, and methods used to ensure the quality of a study (Connelly 2016: 435). Validity concerns the question of whether or not an instrument devised to measure a concept really measures that concept (Bryman 2012: 171) whereas reliability is concerned with the stability, consistency and repeatability of the participants' accounts as well as the investigators' ability to collect and record information accurately (Seltiz, Wrightsman and Cook 1976: 182). However, seeking to differentiate themselves from quantitative researchers, many qualitative researchers avoid the terms validity and reliability (Hoepfl 1997: 58). Instead, they use alternative or suitable terms, such as credibility; transferability; dependability; and confirmability as criteria to judge or assess the trustworthiness of a qualitative study (Hoepfl 1997: 58; Tobin and Begley 2004: 390; Houghton, Casey, Shaw and Murphy 2013: 12). Hence, this study uses the most suitable 'naturalistic terms' alongside the 'conventional terms' as suggested by Hoepfl (1997: 58) and Houghton et al. (2013: 12) for clarification in this regard.

3.12.1 Credibility (internal validity)

Credibility refers to the value and believability of the findings of a study and involves two processes, namely, conducting the research in a believable manner and being able to demonstrate credibility of the research (Houghton et al. 2013: 13). According to Patton (1990) cited in Hoepfl (1997: 59), the measure of internal validity, or more correctly, credibility in a qualitative enquiry, depends on the richness of the data gathered (rather that the sample size) as well as the analytical abilities of the researcher and could also be enhanced through triangulation of data, amongst other techniques. Thus, to enhance credibility, the study:

- ensured, through purposive sampling, that only informants that were in senior positions and who were members of the EHAVC committee and hence highly knowledgeable on the subject of EVs were interviewed to gather primary data for the study, which ensured attainment of rich information;

- ensured that care was taken to consult and reference predominantly published and peer-reviewed material – journals/publications on the subject of EVs, which were abundantly available as well as government and industry reports which provided rich secondary data for the study; and
- triangulated data from the different data sources, i.e., primary data (interviews) and secondary data (documentation).

Another strategy for demonstrating credibility is through so-called prolonged engagement with participants (Tobin and Begley 2004: 392). To this effect, the interviewer ensured that interviewees were asked ad hoc follow-up and prompting questions during the interviews to incite as much information as possible where with every interview, a point was reached where key issues were surfacing repeatedly and no new information emerged with further prompts (Hodges 2011: 90), thus demonstrating fulfilment of this criteria. The researcher was able to easily engage informants either to clarify questions that arose or to ask follow-up/prompting questions because of his position as an automotive product manager working for a large manufacturing company that supplies aluminium products (raw materials for the manufacture of vehicle components) to OEM tier-1 companies and thus had a good knowledge of the automotive sector as well as being acquainted with the subject of EVs.

3.12.2 Transferability (External validity/Generalisability)

According to Thomas and Magilvy (2011: 153), transferability refers to the ability to transfer research findings or methods from one group to another, or "how one determines the extent to which the findings of a particular inquiry have applicability in other contexts or with other subjects/participants". The authors also advocates that one strategy to establish transferability is by proving a dense description of the population studied through descriptions of demographics and geographic boundaries of the study. The study thus provided a dense description of the research methodology for the study, including the profiles of the participants and boundaries of the study to enable the reader or other researchers interested in determining transferability of the findings to other contexts or settings to easily reach a conclusion in this regard.

3.12.3 Dependability (reliability)

Dependability refers to the stability of the research findings over a period of time and over the conditions of the study (Connelly 2016: 435). Thomas and Magilvy (2011: 153) suggested that dependability can be addressed by providing a detailed description of the research methods used in the study in such a way that another researcher can follow the decision trail used by the researcher. Lincoln and Guba (1985: 317) proposed that one measure which might improve the dependability of a qualitative research is the use of an “inquiry audit” in which reviewers examine both the process and the product of the research for consistency. Therefore, to improve dependability, this study ensured that the following aspects were adequately addressed in order to enable the achievement of an audit trail as recommended by Thomas and Magilvy (2011: 153);

- describing the specific purpose of the study;
- discussing how and why participants were selected for the study;
- describing how the data were collected and how long the data collection process lasted;
- explaining how the data was reduced or transformed for analysis;
- discussing the interpretation and presentation of the research findings; and
- clarifying the techniques employed to determine the credibility of the data.

Lastly, the dependability of the study was improved by ensuring that the entire process of conducting the research and generating the dissertation was (peer) reviewed by the supervisor for consistency (Lincoln and Guba 1985: 317) where the necessary rectifications or refinements were made in the process.

3.12.4 Confirmability (objectivity)

Confirmability refers to the accuracy and neutrality of the data and is closely linked to dependability, i.e., the processes for establishing both are similar, according to Houghton et al. (2013: 13). To ensure neutrality, the researcher rechecked or linked the inferences drawn from the interviewees’ opinion to the data collected from secondary sources in keeping with the theme of the study which ensured clarification on the compatibility of the findings of the study with those of other studies. Furthermore,

findings or studies that contradicted the findings or themes of the study were clearly acknowledged and objectively discussed to avoid researcher bias.

3.13 Data Analysis

Qualitative data analysis has been defined as “working with data, organising it, breaking it into manageable units, synthesising it, searching for patterns, discovering what is important and what is to be learned, and deciding what you will tell others” (Bogdan and Biklen 1982: 145). The authors further asserted that qualitative researchers often tend to use inductive analysis of data, meaning that the critical themes emerge out of the data. Subsequently, the data collected for the study was analysed inductively through a conventional qualitative content analysis approach according to the key concepts and themes. The computer-aided data analysis software program, NVivo, version 12, was used to aid the analysis. According to Kolbe and Burnett (1991 cited in Sekaran and Bougie 2016: 350), content analysis is an observational qualitative research method used to systematically evaluate the symbolic contents of all forms of recorded communication. Sekaran and Bougie (2016: 350) added that content analysis could be used to analyse the likes of websites, newspapers, recordings of interviews and that the approach also enables the investigator to analyse textual information and systematically identify its properties such as the presence of certain words, characters, concepts, sentences or themes. Accordingly, the researcher firstly generated transcripts of the recorded interviews. The study then used content analysis to identify concepts in the data that represented the phenomenon being studied. Consistent with the conceptual framework underpinning the study, codes were also developed to aid the allocation of concepts to different themes while simultaneously looking for the emergence of new themes from the data provided by participants.

3.14 Research Ethics: Key Considerations

Ethics in research refers to a code of conduct or expected social norms of behaviour while conducting research which should pervade the research process (Sekaran and Bougie 2016: 13). Robinson (2014: 35) recommended that to ensure good ethical

practice and sensitivity, all potential interviewees should be informed of the study's aims; what their participation entails; of the voluntary nature of their participation; how anonymity will be protected; and any other information that will help them reach an informed, consensual decision to participate. In addition, Sekaran and Bougie (2016: 159) advocated that no one should be forced to participate in a study and that informed consent of the participants should be the goal of the researcher to ensure good ethical practice during data collection. Accordingly, and in keeping with the recommendations put forward by Robinson (2014: 35), the researcher provided the information listed below to all potential interviewees before the interviews to ensure good ethical practice during the data collection process;

- An ethics clearance letter from the Durban University of Technology (Appendix A) to assure potential participants that the researcher had been given permission by the institution to conduct the study.
- A gatekeeper's letter: a signed letter from NAAMSA (Appendix B) granting the researcher permission to contact EHAVC members to collect primary data for the study.
- A letter of information (Appendix C) providing the potential participant with information about the study, which included the aim and a brief background of the study as well as the method of data collection for the study.
- An informed consent letter (signed by the researcher) (Appendix D) to clarify to the potential participants, amongst other things, the voluntary nature of participation. The consent letter also assured potential participants that anonymity and confidentiality would be ensured when processing and reporting the information they would provide. The privacy and anonymity of participants was ensured by using pseudonyms instead of participants' names or those of their companies in the dissertation when reporting the information they provided.
- An interview guide (Appendix E) providing the questions that will be asked during the interview.

These documents were sent (e-mailed) to all potential participants as a package three weeks ahead of the interviews allowing them sufficient time to peruse them to enable them to reach an informed decision about participating as voluntary participation is central to ethical good practice (Robinson 2014: 28).

Furthermore, the observation of ethics starts with the person instituting the research, who should do so in good faith (Sekaran and Bougie 2016: 13). Also, according to the authors, ethical conduct should be reflected in the behavior of the researcher. Sekaran and Bougie (2016: 159) further advocated that the self-esteem and self-respect of the subjects participating in the research should never be violated whatever the nature of the data collection method. As such, the interviewer ensured that interviewees were treated with respect throughout the recruitment and data collection process and care was taken to ensure interviewees were not made to feel discomfort or experience harm in any manner. This was also consistent with the declaration made in the letter of information provided to participants ahead of the interviews. Furthermore, avoidance of any potential risk of harm to participants was further enhanced by ensuring anonymity and confidentiality of informants as discussed earlier since “anonymity and confidentiality is an important step in protecting the participants from potential harm” (Fleming and Zegwaard 2018: 211). As Fleming and Zegwaard (2018: 211) elucidated, harm to participants could range from physical harm, resource loss, emotional and reputational harm.

3.15 Chapter Summary

After reflecting on the aims and objectives of the study, the research philosophy, research approach and research strategies were discussed to clarify the appropriateness of the design used to achieve the study objectives. This included explaining the target population for the study, sampling method, sample size and data collection methods as well as justifying why these were selected. Methods for analysing the data and how the data collection tool (interview questions) was pretested were also clarified, and how validity and reliability of or the trustworthiness for the study was addressed. Lastly, this chapter clarified how good ethics practice was ensured during the study, particularly during the data collection process. The next chapter presents a discussion of the data collected through interviewing of participants.

CHAPTER 4:

DATA ANALYSIS AND RESULTS

4.1 Introduction

Chapter 3 discussed the research methodology for the study, which included the data collection method. This chapter reports on and describes the data collected through semi-structured interviews with respondents selected to participate in the study. The participant's profiles are first discussed. This is followed by explanation of the data analysis strategy employed. The chapter then provides an overview and discussion of the results from the interviews, which explains, from the informants' perspectives, the prospects for adoption and uptake of EVs in South Africa as influenced by such factors such as policy incentives intervention. It also discusses the existing barriers to the uptake of EVs and how these barriers could be overcome. The chapter closes by discussing, from the respondents' point of view, the element of government's involvement in the adoption process as government involvement is anticipated to be a key feature of the model for promoting the adoption of EVs in South Africa.

4.2 Demography of Participants

4.2.1 Response rate

Nine participants were interviewed out of the twelve initially planned, which translates to a 75% response rate.

4.2.2 Participants' Profiles

The participants were grouped according to the automotive business type that they represented; i.e., the four participants each representing an OEM and the five participants, each representing an importer. Each participant was also assigned a pseudonym which allowed the researcher to hide and protect the identity of the participants in presenting, analysis and reporting on the data they provided. As mentioned in the previous chapter, all participants were members of or participated in

the EHAVC committee, representing their organisations. Additionally, each participant had over 10 years' experience in the automotive industry. Collectively, the nine participants had more than 175 years of automotive industry experience. Also, as previously stated, all participants were managers or executives. The following section provides a brief overview of their profiles or more correctly the brief overview of their roles and experience within the automotive industry.

4.2.2.1 Original Equipment Manufacturer (OEM) participant profiles

OEM 1: had 11 years' experience in the automotive industry. As a Head of Electro-mobility, the participant was responsible for all the electro-mobility–related activities such as car sharing and ride hailing in the company. This entailed, inter alia, overseeing cross-functional activities ranging from planning to production, ordering and planning – working with product teams, production teams, marketing people, specifications, customer-focused teams and quality teams. The role also encompassed aspects such as EV loyalty programmes, charging infrastructure (working with private entities that approached the OEM for partnerships on charging infrastructure), customer or after-sales support. The participant's previous roles in the company included those of Product Management and Connected Car Technology portfolios.

OEM 2: had 14 years' experience in the automotive industry. As a General Manager of Product Planning, the participant headed up all the product strategy as well as marketing strategy functions in the organisation. As an example, the company's strategic decisions and the justifications thereof for introduction of EVs into the local markets fell under the Marketing Planning department, which the participant currently headed as a General Manager. The participant spent 13 of the 14 years of automotive experience in the field of Product Planning.

OEM 3: had about 10 years' experience in the automotive industry. The participant's responsibilities as a Senior Manager of Marketing entailed that of a strategic

role such as making sure that the right vehicles were strategically brought to the market. The participant had been in the current role for 5 years but had previously been with other OEMs in different roles including that of Financial Management and Product Marketing portfolios.

OEM 4: was a General Manager of Product Planning with 19 years' automotive industry experience and had a broad understanding of the automotive market and of the EV dynamics. His career background within the automotive industry included roles in Research and Development, Project Management and four years in his current role where he was responsible for all the product planning activities in the company.

4.2.2.2 Importers' participant profiles

Importer 1: had over 22 years in the automotive industry and a passion for EVs. The participant played prominent roles in the automotive industry, including that of being a founder of a start-up company responsible for bringing in an imported automobile brand into South Africa in the early 1990s and setting up channels for importation and networks for distribution (putting up dealerships across the country) and retail to customers. Other roles included being involved in the importer's parent company's programme to assess the relevance of EVs for South Africa and being part of a task team tasked to "go see how South Africa can get EVs going" for importers.

Importer 2: With 11 years in the automotive industry, the participant was, as a General Manager of Product Planning and that of Corporate Sales, responsible for all the product planning functions in the company. This function entailed, amongst others, overseeing inception of all new vehicles and life cycles, forecasting of sales, orders and all other associated logistics activities.

Importer 3: was a General Manager of Sales who spent 14 years in the automotive industry. The participant was responsible for sales activities – imports into the country and sales to the dealerships which, in turn, sold to consumers.

He also led a team of five Development Managers at dealerships across South Africa. Previous roles within the automotive industry included that of Regional Sales Manager at an OEM and another at an importer.

Importer 4: had worked in the automotive industry for just under 40 years but had been with the current automotive company for five years as a Sustainability Manager responsible for EV solutions for the company. The participant's previous roles in the automotive industry were also in the sustainable energy space, ranging from bio-gas to compressed natural gas. The participant also travelled extensively and globally researching alternative energy solutions for the automotive industry.

Importer 5: also had extensive experience in the automotive industry spanning some 35 years. Having worked in different Sales and Marketing portfolios (Sales Management and Product Marketing Management) at both OEMs and importers, the participant oversaw the importation and sales activities for the company, had a keen interest in EVs and participated in various EVs programmes and research activities.

4.3 Data Analysis Strategy

Upon completion of the interviews, a transcript of each interview was made by listening to each interview recording and then writing down the responses verbatim. Each interviewee's responses were written under each of the interview question. Using the computer-aided data analysis program, NVivo-12, cases (i.e., files) were created for each of the nine interviewees wherein their responses to each of the interview questions were allocated to the *cases*. Pseudonyms were assigned to each participant as an identifier for the case and were subsequently used throughout the processing, analysis and reporting of the data in this chapter. Consistent with the conceptual framework and thus in line with the concepts of the literature review, codes, nodes, or themes were created on NVivo to aid the analysis of the data.

Matrix coding as well as graphical representations (in some instances) were used to aid further analysis of the data even though the graphical representations were not necessarily used in the presentation of the results as the study was of a qualitative nature and the use of such graphs lends itself to a quantitative approach. Instead, the participants' responses were quoted or cited to demonstrate their inputs in response to the research questions. Additionally, keywords and phrases common amongst interviewees, which appeared as word clouds, were used to search for the existence or emergence of any new theme/s.

4.4 Adoption Driving Factors

South Africa has a track record for a successful automotive industry backed by the government through supportive policy framework and favourable trade agreements (Lamprecht 2019: 8), which can potentially be used as a launching pad for the stimulation of the domestic EV market. This section of the chapter therefore aimed to investigate this perspective as well as other possible factors that have potential to encourage consumer's preference of EVs in order to grow the local EV market.

4.4.1 The current automotive industry regulatory framework

To explore this element, informants who participated in the study were asked the following question:

- What are your views regarding the current automotive programmes (e.g., policies/ regulatory framework) and their support of the electric vehicle market in South Africa?

Responding to the interview question, OEM 2 stated that:

> *I think in general if we talk about the automotive industry and separate electric vehicles for now, the programmes are very good. And I think the automotive industry is one of the few industries where there is a very clear framework and programmes that have got buy-in from the OEMs, the importers and the government. I think the APDP programme and its new version that runs from this year till 2035 sort of provides 15 years of policy and*

regulatory certainty and I think it is very positive for the industry. I think there has been good engagement with the industry and government in terms of that programme. And so, it's quite clear in terms of the benefits that we can expect from manufacturing locally and the support that we will get and how we can use that local production to also support us with importing vehicles, etcetera and growing the market in general. And obviously that programme extends to suppliers and the integrated industry as a whole. So, I think that is very good.

Similar to the response from OEM 2, participants lauded the current automotive regulatory framework and how it had been beneficial for the success of the sector. They further appreciated how the framework enabled the automotive industry's growth to become the biggest manufacturing sector in the country crucial for the country's economic growth. In particular, the positive sentiment from OEM 2 presented above was also shared by Importer 1 and Importer 5. Still, participants (OEM 1, Importer 1, OEM 2, Importer 2, OEM 3, Importer 3, OEM 4, and Importer 5) were critical of the fact that the current policies were, nonetheless, not supportive of EVs. OEM 1 stated:

Government has implemented, from 2018, the Green Transport Strategy, which was maybe the starting point for some kind of environmental and electrification programme in South Africa. But I think it is, at the moment, more just a direction rather than a specific action point, so I think in terms of hybrids and electric vehicles specifically they can be more focused to clarify what the country's stance will be in the EV space. And that's maybe the gap.

Additionally, Importer 5 expanded this view and further pointed out an opportunity for rectification to include coverage of EVs in the existing programmes, stating in his response that:

In the APDP programme, one of the pillars is the automotive incentive scheme. So it might be important for government to develop a similar scheme within the APDP for vehicle technology to incentivise the OEMs to put up plants to manufacture EVs.

4.4.2 Factors that can encourage consumer's preference of electric vehicles

The interview question posed to participants to investigate this component of the research objective was:

- In your view what is likely to motivate people to want to start buying and using electric vehicles in South Africa?

Answers included:

> *So, cost, perception/education will be the biggest thing and then lastly, I would say charging infrastructure (OEM 1).*
> *I think first of all; price, and secondly is infrastructure for EVs (Importer 1).*

Participants' responses to this interview question went very much like the above two examples by OEM 1 and Importer 1. Broadly, the respondents (OEM 1, Importer 1, OEM 2, Importer 2, OEM 3, Importer 3, OEM 4, and Importer 5) identified cost, i.e., affordability; customer education and/or customer awareness of EVs as well as EV charging infrastructure as the primary factors that could increase the attractiveness of EVs to consumers and had the potential to promote their adoption. These three factors, together with other variables, are discussed in the next section (section 4.5) as the factors were also identified by the respondents as the main barriers to the uptake of the EV market in South Africa, i.e., if they remained in their current state or were not addressed.

Meanwhile, some participants (OEM 3, OEM 4 and Importer 5) believed that some form of 'punishment' (or what is known as disincentivising in the automotive fraternity) could also be effective in stimulating the domestic EV market uptake, although only after the costs of EVs had been made attractive. Participant OEM 4 therefore opined that for the transition to EVs to happen, there must be either a reward or a punishment or a combination of both factors for the customer. He explained that the reward could be some form of incentive from government to the customer and the punishment could be an imposition, by government, of a strict emission regulation that prohibited the sale of vehicles with high levels of emissions in certain key zones such as metros. He further

claimed, citing Europe as example, that this would push consumers towards low-emission technologies such as EVs and concluded thus:

> *I think we need a catalyst in order for customers to make that move from ICE to EVs… I do not see the transition happening by itself.*

Furthermore, participants (Importer 1, OEM 2, Importer 2, OEM 3 and OEM 4) pointed out that although the main drive for EVs was the need to reduce emissions, and hence to migrate the transport sector to zero- or low-emission and energy efficient technologies, the transition to EVs in South Africa would not necessarily address the bigger problem. This, according to the participants, was because electricity generation in South Africa is coal-based. Worse still, and contrary to what it is intended for, the participants did not regard this driver as a lever that could be triggered to promote the adoption of EVs in South Africa. This is reflected in the following statement of OEM 4:

> *With "green", you can only sell so far. I mean green is good. In the end in South Africa, "green" doesn't matter because all our electricity is coal-based. So whether it come from the tail pipe of the car or Eskom's power station, the emission is still there but it is maybe delayed or deferred. So the "green" is not the selling point. Affordability for me is the big issue here in South Africa, and the pleasure of maybe giving back, maybe getting something in return for spending this big money on an expensive EV and not polluting.*

Nonetheless, Importer 1 submitted (expanding on his answer to the interview question) that when an innovation came about there were always early adopters and these were usually people who could afford to spend the extra money on an EV. He added that these were usually people who wanted to be different as well as being attuned to issues of climate change and therefore wanting to make a difference. He added that those were the few people who would possibly buy an EV in South Africa at the moment.

4.5 Barriers to Electric Vehicles Adoption

In the South African context, the barriers to the adoption of EVs could be either current (those that already exist) or those that could be encountered at some stage when the EV market begins to get momentum. Hence, the purpose of this section was to identify pre-existing and/or possible future barriers to the adoption and uptake of EVs in South Africa. Participants were asked the following questions:

- q1: What do you think is discouraging/will discourage people from buying electric vehicles in South Africa?
- q2: In your view, what do you think is discouraging/will discourage vehicle manufacturers in South Africa from building electric vehicles for the local market?
- q3: What do you think is discouraging retailers in South Africa from importing and selling electric vehicles?
- q4: What barriers, if any, do you think South Africa is/will be faced with in its effort to grow the electric vehicle market?

The participants' contributions in response to these questions were as presented and described in sections 4.5.1 – 4.5.10 below.

4.5.1 Purchase price

The one impediment to the adoption of EVs in South Africa cited by all participants (i.e., OEM 1, Importer 1, OEM 2, Importer 2, OEM 3, Importer 3, OEM 4, Importer 4 and Importer 5) as the principal barrier was the high cost of the EV models available in the country compared to the price of equivalent ICE vehicles. According to participants, the purchase price for EVs in South Africa was very high and unaffordable for the average consumer as OEM 1 put it, when answering q1:

> *The first thing I will say is cost. That will kind of be the first thing because you try and make sure that you are not making too much of a loss on these kind of vehicles, so the cost is still a bit high for the average consumer. And that doesn't*

help because what you find is that people are a little bit more cost conscious to begin with.

Also responding to q1, Importer 1 clarified OEM 1's view and put it into context that:

People don't spend the money it costs to buy an EV in South Africa because just an entry level EV will cost you half a million rand plus, and not too many people can afford a half million plus.

Most importantly, not only was the high purchase price of EVs cited by all participants as a barrier to adoption but it was further emphasised or singled out by all the participants as the biggest barrier to the adoption of EVs in South Africa, with OEM 2 concluding, in response to q4, that:

The biggest barrier for customers to purchase these vehicles is the premium they have to pay versus a normal vehicle.

Additionally, the high price of EVs in South Africa was claimed by participants to be compounded by the taxes, import duties and the ad valorem duties imposed on EVs. OEM 4 explained this point while elaborating on his answer to q3 that:

A lot of that, about 25%, is duty driven because we are not local. So if we were to import something, we take the European spec for example or a Japanese spec right hand drive and we import that. And that really mean you should pay a whole lot of logistics and 25% import tax and another 14%, at least, ad valorem, Plus 15% VAT. So, probably you can buy that car for half the price in the original country if you add these taxes and logistics onto it. You can do the sums; it is about 50% taxes plus whatever you get charged on logistics.

The impact of taxes, import duties and ad valorem duties on the price of EVs was brought up by all participants at various points of their discussion when answering these questions. In addition, participants OEM 3 and OEM 4 pointed out that the battery component of EVs were actually the most expensive part of the EV and contributed to

the high cost of the vehicle compared to that of a similar car with ICE even in the global market. Reacting to q3, OEM 3 reasoned that this was because EV batteries were still in their early stage of development and mass production was thus required to push the price down.

Furthermore, participants OEM 1, Importer 1, Importer 2 and Importer 3 explained that another issue with the duties and taxes applied to vehicles was that they affected importers the most compared to OEMs or vehicle assemblers. OEM 1, Importer 1 and Importer 2 clarified when entertaining q3 that OEMs such as Volkswagen and Mercedes-Benz had the ability to offset the "penalties" under the APDP programme through the duty credits they earned from exporting vehicles. On the one hand, as the participants argued, full importers like Jaguar, Volvo and others did not have the ability to do the same as they did not have products to export. In other words, OEMs had the ability to become duty-neutral whereas importers did not have that ability, as Importer 1 explained. As a result, importers were hit a little harder because the import duties were quite high especially for EVs as they were higher than what they would pay for importing an ICE vehicle (OEM 1). This, according to Importer 2, was a problem for importers because they were then unable to price EVs in such a way that they were price-competitive compared to a similar ICE model. As OEM 1 explained, the cost of importing these vehicles affects the price that the end customer pay. Reacting to q3, OEM 1 concluded that:

> *there is therefore a need for the playing field to be levelled so that both importers and OEMs are affected equally*.

4.5.2 Customer education and awareness

Reacting to q4, OEM 4 stated that:

> *One of the biggest barriers we have is maybe education. You know, understanding from a customer's perspective.*

Like the above response by OEM 4, participants were of the view that the potential consumer's lack of education/awareness of EVs was one of the biggest inhibitors to the adoption of these vehicles in South Africa. For instance, Importer 1 maintained in reaction to the same interview question (q4) that another barrier was the paradigm shift for people, or more correctly, absence thereof, i,e., to understand that EV would give a driver very similar performance, if not better, to that of an ICE vehicle. According to OEM 2 and Importer 1, responding to q4, customers were just not aware of the relative technological and economic advantages of EVs. Therefore, intensive marketing was needed to explain the benefits and a lot of customer education was needed for the customer to understand these technologies (OEM 2). Importer 2 concurred that a consumer's paradigm shift through education and awareness campaigns therefore had the potential to steer consumers' purchase options towards EVs and boost market growth. Responding to q4, the participant (Importer 2) asserted that:

> *For your normal guy out there unless you are in his face with some sort of awareness campaign, advertising and detailing the concept that this is how EV's work; this is how much money you save in comparison to diesel or petrol engine vehicle. You know, if there is no awareness campaign for this, for the general public out there, for me it will not motivate people and you are not going see a lot of EVs out there.*

Participants OEM 1, Importer 1, OEM 2, Importer 2, OEM 3, Importer 3, OEM 4 and Importer 5 affirmed that lack of customer education and awareness was a barrier to the adoption of EVs in the country. Responding to q4, Importer 2 concluded that:

You can have the cost in place, you can have the infrastructure in place. But if you do not have that customer awareness campaign you are still not going to sell the car.

4.5.3 Charging infrastructure

Participants mentioned “infrastructure” specifically referring to charging infrastructure for EVs. Largely, all participants mentioned lack of infrastructure as one of the barriers to the adoption of EVs in South Africa and, overall, participants felt that although the existing infrastructure was fairly satisfactory, it still needed considerable development and its public visibility needed to be improved to enable growth of the local EV market. As an example in responding to q1, OEM 2 clarified that:

For a full battery-electric vehicle, there is concern around charging infrastructure because our charging infrastructure in South Africa is not very developed. For example, you can drive from Johannesburg to Cape Town and there will be charging stations along the way but the minute you go off the road you could not find something. We therefore need to develop our charging infrastructure so that we can eventually introduce these vehicles in mass.

Responding to q1, OEM 2 expressed the view that the charging stations needed to be as ubiquitous as petrol stations are in order to drive mass adoption and mass awareness of EVs. By contrast, OEM 1 and Importer 2 expressed the view that the issue of infrastructure could simply come down to education and awareness, or put differently, it went hand-in-hand with education and awareness in addition to the fact that infrastructure was already increasing.

4.5.4 Security of electricity supply

In reacting to q1, Importer 5 stated that:

Now, what I think is discouraging people at the present moment from buying an EV is our electricity supply situation. This is because if you have outages every

second day or two times a day depending on the level of load shedding, people will be concerned that they will buy a car and what will happen if there is no power for an extended period and their battery run flat.

According to participants OEM 2, Importer 2, OEM 3, Importer 3, Importer 4 and Importer 5, reliability of electricity supply in South Africa was a major problem inhibiting the uptake of EVs. Nonetheless, the issue of concerns around the electricity supply situation needed to be addressed through customer education in order to reduce its impact, according to opinions held by Importer 2 when prompted to elaborate further on his response to q1. The respondent reasoned that people would probably always charge their cars at night and the majority of people did not necessarily have load shedding at night in any case; hence, the chances of consumers being able to charge their vehicles throughout the night were actually good.

4.5.5 Range anxiety

As part of their reply to q1, participants OEM 2 and OEM 3 mentioned range anxiety held by the consumer about EVs as one of the barriers to adoption in South Africa. However, OEM 3, intentionally mentioned this element in the past tense clarifying that range anxiety along with other barriers such as infrastructure were being addressed because EVs now offered a 300km to 600km driving range between charges, which was equivalent to a normal tank of fuel. Also discussing q1, OEM 1 concurred, adding that the driving range of EVs also kept growing. When prompted to explain more, he further opined that range anxiety was more of a mindset issue, alleging that the average South African typically did not drive in excess of 100km a day; hence, a paradigm shift was required. OEM 2 further clarified when elaborating on q1 that the perception needed to change because, for example:

if you compare BEV and PHEV the latter charges itself and thus there is/should be no issues around range anxiety specifically for PHEVs.

4.5.6 Battery life and charging time

Importer 5, supported by Importer 3 and Importer 4, was of the view that concerns around battery life, and uncertainties about the resale value of EVs negatively impacted consumer's willingness to purchase EVs. Importer 3 claimed in his reaction to q4 that:

> *Batteries last about eight years and the cost of a battery on an electric vehicle is almost the price of the new car. So then there is that fear that what happens now if I buy this electric vehicle because there are no residual values out there. So nobody has done the exercise to say, this car will be a certain amount and the battery replacement on this car will cost this much but let's try and give you some sort of discount.*

Expanding on his response to q1, Importer 5 added, stating that charging time also had a negative effect in that consumers would not like to wait three hours to charge their car. He gave the following example:

> *if you drive into a petrol station, you will have a full tank within five minutes and so you need something similar, or on average – a comparable waiting period that you can charge your car and then continue with your journey.*

However, other participants such as OEM 1 and OEM 3 disagreed with this point of view and OEM 3 argued when discussing q4 that charging time was no longer a factor because quick chargers were available, which could take as little as 25 minutes to charge up to 80% battery capacity. Yet, he warned that, as with many other electronic gadgets, it was best not to abuse fast chargers as this could negatively impact the quality of the battery.

4.5.7 Availability of EVs

According to OEM 2, responding to q4 (supported by Importer 2 and Importer 3), availability of more product options for consumers could also help stimulate the EV market growth. The participant stated:

We need more product type options as well. Currently, there is very few hybrids in the market and there is even less pure electric vehicles. We need to have more options; we need to have them available as part of normal product ranges. We have had a Toyota Prius in the past, which was a pure hybrid, so you need a situation where on a Corolla, you have a hybrid; on a RAV4 you have a hybrid; on a Hilux you have a hybrid; and the same thing with other brands or the models. And that will also help because you can trust the brand rather than a Nissan Leaf, or a Toyota Prius or a BMW i8, or those kind of stand-alone models. They need to become mainstream to change the product offering so that people just see them as an alternative propulsion method and not as a funny technology and a funny vehicle they don't really understand. Then you will start to see momentum.

Additionally, Importer 5 added (responding to q1) that, separating the hybrids, South Africans currently had only three EV models that were fully electric-powered to choose from and were extremely expensive for the average buyer. This then created a situation where EVs were a luxury purchase rather than a necessity to help reduce emissions, as Importer 3 argued when responding to q4. Importer 5 therefore concluded that there needed to be more EV models available locally to give customers wider options and in doing so, enable the growth of the EV market.

4.5.8 Lack of clear policy direction

When answering q2, OEM 3 shared that:

Policy-wise, we do not have a supportive structure for electric vehicles in the country. We do not have a structure from the government and also from the different policy bodies with trade industry. So there are many challenges that we face in terms of policy direction as the policies do not allow for adoption today.

Lack of clear policy on EVs production was mentioned by participants as a barrier to adoption in South Africa. Sentiments similar to that shared by OEM 3 above, were also shared by OEM 1, Importer 1, OEM 2, Importer 2, Importer 3, OEM 4, Importer 4 and Importer 5. Furthermore, Importer 1 complained when sharing his views in response to

q3 that with the current Master Plan, which matures in 2035 and does not include EVs, whatever Importers and OEMs did for the next 15 years, EVs were not a viable option.

4.5.9 Government's fear of loss of revenue

According to OEM 4, another barrier to adoption was government's concern about possible loss of revenue as a result of, for example, zero-rating taxes and import duties. Responding to q4, OEM 4 stated that:

> *I think the fear is losing money based on tax income because we are going to import these EVs for a start. And, if they incentivise and drop the duty from 25% to zero, they will lose these revenues from every imported EV. So, it is a catch-22 situation.*

This view was also supported by Importer 1 and Importer 5. For example, Importer 1 affirmed when elaborating on his response to q4 that:

> *the government needs every cent of duties that they collect from cars coming into the country for other initiatives that needs to happen in the country*.

4.5.10 Many competing priorities for government

Respondents (Importer 1, OEM 2, Importer 2, OEM 3, Importer 3 and OEM 4) expressed the view that another barrier to the adoption of EVs was the fact that the country had many competing priorities to deal with. They further opined that this was possibly compounded by the lack of revenue at the Treasury and government was thus probably, and perhaps rightfully so, focusing on the priorities such as job creation and surviving Covid-19. This was revealed in the claims by Importer 1 in his response to q4:

> *I think we just don't have the capacity. We have got too many challenges to take care of in South Africa before we worry about EV. I think we got to worry about education; we got to worry about health; and we got to worry about local infrastructure before we start saying, okay let's go and do EVs.*

Also answering q4, OEM 2 alleged further, however with some optimism, that:

> *We all know the current situation. The government is extremely cash-strapped and there isn't a lot of spare money going around. So, although they might be having some desire to promote green technologies but in reality do they have the money to be able to support something like this.*

Participant OEM 4 therefore warned that the problem with leaving such technological advancement unattended for too long could lead to other compounding problems brewing in the background that could compromise the country's economic advancements even further.

4.6 Participant's Suggestions to Overcome the Barriers to Adoption

During the investigation, respondents were also asked for their thoughts on how the existing barriers to the adoption of EVs could be overcome. Participants were therefore asked the question:

- How do you think the barriers (to the adoption of EVs in South Africa) could be overcome?

Participant Importer 1 suggested that there needed to be a government commitment, for instance that government was going to adopt an EV policy and it would take 10 to 15 years to roll out, as an example. Also, some of the responses from participants were as follows:

> OEM 1…*Right now you have got the private sector, the OEMs that are really starting to invest heavily but you also need the government to also come in and I think working together you can start to see success. …So, I think the biggest thing that everybody is looking for is really the standards and regulations for electric vehicles and the minute you see that, it's going to be a tipping point…*

> OEM 2…*I think the new APDP is a very good policy, and within it maybe we can start looking at how we can use that to promote especially the local manufacture of*

these vehicles and start producing the components that go into these vehicles in South Africa and obviously have the ability to export. The demand for these vehicles is high at the moment in overseas markets, and so that can be a real game changer…

OEM 3 *…The government has to do something on policy and public awareness and then people will follow suit because for South Africans, for things to run properly you have to have government running it in the frontline...*

OEM 4*…Maybe what government should be doing is looking where we have buses or big fleets that are under government control to set the example…. to show that we can do this and it can be done. And then maybe people will follow…*

Importer 4*… If I look at the current emission standard in the South Africa it is at Euro-2 and Europe is at Euro-6 and they are talking about Euro 7 technology in 2025. So, South Africa needs to move to tighter emission standards to push both manufacturers and consumers towards cleaner technologies…*

Importer 5 *…There are a few interlinked factors that are critical in developing the electric vehicle market in South Africa and at the top of them is the government policy. So, for me the government incentives, both for the supplier and demand stimulation is critical. There should also be a concerted effort by the industry and the government to drive awareness focused on CO_2 contribution by consumers so that consumers will be made aware of the environmental impact of their purchase options…*

As can be observed from the above statements, the suggestions submitted by participants largely revolved around or pointed to government needing to pave the way or to get involved in the transition process. However, OEM 2 offered another alternative which seemed to suggest that not all the solutions had to come from government and that OEMs could take it upon themselves to lead the transition. He proposed that:

We can make incremental small steps. You can first concentrate on hybrids, which are just a little bit step above your normal ICE, not quite all the way to full electrics but they give you emission benefit. So start with that. Get some momentum going, get some awareness and some public interest with that and then start to introduce plug-in hybrid and then migrate people into full electrics. If OEMs transition their product line in this sequence and creates more interest, it then gets more people involved. As a results, government takes interest and they want to support, etcetera.

4.7 Policy Incentives

This section of the chapter aims to ascertain if policy incentives have the potential to stimulate the adoption of EVs in South Africa and to identify the probable incentives. Participants were asked the following three questions.

- q1: In your view, do you think consumers need to be incentivised to purchase or when purchasing electric vehicles in South Africa?, and if so;
- q2: What incentive/s (financial and non-financial) do you think will be appropriate/ effective?
- q3: How do you think the South African automotive industry could be incentivised to stimulate the electric vehicle market growth?

In answering q3, OEM 2 elaborated thus:

I think with incentives there is different categories. Obviously there is incentives on the manufacturing side to encourage manufacturers to be able to produce electric technology locally. And there is also incentives on the customer side to encourage them to buy the vehicles. So, obviously for companies to start to build locally we need to have a strong domestic market as well as demand on the export side, and so you need to grow that market from a demand point of view and also having incentives on the supply side. There is therefore various ones that you can apply that could make the purchase of these vehicles more appealing.

Generally, the participants' shared sentiments were that incentives were required to improve the local EV market. In addition, participants submitted several suggestions covering both financial and non-financial incentives in answering q2, which also answered q1. Table 4.1 lists the possible incentives to promote the uptake of EVs in South Africa as put forward by participants.

Table 4.1: Incentives suggested by participants

Contributing Participant/s	Type of Incentive Suggested
Financial Incentives	
OEM 1, OEM 2, Importer 2, Importer 3	Reduction in fringe benefits tax
OEM 1, Importer 1, OEM 2, Importer 2, OEM 3, Importer 3, OEM 4, Importer 5	Reduction or removal of import duty and ad valorem tax/Tax rebates
Importer 1, OEM 3, Importer 3, Importer 5	Reduction or removal of VAT
OEM 1, OEM 2, Importer 3, OEM 4, Importer 5	Reduction or zero payment on toll fees
OEM 3, Importer 3, Importer 5	Reduction of licence fees on EVs
Non-financial Incentives	
OEM 1, OEM 2, OEM 4, Importer 5,	Access to bus lanes
OEM 2, OEM 4, Importer 5,	Dedicated/special/priority parking zones
OEM 3, OEM 4	Disincentivising measures

In addition to suggesting the types of incentives that could be applied, most participants, e.g., OEM 1, OEM 2, Importer 2, Importer 3, Importer 5 were of the opinion that any form of incentive that guaranteed some sort of money-back to the consumer would be appropriate for the South African EV market. The opinion was expressed by the participants when answering or elaborating on their answers to q2. For example, OEM 1 stated:

> *For South Africans, it is definitely some sort of monetary incentive in some form of tax deduction or something similar that would work for the markets. I would suggest you provide an incentive that helps their pocket – anything that would help*

the consumer's pocket will work best. It really comes down to the cost factor whether you are incentivising the private consumer or companies.

Also, Importer 3 concurred in answering q2 and added that:

At the moment I think the only way that you are going to catch the customer's ear is by talking something financial – even if it is small, as long as the customer knows he saved money. I don't necessarily think anything non-financial now would work. Maybe if the segment is sort of, at a stage where there is a lot of EV's out there and the market has been developed and then you can start thinking maybe other ways of incentivising.

Therefore, OEM 2 concluded while answering q3 that:

ultimately, for customers to buy more of these vehicles I think there needs to be a clear financial benefit for them.

4.8 Government Involvement

In keeping with the conceptual framework, the purpose of this section of the study is to determine the role that the South African government should play to stimulate the adoption of EVs. Hence, interviewees were asked the question:

- What role, if any, do you think government should play to drive the demand for electric vehicles in South Africa?

Importer 2 started the answer to this question as follows:

So one of the first things that was recognised by the NAAMSA committee is that there is a lack of framework to support EVs especially when it comes to government implementation and obviously the legislative side of it.

Importer 1 substantiated this and emphasised the importance of government involvement to galvanise the adoption process, claiming that:

A partnership between business and government needs to be developed. The OEMs and the importers are ready to facilitate that position because we all have product that fits into that space. So until the government decides that they want to adopt an alternative vehicle technology for South Africa, nothing will change.

In general, participants were in agreement that government's involvement is crucial to the uptake of the EV market in South Africa.

Furthermore, all participants shared the same view that one of the major areas where government's involvement was critical was in defining the policy direction covering the provision of incentives that address the issues of taxes, duties and ad valorem duties which impact heavily on the price of EVs. This opinion was reflected in the statements of Importer 1, Importer 2 and Importer 3 below in response to the interview question.

Importer 1*… the government has to dictate. If they decide that they want to speed up the process of change, we then have to say what duties are they going to take off; what kind of incentives will they give us to help people buy the cars, because all the EVs that come into South Africa are not locally built - they will all be imported at this moment in time…*

Importer 2*… one of the big things in the markets where EVs have been successful has been the assistance from government side when it comes to financial assistance, especially duty reductions and other forms of financial relief even if it comes with a time scale. So what you find in South Africa is that there might have been some talk but nothing really happened in that case…*

Therefore, Importer 3 concludes that:

if we have government incentivising and giving rebates, encouraging manufacturers and importers to participate in electric vehicles, we will definitely see some sales momentum going forward.

According to participants (Importer 2; Importer 5), other key areas where government should play a role included the role of leading and/or sponsoring customer awareness campaigns as Importer 2 explained:

> *What you find is that the road shows or awareness campaigns that do take place are led by the private sector. And I definitely feel it is not necessarily something that should be restricted to just the manufacturer who is trying to sell the vehicles. Like at the moment BMW, Jaguar, and maybe Nissan are some of the bigger guys playing in our local markets. They fully sort of accepted it. I know Nissan globally want to get rid of their diesel engines and they want to get rid of any ICE engine on passenger vehicles like in the next five to ten years. And Nissan locally, will not on their own be able to educate the entire customer base out there on EVs, infrastructure, and how it works, etcetera. This needs to be a local effort by all manufacturers individually with their own brands. But also, this might be where your government also comes in to play that role.*

Importer 2 reasoned further that individual companies could only reach a certain percentage of potential customers with their awareness campaigns whereas government, on the other hand, had the potential and the capacity to reach a larger portion of the general public. To the contrary, participants OEM 2 and Importer 3 opined that both the OEMs and retailers should be playing a role in educating the customer since they were the ones who ultimately wanted to sell the vehicles. Therefore, the responsibility rested on them. OEM 2 further acknowledged that it was government that had to put the infrastructure and/or regulations in place to support it. Additionally, OEM 2 emphasised that government could help by purchasing the vehicles themselves to ignite the awareness campaigns because they had big fleets.

Last but not least, Importer 1 and Importer 5 highlighted the importance of having alignment amongst government departments with regard to policy direction to ensure a seamless transition to electro-mobility from ICEs. Importer 1 warned while elaborating on his response to the interview question, that:

I think government has people in their system that are absolutely anti the motor industry incentive programme. I know for a fact in the dti and the Treasury, people are against the programmes. And then obviously there are people that are for the programme. And this could be a problem in itself.

Lastly, each interview session ended with the question:

- Is there anything else you would like to add to what we have discussed?

The vast majority of participants reiterated, in reacting to this question, some of the points they have previously made whereas others submitted somewhat new insights most of which were, nonetheless, applicable to the themes identified by the conceptual framework and were allocated accordingly during the analysis of the data.

4.9 Chapter Summary

In this chapter, the data collected through interviewing of respondents was presented and described. The chapter started by first presenting profiles of the participants to provide information about their level of seniority in their organisations and information about their experience relevant to the automotive industry. The chapter then presented an overview as well as discussions of participants' contribution to the study under headings recommended by the conceptual framework that guided the study. The element of government involvement in the transition process was added to the discussion as suggested by Moon and Bretschneider's (1997: 60) 'framework for the diffusion of government-sponsored innovation'. Hence, it was the anticipation of the study that this feature would play a key role in the model that the researcher intended to propose as an outcome.

Perspectives were sought from participants as to the factors that had the potential to galvanise the EV market uptake in South Africa; the barriers to the adoption of EVs; and participants' views on how the barriers could be overcome were discussed. The study was guided by the conceptual framework discussed in Chapter 2. The next chapter revisits the conceptual framework but focuses on discussing a proposed model for the

promotion of the adoption of EVs in South Africa. This will be followed, in Chapter 6, by discussion of the research findings in response to the research objectives. This then leads to the generation of conclusions and recommendations, which are presented in the final chapter. The recommendations also address the last objective of the study.

CHAPTER 5:

PROPOSED MODEL

5.1 Introduction

In Chapter 2, which critically reviewed the literature relevant to the study, a “general framework of public policies for innovation diffusion” was introduced and discussed briefly. The framework was subsequently adapted and extended to develop a conceptual framework to guide the research. The current chapter is also an extension of the literature review (Chapter 2) as it builds on the framework discussed to propose a framework for the promotion of the adoption of EVs in South Africa. In the wake of the findings, the chapter deals specifically with the framework developed and discusses each aspect/section of the model in more detail. This is necessary as the framework is aligned to the last study objective, namely, “Propose a framework to stimulate the adoption of electric vehicles in South Africa” that is also a contribution to knowledge.

5.2 Proposed Framework to Promote the Adoption of Electric Vehicles in South Africa

The study incorporated the “state government-as-innovation-diffuser role” element of Moon and Bretschneider’s (1997: 60) model in Caiazza’s (2015: 1410) general framework of public policies for innovation diffusion to propose a framework for the promotion of the adoption of EVs in South Africa. The resultant model is as depicted in Figure 5.1.

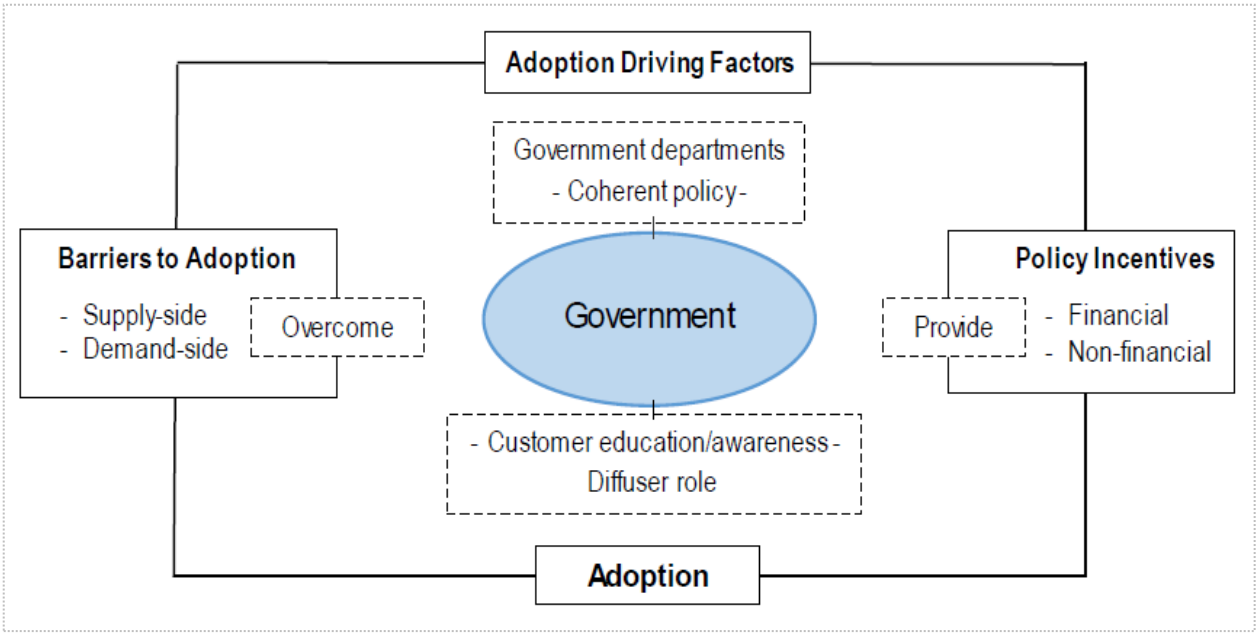

Figure 5.1: A framework/model to promote the adoption of electric vehicles in South Africa

Source: Author's own construction, based on Caiazza (2015: 1410).

The study not only incorporates government involvement in the proposed model but also situates 'government' in the centre of the proposed model to emphasise, in keeping with Caiazza's (2015) views, the fundamental role that government plays (or should play) in the diffusion of innovation process. The study's proposed model thus posits the role of government and/or its involvement as key to the adoption and uptake of EVs in South Africa, or without which no significant progress would be made.

The proposed framework/model is described briefly as follows:

- Government has to play a central role in the quest to promote the adoption of EVs in South Africa by defining, adopting and implementing a coherent EV policy framework to stimulate the local EV market uptake.
- The factors driving the adoption as well as the existing and potential future barriers to the adoption of EVs in the South African context need to be identified.

- Government could leverage on existing factors responsible for the success of South Africa's automotive industry and build EV policies around the existing automotive policy framework.
- Government should also aim at removing any barriers (supply- and demand-side barriers) to the adoption of EVs.
- Policy incentives, both financial and non-financial incentives, are levers that government could actuate to overcome existing barriers to the adoption of EVs in South Africa, and thus encourage the uptake of the EV market.

The following sections expand further on the key elements of the proposed model for the promotion of the adoption of EVs in South Africa.

5.2.1 The role of government in stimulating the adoption of electric vehicles in South Africa

According to the literature, governments play a central role in driving EVs market penetration through implementation of policies and measures to increase the attractiveness of EVs to consumers and potentially boost their adoption rates (Sierzchula et al. 2014: 183; Silvia and Krause 2016: 105). Accordingly, Montmasson-Clair, Dane and Moshikaro (2020: 36) pointed out that, for South Africa, a key lesson from international experience is that government commitment through policy interventions guided by a vision statement, policies and measures, and a set of targets is required to stimulate investment in EVs and the broader EV ecosystem in South Africa. Additionally, Moon and Bretschneider's (1997) empirical study assessing how government's role as both a sponsor and a diffuser of an innovation affects the adoption-diffusion process found that the likelihood of adoption is highly associated with active interaction between the governmental agencies and potential adopters and information flows from the state government. In other words, the more aggressive government involvement is, the more likely it is that any potential adopter may accept the innovation (Moon and Bretschneider 1997: 61). Government involvement could therefore accelerate the overall pace of the innovation adoption process. Also, most importantly, Moon and Bretschneider (1997: 61) asserted that "innovation developed or

sponsored by government is likely to be a subsidised product which presumably has a lower price", and clarified that while private enterprises seek to maximise profits, public agencies might seek to minimise costs or maximise the number of beneficiaries. It can, therefore, be deduced that the South African government's involvement in the mission to promote the adoption of EVs would therefore be of utmost importance as the high upfront cost of EVs in South Africa, as an example, is among the main barriers to the uptake of domestic EVs market.

Ironically, one of the biggest barricades to the wider adoption of EVs in South Africa, according to reports (Labuschagne 2020: 2), is the lack of government commitment. As Labuschagne (2020: 2) stated, citing a BMW representative, "there has, to this point, been very little government support for EVs in South Africa". It, therefore, follows that as governments globally are at the core of the success of the uptake and success of EV markets, as has been evidenced by international experience, the South African government would need to correct its position with regard to EVs to enable uptake in the local EV market.

Governments' key policy mechanisms to stimulate the adoption of EVs in global markets, according to literature (Coffman et al. 2017; Egbue and Long 2012; IEA 2013; Langbroek, Franklin and Susilo 2016; Steinhilber, Wells and Thankappan 2013, cited in Neaimeh et al. 2017: 474) include providing financial incentives such as:

- purchase subsidies

as well as non-financial incentives such as:

- free or dedicated parking spots;
- access to bus lanes;
- raising consumers' awareness on EVs; and
- interventions such as supporting the development of EV charging facilities.

Therefore, government's policy intervention entails direct and/or indirect fiscal expenditures on mechanisms aimed at vehicle electrification. The Chinese government,

for example, had already spent (in 2018) $3 billion on promoting EVs (WEF 2018: 4). However, “given many competing priorities for limited government funding in sub-Saharan Africa” (WEF 2018: 5), including South Africa, allocating money for the promotion of EVs in South Africa could prove to be a challenging undertaking. Although this would not absolve the government of the critical role it needs to play to support the local EV market, it could, amongst other possibilities, compel OEMs to explore and use alternative solutions. Hence, government would still need to adopt and implement policies to stimulate the uptake of the local EV market.

5.2.1.1 Significance of coherent government policy in stimulating the adoption of electric vehicles in South Africa

Central to the role that governments play in stimulating the adoption of EVs is the policy commitment that goes with it. As pointed out earlier, policy interventions should ideally be guided by a vision statement and a set of targets. Also as highlighted in the previous sections, governments that have had successful EV market uptake were characterised by clearly defined objectives, and targets on EVs, amongst other attributes. As it stands, South Africa lacks a clear policy position on the electrification of vehicle in the country (Labuschagne 2020: 2). This is an undesirable position with regard to the uptake of EVs in South Africa and, therefore should also be the starting point for government to rectify, i.e., to clearly state and define its policy direction on EVs that should ideally be followed by implementation. Of supreme importance in this endeavour would be to avoid policy misalignment amongst the relevant government departments which could impede South Africa’s progress in its quest to transition from ICE vehicles to EVs. Per the example cited earlier in the section 2.5.2, the Chinese government despite having clear EV targets suffered a setback which hindered its incentive programme as a result of “fragmented authority” and “local protectionism” (Li, Yang and Sandu 2018: 2). According to Dane (2014: 20), there appeared to be a lack of coordinated approach to stimulating the EV market in South Africa among government’s various departments, namely; the DoT, the dti and the DEA as an example. Each of these departments was interpreted by Dane (2014: 20) as driving its own objectives and prioritisation strategies with regard to e-mobility or EVs. According to Dane (2014: 20), EVs were not included

in the dti's Master Plan whereas the DoT regarded e-mobility as a long-term strategy. Thus, for a smooth and effective transition to EVs in South Africa there needs to be a clear alignment or policy coherency among, for example, the dti and the Treasury, wherein all departments agree on EV commitment, objectives and targets, and prioritisation for the country.

5.2.1.2 Significance of customer education/awareness in stimulating the adoption of electric vehicles in South Africa

Earlier in section 2.4 of Chapter 2, lack of consumer's awareness of EVs was discussed as an obstacle to the adoption of EVs in South Africa. In order to overcome this barrier the proposed model, in keeping with Moon and Bretschneider's (1997: 60) 'framework for the diffusion of government-sponsored innovation', submits that government would need to play a leading role (as opposed to, for example, only partnering with the private entities that take the initiatives) in increasing customer's awareness of EVs in order to stimulate the EV market uptake in South Africa. In other words, the proposed model submits that activities such as awareness campaigns on EVs should also be government-led.

5.2.2 Providing policy incentives to stimulate the adoption of electric vehicles in South Africa

Another important feature of government's policy intervention to stimulate the adoption of EVs in the country could be the provision of context-specific incentives comprising of both financial (monetary) and non-financial elements.

5.2.2.1 Financial Incentives

Of the possible forms of financial incentives (such as the examples in Table 2.4), literature (e.g., Jin et al. 2014 and Jenn et al. 2018) indicated that purchase subsidies which include tax credits and rebates, including income tax credits and sales tax exemptions (Jin et al. 2014: 28) were the most effective monetary incentives in driving the sales of EVs. Reduction of the high purchase price of EVs (compared to that of its

ICE counterparts), through direct purchase subsidies, e.g., reduction or removal of tax and the ad valorem duties on EVs should therefore be at the core of the South African government's policy intervention priorities to catalyse the adoption of EVs.

Additionally, recent studies assessing the impact of policy mechanisms on EV adoption found that policy interventions may have different impacts across different groups of people: for example, early adopters versus mainstream consumers (Langbroek, Franklin and Susilo 2016: 94; Silvia and Krause 2016: 105), indicating the need for a targeted intervention approach. South Africa could thus adopt different forms of context-specific financial incentives to kindle the local EV market.

5.2.2.2 Non-financial incentives

Similarly, different forms of non-financial incentives that governments provide in international markets have had different effects on stimulating EV adoption. For instance, Jenn et al. (2018: 349) found that access to high-occupancy-vehicles lanes was a significant contributor to the adoption of EVs in the USA. Given the budding South African EV market, there seems to be insufficient data about which non-financial policy incentives would be most effective in stimulating EV purchases. Even so, industry experts (Labuschagne 2020: 3) suggest that educating consumers on EVs is key to overcoming most barriers to adoption. Better still, in addition to government policy on enhancing customer education on EVs, Montmasson-Clair, Dane and Moshikaro (2020: 43) suggested alternative (non-financial) policy options for South Africa comprising of policies beneficial to EVs such as the use of dedicated lanes. They also recommended policies that are restricted to EVs or disincentivising policies, e.g., restriction of ICEs in certain areas. According to Langbroek, Franklin and Susilo (2016: 94), non-financial incentives, such as access to bus lanes and free parking, were found to be efficient alternatives to expensive subsidies in other markets. They, however, advised that these kind of policy incentives be used only temporarily to avoid unintended consequences such as overcrowding in (those) dedicated lanes and encouraging the use of EVs as opposed to using public transport. The latter is, however, unlikely to pose a problem in South Africa given the small number of EVs to begin with.

5.2.3 Overcoming supply-side and demand-side barriers to stimulate the adoption of electric vehicles in South Africa

Government need to clarify supply-side and demand-side policy direction directly aimed at overcoming barriers in order to catalyse the growth of the EV market in South Africa. Several barriers to the adoption and uptake of the EV market in South Africa were identified and discussed in section 2.4. These could further be categorised as either supply-side or demand-side barriers. The following two sections (5.2.3.1 and 5.2.3.2) explain this categorisation with selected examples and, most importantly, how they could be used as government policy tools to galvanise the uptake of the EV market in South Africa.

5.2.3.1 Supply-side policies

Supply-side policies, according to Melton, Axsen and Goldberg (2017: 263), have the potential to reduce the price of EVs over time through competition. For example, the zero-emission vehicle mandate in California encouraged or required vehicle manufacturers to develop and sell EVs en masse, which in turn helped lower EV prices though competition. Therefore, adoption of supply-side policies by the South African government, such as introducing low- and zero-emission vehicle mandates and regulations on the emission of local pollutants; tightened fuel economy standards; and restrictions on the circulation of vehicles on the basis of their pollutant emission performances (Lamprecht 2019: 41), could be particularly beneficial as the EVs price tag is one of the major barriers to the uptake of EVs in South Africa. A positive knock-on effect is that consumers will also have a wider choice of EV models as discussed in Chapter 2.

5.2.3.2 Demand-side policies

Likewise, government could adopt policies squarely aimed at overcoming demand-side barriers, or those barriers that potential adopters/consumers are likely to encounter when they first become aware of and adopt an innovation. According to Caiazza (2015: 1409), “the first barrier affecting the diffusion of innovations on the demand side is a

lack of interaction between producers and users, which makes it impossible for potential adopters to know that the innovation is available" and, most importantly, what its relative advantages and benefits are. Therefore, from the government-sponsored innovation diffusion approach, South Africa could benefit from adopting awareness-related policy strategies that ensure dissemination of EV-related information to the potential adopters/ consumers to increase their awareness of EVs. This could include policies that ensure the following aspects as suggested by Montmasson-Clair, Dane and Moshikaro (2020: 44): carrying out marketing and education campaigns to raise awareness; increasing visibility of EVs through a targeted campaign to electrify highly visible public or private fleets; and most importantly, getting potential buyers to experience EVs.

5.2.4 Electric vehicles adoption driving factor/s in South Africa

The 'adoption driving factors' variable was added to Caiazza's (2015: 1410) framework to develop the proposed model as it was observed from literature that this variable has, in the South African context, the potential to contribute to the adoption of EVs in South Africa. This is because the automotive industry already has a favourable relationship with government. Specifically, the automotive industry has had backing from the government over many years through deployment of industrial policies and favourable trade agreements, which resulted in some of the major international OEMs investing and building manufacturing facilities in the country (Lamprecht 2019: 8). As a result, the automotive industry is the biggest manufacturing sector in South Africa's economy that contributes ~7% of the country's GDP (the dti 2019: 22), and thus one of government's most important economic partners. Therefore, from the point of view of vehicle manufacturing, retailing and a supportive industry policy, South Africa would appear to present a favourable environment for the adoption of EVs.

5.3 Chapter Summary

This chapter focused on discussing the key aspects of the proposed model for promoting the adoption of EVs in South Africa. The model centred around the role that government could or should play to stimulate the adoption of EVs in South Africa by

providing an enabling environment characterised by defining, adopting and implementing clear policies and targets primarily aimed at overcoming barriers to the adoption of EVs in the country. The next chapter present and describes the research findings with a view of drawing conclusions and making recommendations.

CHAPTER 6:

DISCUSSION OF THE RESULTS

6.1 Introduction

As outlined in Chapter 1, the main objective of the study was to investigate factors that have the potential to promote the adoption of EVs in South Africa. To collect primary data for the study, interviews were conducted with selected participants within the automotive industry covering both OEMs and Importers of vehicles. The data collected through semi-structured interviews was presented in Chapter 4. This chapter discusses and interprets the data in response to the research objectives with the view to generating recommendations to be presented in the next (and final) chapter.

Guided by the conceptual framework based on the 'general framework of public policies for innovation diffusion' developed by Caiazza (2015: 1410), qualitative data was collected and examined in order to respond to the research questions. The qualitative data was examined using content analysis to relate the elements generated from the literature review to the research findings using the conceptual framework in order to provide structure. The qualitative data presented in Chapter 4 was analysed with the themes from the literature review.

The four research questions for the study were as follows;

- What are the factors that have potential to stimulate/drive the adoption of EVs in South Africa?
- What policy initiatives in the form of incentives will have positive effect on the stimulation of adoption of EVs in South Africa?
- What are the pre-existing or possible future barriers to the adoption and uptake of EVs in South Africa?
- How can the barriers to the adoption and uptake of EVs in South Africa be overcome:

The conceptual framework developed in Chapter 5 highlights key variables that are at play in the adoption process of a new technology. This chapter discusses these

variables and their impact on the adoption or lack thereof of EVs in South Africa, under the headings that responds to the research questions. Also, some of the earlier discussions in the literature review are revisited to strengthen the discussions of the research findings, thereby enhancing the trustworthiness (Connelly 2016: 435) of the study.

6.2 Factors that have Potential to Stimulate/ Drive the Adoption of Electric Vehicles in South Africa

Through shared opinions from the respondents who were interviewed, three main factors that have potential to stimulate the growth of the EV market in South Africa were identified. These were affordable purchase price, sufficient and publicly visible charging infrastructure, and customer's awareness and education on EVs.

Additionally, the literature review identified the existing automotive regulatory framework as having the potential to facilitate transition to EVs wherein lawmakers could identify and address the gaps in the existing policies so that they would also cater for EV manufacturing. Hence, the existing regulatory framework was considered to be an important factor that could expedite the transition process. This is because the automotive industry is the biggest manufacturing sector in the country contributing nearly 7% of the country's GDP, amongst many other important attributes, and thus a key sector for the country's economic growth as elaborated upon in the literature review section. The research's findings supported this view and participants further pointing out areas where gaps in the existing policies that need to be addressed existed. For instance, in the APDP programme, one of the pillars is the automotive incentive scheme. So it might be important for government to develop a similar scheme within the ADPD for vehicle technology to incentivise the OEMs to put up plants to manufacture EVs. This was in keeping with literature which revealed that the existing automotive policies such as the GTS (2018 – 2050), while being good in terms of addressing the issue of GHG emissions in the transportation sector, lacked clear commitments with regard to the support for EVs.

Another important driver for the electrification of vehicles suggested by literature was the urgent need to curtail GHG emissions in response to air pollution, global warming and climate change concerns and to enable South Africa to achieve its committed GHG emissions target to the Paris Agreement. However, both the literature and findings from participants indicated the need for South Africa to also embrace renewable energy sources in order to reap the full benefits of transforming the transport sector to zero- or low-emission technologies such as EVs. The study, therefore, found that the "green approach" was not a strong motivator for consumers to switch from ICE vehicles to EVs. Instead, other levers such as imposing punitive measures for polluters or incentivising (rewarding) the industry not to pollute or applying both measures in parallel stand a better chance to stimulate a transition to from ICEs to EVs in South Africa.

Therefore, there is a need for South Africa to embrace and pursue the use of renewable sources of electricity for charging of EV batteries before embarking on a drive to adopt EVs, and especially if the objective is to lower GHG emissions to achieve South Africa's committed NDC to the Paris Agreement on climate change. In addition, one study cited in the literature review suggested alternative approaches such as the conversion and use of photovoltaic carports to charge EVs during the day – a view buttressed by respondents who participated in the study. This will, therefore, have the added advantage of sending the message of commitment on the part of government to stakeholders involved in the transition process including manufacturers and consumers and subsequently lead to enhanced willingness to adopt EVs.

6.3 Policy Incentives to Stimulate the Adoption of Electric Vehicles in South Africa

The literature demonstrated, using selected examples, the efficacy of financial and non-financial incentives in stimulating the adoption of EVs in international markets. It also further presented a list of possible incentives that could be applied in other emerging markets such as South Africa. The study also found, through the shared views from informants, that policy incentives were key to the adoption of EVs in South Africa. It was noted from the findings that, for the local context, the type of incentives that will be

necessary where the EV market is very limited are those that guarantee some form of direct financial benefit for the consumer when purchasing an EV. Examples of these include direct rebates, reduced or zero-rated VAT and taxes. This was consistent with literature where, for instance, studies (e.g., Jenn, Springel and Gopal 2018: 356; Jin, Searle and Lutsey 2014: 1) found that sales of EVs in the USA were directly related to subsidies offered such as rebates or tax credits. On the other hand, non-financial incentives that are beneficial to EVs such as restricted access to ICE vehicles into certain zones were found to have the potential to boost the adoption of EVs, but only once the EV market has started to grow substantially.

The findings of the study also highlighted the importance of ensuring that government interventions through policy incentives are targeted at addressing the barriers already identified and therefore likely to be experienced from both the supply-side and the demand-side of the adoption process. The most important ones in this context are the price factor from the supply-side perspective and the issue of education and awareness from the demand-side. This will ensure that manufacturers are incentivised to build or sell EVs and more consumers are encouraged to purchase EVs. Ironically, it is the EV policies that are yet to be put in place in South Africa to enable the uptake of EVs. This situation, nonetheless, offer South Africa a great opportunity to learn from the pitfalls that other countries with developed EV markets were not able to foresee and to devise more advanced and effective policies on EVs to stimulate adoption.

6.4 Barriers to the Adoption and Uptake of Electric Vehicles in South Africa

The study found that many barriers to the adoption and uptake of EVs in South Africa exist. This was evident in the possible barriers commonly identified by all participants. The most important barriers or those cited by the vast majority of participants were the high purchase price of EVs; availability and visibility of charging infrastructure as well as customer education and awareness of EVs. Overall, the findings corroborated those that emerged from the literature review section of the study, except that the majority of informants argued that driving range (also identified by the two sources of data to be an issue) is progressively becoming less of a deterrent to consumers as manufacturers are

continuously improving the range of EVs. According to literature, and in comparison to findings from respondents, the major obstacles to the adoption of EVs are the high purchase price, the limited driving range of EVs and limited charging infrastructure. This indicated a good agreement between the two sources of data. Thus, the study finds that the biggest barrier for customers to purchase EVs is the premium they have to pay versus that of an ICE vehicle.

Therefore, addressing the price factor holds the biggest potential for stimulating the adoption of EVs in South Africa as is the case in international markets. Also, the study found that, next to the price aspect was the need to improve the available and especially the visibility of charging infrastructure for EVs. Some participants argued, for example, that the charging infrastructure needed to be more commonplace or visible at refueling stations in the country, whereas others argued that the charging infrastructure was fairly well developed and perhaps what was needed were enhanced customer education awareness campaigns. The latter argument was supported by literature pointing out further that the local charging infrastructure is, in actual fact, on par with those in some of the developed nations – notably, Germany in terms of plug-in EVs to charging points ratio. Nonetheless, there was also clear evidence from the study findings (both literature and participants' insights) that although the charging infrastructure in the country was to a large extent adequate, its visibility and coverage could be improved to have a deep impact on the adoption of EVs.

Similarly, consumers' concerns about long charging times of EVs were viewed by some participants as a factor that stifled the sales of EVs in South Africa, whereas other participants argued that this element was a 'mindset' issue where a paradigm shift was needed instead. For example and as discussed in section 2.6.4, a recent (2020) survey of South African car buyers found that 61% of respondents cited charging infrastructure as the biggest deterrent to EVs purchases, and 60% also believed that charging time was a major disadvantage that deterred consumers from investing in EVs. These seem to be substantial numbers. Therefore, given the divided views from the informants who participated in this research about the two factors (charging infrastructure and charging

time), this illuminates the necessity for customer education and awareness to address some of the misconceptions that exist about EVs.

Additionally, as evidenced in the research findings and suggested in the literature, customer education and awareness has the added advantage of also lessening the effect of other barriers to EV adoption that the study identified – notably issues of range anxiety; concerns about battery life and charging times; and the issue of concerns around electricity supply and availability in South Africa. Therefore, customer awareness campaigns emerged as an important barrier that must be addressed to enable the uptake of EVs in South Africa.

Furthermore, one of the most important and perhaps problematic barriers to the adoption of EVs highlighted by the WEF (2018: 5) would be that claimed to be inherent to sub-Saharan markets, including South Africa of the “many competing priorities for limited government funding in sub-Saharan Africa”, which the findings of the study also illuminated. Nonetheless, subjects who participated in the study were optimistic that the situation was not all negative and that with persistent small steps, a solution would be found to overcome the barriers and grow the local EV market. This optimism could further be pinned on the premise that most of these barriers are interconnected. Thus, solving one hurdle addresses or impacts on the other and it, therefore, becomes the question of finding and striking the right balance. For instance, taking taxes and duties away from the sales of EVs to make them affordable to consumers equates to taking revenues away from the state, as the study found. The balance in this case could be to identify the area in the whole supply-and-demand ecosystem where financial benefits for the government could be restored to render any proposed solution to the conundrum justifiable to all stakeholders involved and therefore potentially lead to a viable solution.

Lastly, the above aspects would ideally require a clear government policy on EVs, which was found to be non-existent at the moment and therefore a major barrier to the adoption of EVs in South Africa. The findings suggested presence but rather scant government involvement in examples such as partnering with the private sector in battery technologies which must be acknowledged. However, the study found no

evidence of government involvement in areas that could bring a step change in the EV adoption process. At the end, policymakers eventually still have to make a case for the costs of supporting the adoption of EVs versus the emission benefits that could be realised amid the ever-present and often pressing challenges that the government faces.

6.5 Overcoming the Barriers to Adoption

With the objective of closing the gaps found during the critical literature review, the study suggested possible means of overcoming the barriers to the adoption of EVs in South Africa. To a large degree, informants who participated in the study validated these suggestions. Furthermore, a collective opinion from participants pointed to the fact that government ought to be involved and provide an enabling environment for the adoption and uptake of the EV market in South Africa. For example, participants opined that government needed to define EV-specific policies, which include, amongst other interventions, providing incentives aimed at removing existing barriers. Incentives could include reducing or zero-rating taxes and duties or providing direct rebates on EV purchases to remove the cost barrier and subsequently sway many customers toward EVs.

Lastly, the findings of the study are in agreement with those of previous similar studies. In particular, a study by Kwame (2019: 111) found that “some major challenges faced by EV adopters in South Africa include high initial cost, limited charging infrastructure, battery technology and lack of a government support system”, all of which are aligned with the findings of the study. The study, however, goes further to propose a framework to overcome these challenges to make the purchase of EVs more attractive to potential consumers.

6.6 Chapter Summary

In South Africa, some advantages exist to help stimulate the adoption of EVs. Equally, barriers to adoption abound. This chapter highlighted how the existing opportunities could be exploited to aid the adoption of EVs; the extent to which barriers are

problematic to the adoption process; and how existing barriers could be overcome. This chapter discussed the study findings in response to the research objectives with the view to generating and making recommendations. The next chapter summarises the dissertation, presents the conclusions and makes recommendations.

CHAPTER 7:

CONCLUSIONS AND RECOMMENDATIONS

7.1 Introduction

Chapter 6 discussed the findings of the study in response to the research objectives with the view of generating and making recommendations. The main objective of the study was to identify factors that have the potential to stimulate the adoption and uptake of EVs in South Africa. The aim of the research was to develop a framework to stimulate the adoption of EVs in South Africa. Limitations of the study are discussed to highlight some of the challenges encountered during the research process. This chapter presents the conclusions and make the recommendations based on the findings of the study. The recommendations, in addition, address the last objective of the study and are thus guided by the proposed framework for promoting the adoption of EVs in South Africa (Figure 5.1). Lastly, recommendations for future research are made.

7.2 Limitations of the Study

While the researcher aimed to collect primary data for the study from all seven international OEMs represented in South Africa, some of them could not take part in the study: company policy was cited as the reason for not participating. This was considered a limitation or weakness in the study because, as the researcher observed when administering the interviews, the respondents' responses to the interview questions were, to some extent, informed by their companies' strategy to transition from ICE to EVs.

A delay in the faculty office of the University to release an Ethics Clearance letter led to delays with the commencement of data collection.

Also, given the use of the case study approach to conduct the research, the findings from the study cannot be generalised to a wider population of interest.

7.3 Conclusions

The study conducted a thorough literature review on the subject of EVs to address the study's aim and objectives. Interviews were conducted with respondents purposefully selected within the automotive industry, which ensured a holistic approach to achieve the aim of the study and to address the research objectives. In general, the findings from interviews validated the findings from the literature review.

7.3.1 Conclusions from the literature review

The literature review discussed the history of the EV. Guided by the conceptual framework based on the 'general framework of public policies for innovation diffusion' developed by Caiazza (2015: 1410), the literature review also discussed in detail the regulatory and policy framework that governs South Africa's automotive industry. It was concluded from literature that South Africa had a good automotive policy framework that could be built upon to devise a policy that would encourage the adoption of EVs. The need to reduce CO_2 emissions to mitigate for global warming and climate change was found to be a driving factor. However, this would be the case only if electricity used to charge EVs was generated from renewable energy sources. It was, therefore, not a strong driver for South Africa owing to its fossil-fuel-based electricity generation systems.

The literature review also concluded that many forms of financial and non-financial policy incentives have been successful in stimulating the adoption of EVs in international markets. Several examples of the incentives adopted in off-shore markets could also be successful in stimulating the adoption of EVs in the South African context. Likewise, the literature review found that many barriers could impede the adoption of EVs in South Africa, notably the high purchase price, availability of EV charging infrastructure, customers' education and awareness and the availability/stability of electricity supply in the country.

Additionally, government involvement, which is currently lacking in South Africa, was found to be imperative for the stimulation of the adoption and uptake of EVs. Broadly,

government needs to create an enabling environment for adoption of EVs in the local market through the adoption policies that make EV purchases more attractive relative to ICE vehicles.

7.3.2 Conclusions on factors that have potential to stimulate the adoption of electric vehicles in South Africa

Three main factors were found to be key to the stimulation of the adoption and uptake of EVs in South Africa. These were affordable pricing of EVs, adequate and publicly visible charging infrastructure, and educating consumers about EVs. In the literature review, these were discussed and elaborated on as barriers to adoption but are nonetheless equally important factors that could make EVs more attractive once they have been addressed. The need to reduce GHG emissions to reduce local air pollution and to mitigate for global warming and climate change was, on the other hand, found to be unlikely to motivate consumers to purchase EVs in South Africa. The study found, instead, that the adoption of policies that either reward non-polluters or punish polluters or a combination of both mechanisms have the potential to catalyse the uptake of EVs in the domestic market. Government policies that could have the biggest impact included imposing stricter emission regulations for the automotive industry to steer both manufacturers and consumers away from perpetuating ICE technologies to EVs.

7.3.3 Conclusions on the possible barriers to the adoption of electric vehicles in South Africa

According to the findings, the high upfront cost of EVs, inadequate charging infrastructure and lack of customer's awareness of and education on EVs were the three main barriers to the uptake of the EV market in South Africa. Also, consumer education and awareness was believed to be crucial in weakening the effect of some of the barriers to adoption that the study identified, especially range anxiety, availability of charging infrastructure and concerns about battery charging time and stability of electricity in South Africa. Lack of government support was also found to be an equally important barrier to the adoption of EVs in South Africa.

The research also brought to light the fact that in sub-Saharan markets such as South Africa there are many competing priorities for the government, such as issues of employment, education, and healthcare. Barriers to the adoption and uptake of the EVs could be different from those in developed markets where governments are directly involved in the adoption process. This could be exacerbated by the fact that the funds that are required to sponsor these projects in sub-Saharan markets are usually limited, thus, forcing the government to have to weigh their options and priorities more carefully. This could result in a situation where the government is then seen as not putting the right policies or resources in place, for instance, to enable it to achieve its GHG emissions target in line with its submission to the Paris Agreement on climate change.

7.3.4 Conclusions on policy-incentive interventions

It was concluded from the findings that interventions such as policy incentives are key to stimulating the EV market uptake in South Africa, especially those relating to the cost factor. Although it was not the objective of the study to rank the elements that have potential to boost the uptake of EVs in the local market, the study nonetheless found that policy interventions that are not aimed at directly rewarding consumers financially have the potential to be effective only after the major barriers such as the high capital cost of EVs have been addressed and the EV landscape has started to gain momentum. Additionally, the study found that policies that are restrictive of ICE technology or disincentivising policies such as laws that restrict entry of ICE vehicles into certain key zones, especially in cities, have the potential to boost the growth of the EV market.

Through a combination of the literature review and inputs from participants, a number of possible policy incentives that could be adopted or considered for adoption to drive the demand for EVs in South Africa were identified. These comprised of examples of financial and non-financial incentives as tabulated in section 4.6, most of which have been proven successful in international markets.

7.3.5 Latest developments with regards to electric vehicles policy in South Africa

In May 2021 (around the time when this study/dissertation was being concluded) the Department of Trade, Industry & Competition (the dtic) released a draft Green Paper on the advancement of New-Energy vehicles in South Africa (Venter 2021) titled 'The South African Road to Production of Electric Vehicles (The Roadmap)'. The draft Green Paper was gazetted for public comment with the aim to finalise the strategy within 90 days and to submit policy proposals to Cabinet for consideration by October 2021, per the dtic ministry (Venter 2021). According to Malinga (2021: 2), "the Draft Green Paper seeks to develop a framework upon which a comprehensive and long-term automotive industry transformation policy on new EVs can be developed". This therefore appears to be an encouraging development for the automotive industry. It also possibly signals the beginning of positive changes that are to come from government which will enable the transition of the domestic automotive landscape from the traditional ICE vehicles to EVs.

7.3.6 Conclusions on the framework to stimulate the adoption of electric vehicles in South Africa

By addressing the first three research objectives and based on the combination of the 'general framework of public policies for innovation diffusion' developed by Caiazza (2015: 1410) and Moon and Bretschneider's (1997: 60) 'framework for the diffusion of government-sponsored innovation', a model (Figure 5.1) for promoting the adoption of EVs in South Africa was proposed.

7.4 Recommendations

This section of the final chapter of the study presents the recommendations using the main elements of the proposed framework/model for the promotion of the adoption of EVs in South Africa as headings since it addresses the last research objective. As stated earlier, the findings from both the literature review and the contributions by participants who took part in the study complemented each other, and the

recommendations therefore are drawn from both data sources. The recommendations are presented below.

7.4.1 Recommendations on adoption driving factors

Leveraging on the existing (automotive) industrial policy, lawmakers, taking note of the possible factors that have potential to stimulate the domestic EV market (i.e., a competitive purchase price, good, visible EV infrastructure and the imposition of stricter emissions regulations), could work to build EV policies by closing the gaps that exist in the current policies. This could entail inter alia, clarifying the definition and classification of EVs to effectively address the cost factor. For instance, EVs could be classified in policies as normal products (rather than heavily taxed luxury items) to make them the necessity that they ought to be to help government in its mission to lower the road transport emissions to achieve its NDC target as pledged to the Paris Agreement on climate change.

7.4.2 Recommendations on financial and non-financial policy incentives

The study found that financial support from government is crucial for the success of the local EV market. Also, certain forms of non-financial incentives such as policies that are restricted to EVs were also found to be important. Hence, it is important for policymakers to recognise that the need for a clear policy framework clarifying both financial and non-financial incentives is crucial to enable the overall automotive market to swing towards EVs, i.e., to influence manufacturers to build and customers to purchase EVs. However, as the study found, financial incentives that directly reward the customer for purchasing EVs must be prioritised over non-financial incentives as the latter were found to be likely to be effective only after the major barriers to adoption such as the high price tag on EVs had been removed. Both financial and non-financial policy interventions have the added advantage that they could be introduced temporarily to achieve certain defined targets and then altered and re-altered at different stages of the adoption process as and when necessary. Hence, this could persuade the policymakers. Another advantage could be that non-financial incentives such as free

parking and access to bus lanes could be intensified to displace the more expensive financial policy interventions in the process thereby reducing the financial impact on government.

7.4.3 Recommendations on overcoming demand-side and supply-side barriers

To galvanise the uptake of the EV market, it is also important for policymakers to recognise and appreciate the need for policy incentive programmes that are specifically targeted at removing the barriers to the uptake of EVs in the country. As an example, the adoption of a zero- or low-emission vehicle policy has the potential to reduce the price tag on EVs over time as a result of mass production, thereby addressing this important supply-side barrier to adoption.

In addition, it is important for policymakers to use a holistic approach. The ideal would thus be to complement the EV policy with policies that encourage the use of renewable sources of energy for EV charging infrastructure as an example. This has the potential for policies to be perceived as environmentally responsible, resulting in a broader buy-in from the various stakeholders including adopters and potentially boosting the uptake of EVs. Furthermore, sustained dissemination of information to potential customers will be an important intervention by government to improve the attractiveness of EVs and would address other critical demand-side barriers relating to the economic, technological and environmental benefits of EVs.

7.4.4 Recommendations on government as a sponsor

Taking cognisance of the many initiatives and efforts already being taken by the private sector to grow the local EV market, government needs to pay heed to the crucial role that it could play by becoming the biggest sponsor of the transition process to catalyse the uptake of EVs. It is, therefore, important for policymakers to then devise clear policies with regard to EVs in South Africa and to provide a rollout plan with clear and specific targets and implementation time frames. Additionally, it is key that policymakers in the dtic ensure buy-in to the EV policy and its roll out plan or prioritisation strategies by other government departments to avoid possible policy disagreements within the

government itself. Also of importance are policies that provide guidance and commit government to programmes that assist the private sector with awareness campaigns to educate the broader customer base about EVs, remove misconceptions held by the consumers and generally increase the attractiveness of EVs. Ideally, this intervention should be government-led in order to yield maximum benefit.

7.4.5 Recommended model

The study closed by proposing a framework or a model for the promotion of the adoption of EVs in South Africa that primarily aims at addressing the existing barriers. The proposed model recommends that government leads the transition process in order to facilitate the uptake of EVs in South Africa.

7.5 Future Research

- The current study proposes a framework for the promotion of the adoption of EVs in South Africa that places government at the centre of the model. However, further research is needed on how this would be realised taking into account the ever-present priorities that the state faces including recent challenges brought about by the Covid-19 pandemic.

- The study also noted that an “Electric Vehicle Road Map” was launched by the dti (now the dtic) in 2013 but never fully adopted. Elements of the 2013 Electric Vehicle Roadmap, notably the commitment to purchase EVs for government departments was “recommitted” in the GTS (2018 – 2050). This seems to suggest the existence of difficulties with policy implementation within government. A future study could investigate the reasons for this.

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APPENDICES

APPENDIX A: ETHICS CLEARANCE LETTER

MANAGEMENT SCIENCES: FACULTY RESEARCH ETHICS COMMITTEE (FREC)

27 November 2019

Student Name: **Mr SM Mohubedu**
Student No: 20926934

Dear Mr SM Mohubedu

MASTER OF MANAGEMENT SCIENCES: BUSINESS ADMINISTRATION

TITLE: Developing a framework to promote the adoption of electric vehicle in South Africa.

Please be advised that the FREC Committee has reviewed your proposal and the following decision was made: **Approved – Ethics Level 2**

Date of FRC Approval: 27 November 2019

Approval has been granted for a period of two years from the above FRC date, after which you are required to apply for safety monitoring and annual recertification. Please use the form located at the Faculty. This form must be submitted to the FREC at least 3 months before the ethics approval for the study expires.

Any adverse events [serious or minor] which occur in connection with this study and/or which may alter its ethical consideration must be reported to the FREC according to the FREC SOP's.
Please note that ANY amendments in the approved proposal require the approval of the FREC as outlined in the FREC SOP's.

Yours sincerely

Prof JP Govender
Chairperson: Faculty Research Ethics Committee

APPENDIX B: GATEKEEPER'S LETTER

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LEADING THE SA AUTOMOTIVE INDUSTRY

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PARTNERSHIP | CONSISTENCY | TRUST

27 October 2020

TO WHOM IT MAY CONCERN

NAAMSA agrees to grant permission to Mr SM Mohubedu (student no. 20926934) to interview members of the NAAMSA EHAVC to collect primary data for his Master of Management Sciences research Dissertation titled "Developing a framework to promote the adoption of electric vehicles in South Africa".

NAAMSA understands that findings of this research will be used in the academic field and could add value to the South African automotive industry. NAAMSA also recognises that it remains the prerogative of individual NAAMSA member companies to participate in the study or not.

Kind regards

Dr Norman Lamprecht

Executive Manager : Trade, Exports and Research

APPENDIX C: LETTER OF INFORMATION

DURBAN UNIVERSITY OF TECHNOLOGY
INYUVESI YASETHEKWINI YEZOBUCHWEPHESHE

LETTER OF INFORMATION

Title of the Research Study: Developing a framework to promote the adoption of electric vehicles in South Africa.

Principal Investigator/s/researcher: Simon Mabushi Mohubedu

Co-Investigator/s/supervisor/s: Dr. Akwesi Assenhoh-Kodua

Brief Introduction and Purpose of the Study:
As part of the Paris Agreement on climate change, South Africa has pledged a reduction of its greenhouse gas (GHG) emissions to peak at 398 to 614 Mt CO_2 –eq for the period 2025 to 2030. South Africa has also realized that the adoption of electric vehicles (EVs) in the domestic market will contribute significantly to the reduction of its transport-related GHG emissions to help achieve its emission targets. While a number of first world nations are beginning to adopt EVs as an agendum to reducing GHG emissions globally, South Africa is, however, lagging behind in this regard. Although government is considering a number of measures to stimulate the adoption of EVs, there is little evidence that a clear policy framework is in place or has been deployed. Against this background, the study aims to identify factors that have potential to promote the adoption of EVs in South Africa. To achieve this aim, the study will adopt a qualitative approach wherein data will be collected from prominent stakeholders within the South African automobile industry. It is hoped that the study will aid policymakers either in the development of new policies or to enhance existing policies to stimulate the adoption of EVs in South Africa.

Outline of the Procedures: Semi-structured interviews with members of the NAAMSA EHAVC will be administered to collect primary data for the study.

Risks or Discomforts to the Participant: There will be no risks to the participants.

Benefits: It is intended that the study will culminate into the proposal of a policy framework that could hopefully be of value to policymakers either in the development of new policies or to enhance existing policies on the electrification of vehicles in South Africa. The results of the study will also be made available to all participants.

Reason/s why the Participant May Be Withdrawn from the Study: Should participants wish to withdraw from the interview, there will be no adverse consequences.

Remuneration: Participation is voluntary and participants will not receive any remuneration.

Costs of the Study: Participants will not incur any costs for taking part in the study.
Confidentiality: Interviews will be treated with strict confidentiality and anonymity of participants and that of their companies is assured.

Research-related Injury: Data collection will be conducted through online interviews and there is no expected research-related injury to the participants.

Persons to Contact in the Event of Any Problems or Queries: Please contact the researcher (tel. no. 087 285 7010 or 083 632 1691), my supervisor (tel. no. 031 373 5374) or the Institutional Research Ethics administrator on 031 373 2900. Complaints can be reported to the DVC: RIE, Prof S Moyo at dvcrie@dut.ac.za

14 January 2021

APPENDIX D: INFORMED CONSENT

DURBAN UNIVERSITY OF TECHNOLOGY
INYUVESI YASETHEKWINI YEZOBUCHWEPHESHE

CONSENT

Statement of Agreement to Participate in the Research Study:

- I hereby confirm that I have been informed by the researcher, Simon Mohubedu, about the nature, conduct, benefits and risks of this study - Research Ethics Clearance Number: (refer ethics clearance letter).
- I have also received, read and understood the above written information (Participant Letter of Information) regarding the study.
- I am aware that the results of the study, including personal details regarding my sex, age, date of birth, initials and diagnosis will be anonymously processed into a study report.
- In view of the requirements of research, I agree that the data collected during this study can be processed in a computerised system by the researcher.
- I may, at any stage, without prejudice, withdraw my consent and participation in the study.
- I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in the study.
- I understand that significant new findings developed during the course of this research which may relate to my participation will be made available to me.

Full Name of Participant	Date	Time	Signature

I, Simon Mohubedu (name of researcher) herewith confirm that the above participant has been fully informed about the nature, conduct and risks of the above study.

Simon Mohubedu	14/01/ 2021	
Full Name of Researcher	**Date**	**Signature**
N/A		
Full Name of Witness (If applicable)	**Date**	**Signature**
N/A		
Full Name of Legal Guardian (If applicable)	**Date**	**Signature**

APPENDIX E: INTERVIEW GUIDE/SCHEDULE

Developing a framework to promote the adoption of electric vehicle in South Africa.

Demographics

What is your position in the company?
Briefly, what are your roles and responsibilities in this position?
How long have you been in the position?

Adoption drivers

- What are your views regarding the current automotive programs (e.g., policies/regulatory framework) and their support of the electric vehicle market in South Africa?
- In your view what is likely to motivate people to want to start buying and using electric vehicles in South Africa?

Policy Incentives

- In your view, do you think consumers need to be incentivised to purchase or when purchasing electric vehicles in South Africa?, and if so;
- What incentive/s (financial and non-financial) do you think will be appropriate/ effective?
- How do you think the South African automotive industry could be incentivised to stimulate the electric vehicle market growth?

Barriers to adoption

- What do you think is discouraging/will discourage people from buying electric vehicles in South Africa?
- In your view, what do you think is discouraging/will discourage vehicle manufacturers in South Africa from building electric vehicles for the local market?
- What do you think is discouraging retailers in South Africa from importing and selling electric vehicles?
- What barriers, if any, do you think South Africa is/will be faced with in its effort to grow the electric vehicle market?
- If so, how do you think these barriers could be overcome?

The role of government

- What role, if any, do you think government should play to drive the demand for electric vehicles in South Africa?

Is there anything else you would like to add to what we have discussed?

APPENDIX F: CONFIRMATION OF PROFESSIONAL EDITING

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26 July 2021

Confirmation of professional editing

DEVELOPING A FRAMEWORK TO PROMOTE THE ADOPTION OF ELECTRIC VEHICLES IN SOUTH AFRICA
By
Simon Mabushi Mohubedu

I declare that I have edited and proofread this thesis. My involvement was restricted to language usage and spelling, completeness and consistency and referencing style. I did no structural re-writing of the content.

I am qualified to have done such editing, being in possession of a Bachelor's degree with a major in English, having taught English to matriculation, and having a Certificate in Copy Editing from the University of Cape Town. I have edited more than 200 Masters and Doctoral theses, as well as articles, books and reports.

As the copy editor, I am not responsible for detecting, or removing, passages in the document that closely resemble other texts and could thus be viewed as plagiarism. I am not accountable for any changes made to this document by the author or any other party subsequent to the date of this declaration.

Sincerely,

Dr J Baumgardt
UNISA: D. Ed. Education Management
University of Cape Town: Certificate in Copy Editing
University of Cape Town: Certificate in Corporate Coaching

Professional EDITORS' Guild

Jacqui Baumgardt
Full Member

Membership number: BAU001
Membership year: March 2021 to February 2022

jaybee@telkomsa.net
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APPENDIX G: CONFIRMATION OF SUBMISSION OF A PAPER FOR JOURNAL PUBLICATION

Mohubedu, Simon

From: em.jepo.0.7556e9.cb0b9a48@editorialmanager.com on behalf of Energy Policy <em@editorialmanager.com>
Sent: Sunday 15 August 2021 21:31
To: Mohubedu, Simon
Subject: Submission Confirmation

Re: Developing a framework to promote the adoption of electric vehicles in South Africa.
Simon Mabushi Mohubedu; Dr. Akwesi Assensoh-Kodua
Full length article

Dear Simon,

Your submission entitled "Developing a framework to promote the adoption of electric vehicles in South Africa." has been received by Energy Policy

You may check on the progress of your paper by logging on to the Editorial Manager as an author using the following link, the URL is https://www.editorialmanager.com/jepo/.

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Kind regards,

Editorial Manager
Energy Policy

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Developing a framework to promote the adoption of electric vehicles in South Africa

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