Exploring factors that will influence the adoption of electrical vehicles by South African customers

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ABSTRACT

Global warming is causing unforeseen, uncontrollable – and damaging – weather patterns and the world is seeing increased pressures from numerous stakeholders to force change to preserve the environment for current and future generations. These pressures are directed towards governments, companies and industries, with the objective to reduce carbon emissions. One of the industries that is under the spotlight to implement change is the automotive industry, as tailpipe emissions of internal combustion engine vehicles contribute significantly to the annual global carbon emission output.
One possible solution to reduce carbon emissions is to increase the widespread adoption and utilisation of electrical vehicles. Virtually every large traditional vehicle manufacturer has commenced with the development and production of electrical vehicles, and large investments are planned in the nearby future. Vehicle manufacturers, who are solely focusing on producing electrical vehicles, such as Tesla motors and Rivian trucks, have seen tremendous success in the past. Certain countries around the world, including Norway, China, the United States of America and Europe, have seen increased adoptions of electrical vehicles.

The objective of this research study is to determine the factors that will increase the adoption rate of electrical vehicles by South African customers. A qualitative research study was employed to determine these factors, and 11 profound themes were identified. These themes are: *Trust, insufficient electricity, recharging infrastructure, cost of electrical vehicles, taxation incentives, long travel distances required in South Africa, timeframe, willingness to adopt electrical vehicles, future international supply of electrical vehicles, opportunity to manufacture vehicles in South Africa* and *the future need for internal combustion vehicle engines.* The South African industry has two main sectors, including a manufacturing sector, whereby vehicles are produced locally on behalf of international vehicle manufacturers and these vehicles are exported to a vast number of export markets, with Europe being the largest importer of South African-produced vehicles and a local retail sector where vehicles are sold to final customers. The successful implementation of these identified themes could arguably lead to higher adoption rates of electrical vehicles and the significance to increase the adoption rate would not only be beneficial to the environment, but will arguably benefit the South African

automotive industry as a whole, pertaining to the economic benefits associated with exporting vehicles.

Keywords: Global warming, carbon emissions, electrical vehicles, South African automotive industry, factors influencing the adoption of electrical vehicles

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It felt very strange to write this acknowledgement page without using any sources, and consequently not referring to those sources in the proper Harvard-method of referencing. It is even stranger to refer to myself, when I am indeed writing this page…myself. With that in mind, to the future readers of this page, I can guarantee that I converted my own thoughts into my own words on this page. Turnitin agreed with me and provided a clear report, with minimal anomalies.

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LIST OF ABBREVIATIONS

ICE:	Internal combustion engine vehicle
EV:	Electrical vehicle
BEV:	Battery electrical vehicle
HEV:	Hybrid electrical vehicle
PHEV:	Plug-in hybrid electrical vehicle
FCEV:	Fuel cell electrical vehicle
OEM:	Original equipment manufacturer
FC:	Fuel cell
LCV:	Light commercial vehicle
GDP:	Gross domestic product
ROI:	Return on investment
CEO:	Chief executive officer

DEFINITION OF KEY CONCEPTS

Economies of scale: “Economies of scale are said to exist if long-term average costs decline as output increases” (Buyle *et al*., 2018:5).

Gross domestic product: Measures the economic value of goods and services produced within the borders of a country and purchased by final consumers (Callen, 2020).

Disposable income: It is the net income a consumer has left, subsequent to deductions made, including for example, taxation (Cautero, 2020).

Globalisation is utilised to describe the interdependence of global economies and populations because of economic partnerships, trade in goods and services, the movement of investments, the movement of people and technology (PIIE, 2019).

Return on investment is utilised to measure the effectiveness of one investment compared to the efficiency of other investments, relative to the cost made pertaining to the investment (Chen, 2020).

Bull market is defined as a market that is aggressively increasing over a period of time and the two largest contributing factors are 1) a strong economy, and 2) high employment levels (Town, 2016).

Vehicle parc means the number of registered vehicles within a certain geographical region (Hedges and Company, 2014). Therefore, for this research study it means the number of registered vehicles in South Africa.

CHAPTER 1 INTRODUCTION TO STUDY

1.1 Introduction: Background

This research study concerns the primary investigation of factors that will positively influence the adoption rate of electrical vehicles (EVs) by South African customers. The study will include trends and forecasts concerning the possible future of the global automotive industry and will contain a detailed discussion concerning the importance of the automotive industry to the South African economy as a whole and consequently the need for South Africa to manufacture demanded vehicles. The research procedure will outline multiple dynamics, which may constitute the increased uptake of EVs by customers as well as the investigation of the relationship between the identified dynamics.

EVs have become more relevant than ever before to assist countries and organisations in reducing their demand for fossil-based fuels, including crude-oil, gas and coal; and to decrease the rate of greenhouse gas emissions into the atmosphere (Mohammadi, 2018:2). These gases originate from processes conducted in manufacturing factories, the electrical generating industry and the transport sector, which are causing the temperature of the earth's atmosphere to increase causing detrimental effects on civilizations and ecosystems (Rueangphankun *et al*., 2018:1483).

The global energy sector is changing at a rapid pace; factors responsible for this change include uncertain energy prices and security pressures to reduce carbon emissions and the economic benefits associated with making the change to clean energy (Hamed & Al-Eideh, 2018:364). It can be argued that the automotive industry is one of the industries under the most pressure to reduce carbon emissions as road transport is a large contributor to climate change, making this industry responsible for 17% of the global greenhouse gas emissions (UNFCCC, 2018). The statement above is confirmed by the views of Nava (2017:1), who confirms that the transportation sector is responsible for a third of the greenhouse gases in the atmosphere, and consequently the reason why the sector is pressured for change. The South African transport sector, according to Posada (2018:4), emitted 13% of the total greenhouse gas emissions of the country, second only to the energy generation industry of South Africa.

An international climate change agreement was signed by 195 countries in Paris (Paris Agreement) in the end of 2015 with the goal to drastically reduce greenhouse gas emissions and to maintain the increase of global warming below 2 degrees Celsius (Jacobs, 2016:314). South Africa also supports the agreement by committing to reduce greenhouse gas emissions with 42% by 2025 and South Africa's deputy finance minister in 2019, Mondli Gungubele, emphasised that climate change is a reality and South Africa will have to prepare for a carbon-controlled economy in the medium- to long term (Persens, 2019). In fact, South Africa ratified its pledge to the Paris agreement by committing that the current level of carbon emissions will reach a limit in 2025, remain constant for the following 10 years up until 2035 and then commence to subdue after 2036 (Gosling, 2019).

In order to achieve the goals set out by the Paris agreement, transport emissions need to be reduced by 90% by 2050; this exuberant change will not be achieved by minor improvements to existing vehicles, but will require a fast-tracked move to electro-mobility (Transport and Environment, 2018:4). The United Nations Framework Convention on Climate Change also argues that the accelerated utilisation of low emission and electrical vehicles must be adopted to achieve the principal goal of the Paris agreement (UNFCCC, 2018). This argument is supported by Lutsey (2015:8), who maintains that an increased adoption rate of EVs is required to achieve the long-term targets.

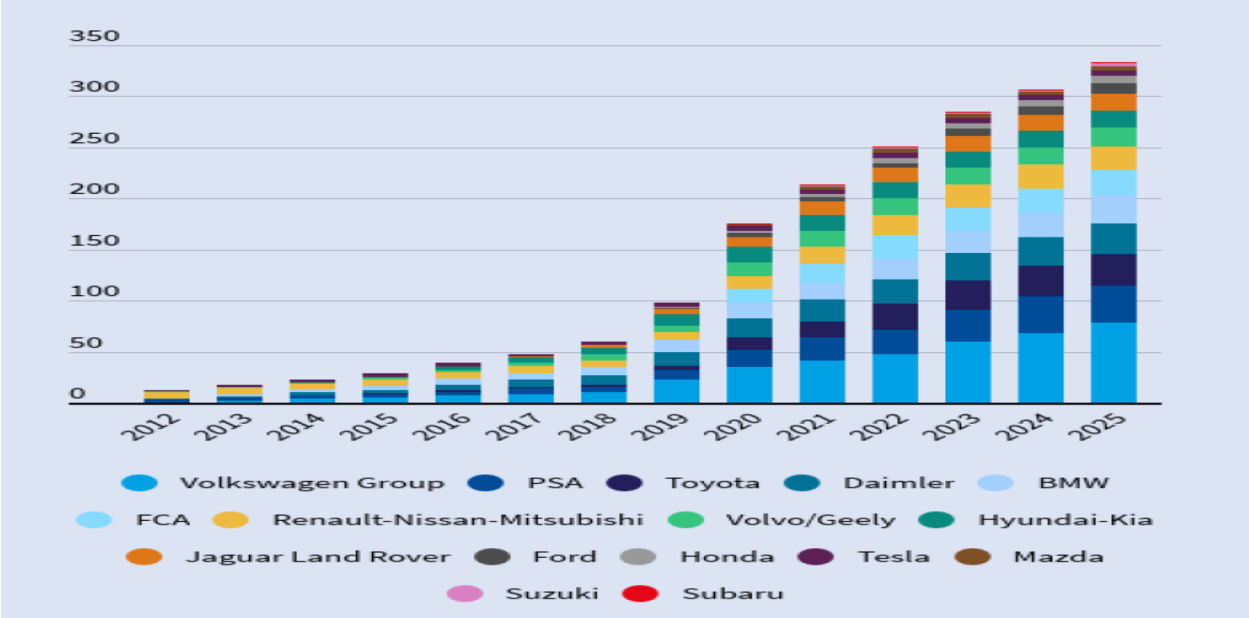
France and the United Kingdom are committed to achieving the goals of the agreement and have already announced that petrol and diesel vehicles will be banned by 2040 (Schneider, 2017). This statement is supported by Bhandhubanyong and Pearce (2019:2), who specified that the United States and China are the leaders concerning the adoption rate of EVs; however, a number of countries in Europe, including France, the United Kingdom, Austria, Netherlands and Norway have proposed legislature to prohibit the production of new ICEVs within the succeeding 20 years. New Zealand has likewise introduced a zero carbon bill to achieve net-zero carbon discharges by 2050 (Council *et al*., 2018:1).

It was reported by Ferguson (2019) that foremost vehicle manufacturing companies around the globe are preparing to phase out ICEVs. For example, Volvo has announced, commencing in 2019, that every new model produced by the automotive company will

incorporate an electrical powertrain, including plug-in hybrid vehicles, hybrid vehicles and battery electrical vehicles (Schneider, 2017).

Approximately 120 new EV models are currently introduced to markets on an annual basis, an increase from a 12-monthly average of 20 new models from the past seven years (Baik *et al*., 2019). The figure below is a forecast of the number of EVs that will be on offer to customers in Europe from the foremost vehicle manufactures around the globe.

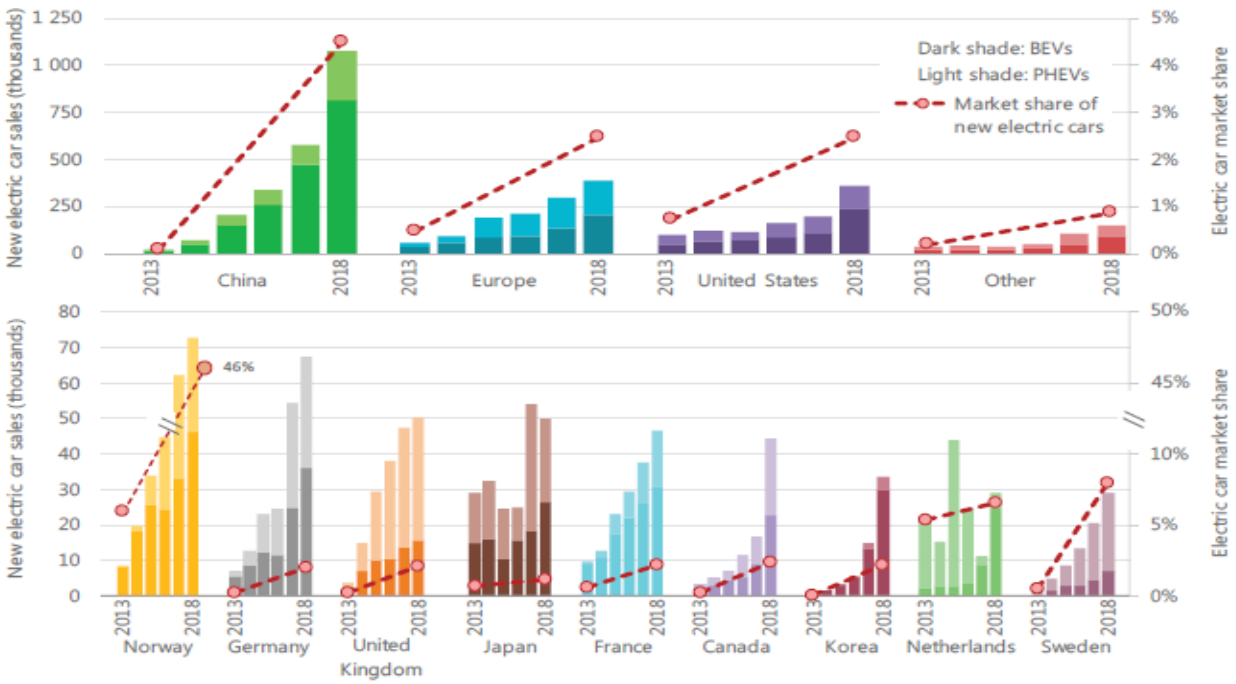
Figure 1-1: Total number of EVs on offer to customers in Europe by vehicle producer



Source: IEA (2019:10)

This increased production of EVs is in response to the increased sales of EVs around the globe (Figure 1-2). It is estimated that EV sales will reach a market share of 7.7% of total vehicles sold in 2025 (J.P. Morgan, 2018). Supporting this statement, EV sales will increase from two million units in 2018 to 12 million units in 2025 (Deloitte, 2019:4). According to MacDonald (2016), sales forecasts for EVs will increase to 41 million units by 2040. Concerning the stock levels of EVs, it is projected that the aggregate global stock level for EVs exceeded the 2 million mark in 2016 (The Oxford Institute for Energy Studies, 2018:2). The figure below indicates the growth of EV sales from the period 2013 to 2018 as well as the market share increase of EVs.

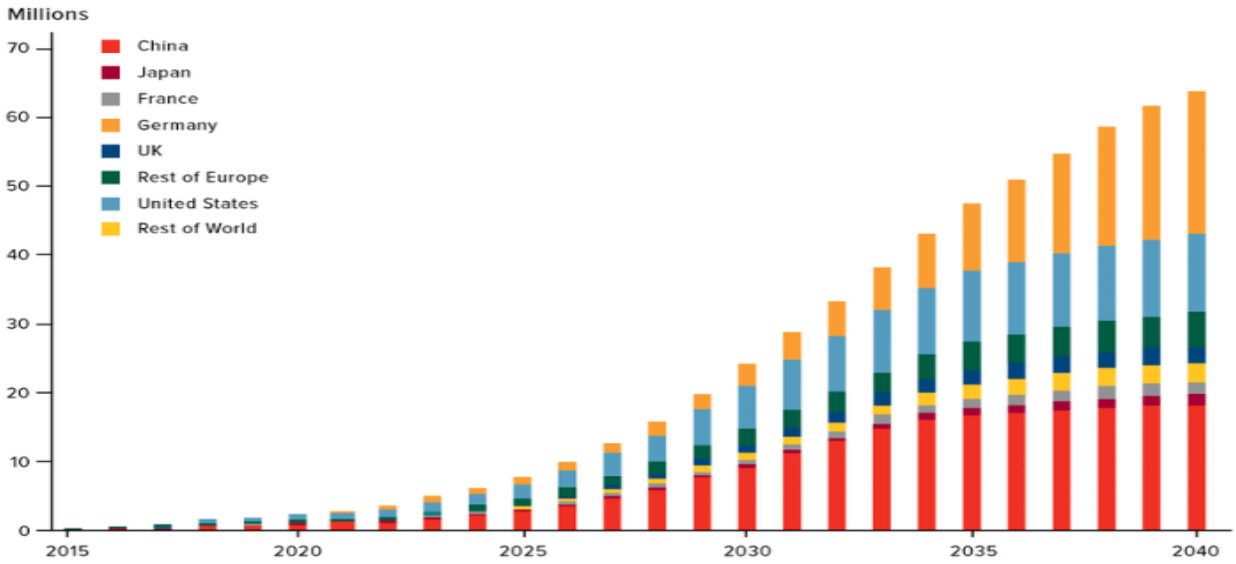
Figure 2-2: Global electrical vehicle sales and market share



Source: IEA (2019:10)

The figure below represents a visual display of the demand forecast of EV starting from 2015 to 2040. The figures indicate the start of exponential growth in the demand of EVs from 2025.

Figure 3-3: Demand forecast of electrical vehicles



Source: Mohammadi (2018:4)

Numerous international studies in different countries, spread across the globe, have been performed on the factors influencing the adoption of EVs. For example, any kind of tax motivations and a public-accessible charging infrastructure are the leading factors influencing the adoption rate of EVs in the United States (Narassimhan & Johnson, 2018:9). A study performed in Trinidad and Tobago found that human factors, including gender and age, do not encourage the uptake of EVs, but support systems, the safety of EVs and government enticements are the major factors (Adeyanju *et al.,* 2018:21). A study conducted in the country of Jordon agrees with the findings of the study performed in Trinidad and Tobago, in which the study found that there were no correlation between gender and the uptake of EVs; however, the lifespan of batteries is a main deterring factor for the uptake of EVs (Mahadin & Economics, 2018:59). An Australian case study performed concluded that investment in recharging infrastructure would encourage customers to purchase an EV, the lack of information available to customers concerning EV operation and ownership would need to be addressed and a central data collection point regarding the location and type of recharging points is required (Broadbent *et al*., 2019:11).

Nevertheless, initial peer-reviewed publications of factors that will stimulate the uptake rate of EVs in South Africa were not identified in the preliminary search. Furthermore,

South Africa's Department of Trade and Industry launched the electrical vehicle industry roadmap in 2013, to stimulate the local EV market, to assist to reduce global warming, to increase investments within South Africa and to develop employment opportunities by educating the public and to introduce investment support programmes with a supporting regulatory framework (DTI, 2013).

However, in South Africa, the number of hybrid vehicles sold in 2018 only amounted to 144 units, which is a decline from 303 units in 2017 and merely 58 battery EVs were sold in the same year, a decline from 68 units in 2017 (AIEC, 2019:16). Therefore, it can be argued that further research is required to determine the factors that will contribute to an increased uptake of EVs in South Africa; consequently, a research opportunity was identified.

1.2 **Problem statement**

Vehicles produced in South Africa are manufactured and exported to generate import credits to obtain imported vehicles at more favourable prices for the local market (AIEC, 2019:19). Locally produced vehicles that are exported to 155 destinations around the world do not only reduce the prices of imported vehicles, but are contributing to South Africa's economy, with automotive products exported in 2018 amounting to R 178.8 billion (AIEC, 2019:5-6). The automotive industry in South Africa plays a significant role with regard to contributions to the country's GDP, which totalled 6.9% of total GDP, innovation, skills development and foreign direct investment, which amounted to R 8.2 billion in 2017 by the seven foremost OEMs in the country (AIEC, 2018:5). The South African automotive industry is comprehensively dependent on the supplementary economies-of-scale provided by vehicle exports, and these exports are critical to ensure the industry remains competitive in global markets to ensure its success by producing globally demanded vehicles (AIEC, 2019:19; Export.gov, 2019).

The global economy has commenced to shift to a lower-carbon economy with the demand forecasts for South Africa's high-carbon exports, including ICEVs expected to decrease; therefore, South Africa needs to follow the international trends concerning climate change to not be at risk of losing international export markets (WWF, 2019). This statement is supported by Gosling (2019), who reported on an announcement made by Andrew Gilder, who is the director of Climate Legal, that the South African economy is part of the global

economy, which is moving to a low carbon economy and South Africa might become uncompetitive if local industries do not transform to reduce carbon emissions. Although the EV market remained relatively insignificant in the past compared to normal conventional vehicles, the markets for EVs are suspected to increase exponentially, driven by forces including improvements in energy storage systems and incentive programmes assisting the increased uptake of EVs by customers (Wolfram & Lutsey, 2016:2). The increase in EVs is already being witnessed as the number of passenger EV units sold in 2018 around the globe amounted to 1.26 million – an increase of 74% year-on-year (AIEC, 2019:38). OEMs operating in South Africa have predominately manufactured ICEVs and export almost half of these vehicles to countries such as the USA and Europe; however, the demand is expected to decrease considerably in light of ICEVs being restricted in favour of more environmentally-friendly EVs (KPMG, 2020).

Neale Hill, who is the managing director of Ford Motor Company South Africa and Sub-Saharan Africa, made the announcement that although South African vehicle sales remain a critical segment for the vehicle manufacture, he is of the opinion that the future viability and sustainability of vehicle manufacturers operating in South Africa are to expand the global export markets (Ford Motor Company, 2019). This statement is supported by Lamprecht *et al.* (2017:13), who maintained that the vehicle industry in South Africa is export-focused and the challenge is to achieve the set objective of producing 1 million new vehicles per annum by 2020 in a global and saturated vehicle market, whereby vehicle production surpasses the demand for new vehicles.

It was announced by Thomas Schafer, who is the Head of the Sub-Saharan region and Volkswagen South Africa, that the South African government has been hesitant to prioritise e-mobility; however, as part of the global vehicle production network and a location profoundly reliant on vehicle exports, South Africa cannot afford to lack the adoption of new vehicle technology (Volkswagen AG, 2019). This announcement is supported by Droppa (2017), who reported that South Africa exports vehicles to numerous developed countries and to manufacture vehicles for these first-world markets as well as vehicles for the domestic market is not only inefficient, but also negatively affects the global competiveness of South Africa's vehicle manufacturing sector. Neale Hill indicated that vehicles produced in the Ford plant located in Silverton, Pretoria, South Africa are either destined for the local market, through the South African Ford dealer

network, or for shipment to the export markets spread across the globe (Ford Motor Company, 2019). Therefore, by taking the above into account, it can be concluded that vehicles manufactured in South Africa are produced with similar characteristics intended for either the local- or international market.

On the contrary, it was reported by Venter (2019) on an announcement made by the South African Minister of Trade and Industry, Ebrahim Patel that the country can commence with the production of EVs, without firstly developing a local market and supporting infrastructure for these vehicles. However, it was reported by Smyth (2019) that the current CEO of Toyota Europe and chairman of Toyota South African Motors, Dr Johan Van Zyl, announced that it is important to develop a local market, in order to mitigate the sole reliance on exports. It was reported by Welle (2018) that the African continent is already the dumping ground for old-technology vehicles that no longer meet the required emission standards in developed countries, which has a detrimental effect on the residents of these countries. Therefore, it can be argued that not only is South Africa at risk of losing vehicle exports to countries demanding more environmentally friendly vehicles in the future, if amendments to vehicle production assembly lines are not implemented, but also be at risk of becoming the dumping ground for old technology-vehicles as already the case with the country's African counterparts.

Therefore, the research problem that needs to be addressed in this study is what factors will promote the increased uptake of new vehicle technologies – with forecasts being indicative that it will be EVs – in South Africa, resulting in the risk elimination of only receiving old-vehicle technology product offerings. The following principal research question is therefore posed: "What factors will influence the adoption rate of electrical vehicles by South African customers?"

1.3 Research objectives

1.3.1 Primary objective

To determine the factors that will influence the adoption rate of electrical vehicles by South African customers.

1.3.2 Secondary objectives

- To understand the new vehicle technology being produced by vehicle manufacturers.
- To define the different EVs being produced by vehicle manufacturers.
- To understand the essence of factors positively influencing the adoption rate of electrical vehicles by customers in the leading countries and to determine whether a correlation exists.
- To determine the factors influencing the adoption or non-adoption of innovation by customers.
- To determine the future possibility of South African-based vehicle manufactures to produce EVs.
- To better understand the current oil refinery- and carbon taxation environment in South Africa.
- To empirically investigate the factors, which South African customers favour, to convince them to purchase an EV, rather than a conventional ICEV.
- To recommend future research studies that can be performed.

1.4 Significance of the study

The significance of this study is to obtain solutions to management predicaments concerning the uptake of EVs and to determine the best possible way forward to incorporate EVs into the South African economy, by ensuring the development and implementation of adequate supporting structures to ensure the widespread use of EVs.

As mentioned in the problem statement of this research study, South Africa is not in a position for the local automotive industry to be uncompetitive, and globally demanded vehicles should be produced. The economic contributions in the form of GDP, employment and foreign direct investments are too significant for South Africa. It was reported by Cronje (2018) that South Africa's president, Cyril Ramaphosa, announced an investment conference, which includes domestic and international investors with the objective of identifying opportunities in South Africa and to attract investments in excess of R1 trillion over the past five years. The local automotive industry is critical for South Africa's investment drive for the country, as the vehicle manufacturers announced an investment of more than R4 billion to produce a new vehicle and the establishment of a

R6 billion fund to ensure the participation of local South Africans in the automotive industry over the next decade (Hogg, 2019). It was also mentioned that the economies of scale are important for the local automotive industry and it can be argued that it is not economically viable to produce one vehicle to certain technological specifications for international markets and another vehicle with lesser technological advancements for the local market. The introduction to this study highlighted certain factors that increased the adoption of EVs in other countries, for instance a decent battery recharging network system and government incentives to encourage customers to purchase EVs; however, the current market conditions do not support the widespread use of EVs in South Africa.

Based on the global sales and global forecasted figures of EVs, it can be argued that not only will the South African automotive industry be required to manufacture high quantities of EVs, but other automotive industries, located in countries spread across the globe, will likewise also be required to manufacture EVs. This will debatably result in less quantities of ICEVs being produced for universal markets. This can result in a decrease of ICEVs' product offerings not only to the world, but to South Africa as well, which will force local customers to drive their ICEVs for longer periods if the infrastructure is not available to support the utilisation of EVs. This will be a predicament for not only vehicle manufacturing companies, but also for the South African government, as the introduction of this research study highlighted the importance of the vehicle manufacturing contributions to the national GDP. However, the retail market for new vehicles in South Africa contributed 2.5% to the GDP of South Africa (AIEC, 2019:5). A reduced number of new vehicles will be sold if a situation exists where customers are forced to drive their ICEVs for longer periods due to a lack of EV supporting infrastructure.

South Africa ranked 24th in global new vehicles sales with a small universal market share of only 0.58%, which totalled to 557 701 vehicles sold in 2017 (AIEC, 2018:13, 15). The South African market is consequently minor compared to other global counterparts and it can be argued that it will be unlikely for vehicle manufacturing companies to invest in research and development activities to improve the existing technology of ICEVs for small markets where the return on investment might not be sufficient. The risk for vehicle manufacturing companies is the lack of economies of scale to produce vehicles for small markets; the focus of these companies will be to target large vehicle markets across the global and to produce vehicles that are demanded by these markets. To support this

statement is the incident that has already occurred when General Motors made the decision to deploy capital to markets that promise higher investment returns and the company decided to phase out continuous and increased investment plans into South Africa as it would not provide the expected returns compared to other international investment opportunities (General Motors, 2017).

The solution to management predicaments will include the factors that will result in customers adopting EVs, which, in turn, can contribute to the development of strategies to ensure structures are developed to support the market for EVs. Not only will economic benefits be achieved through the increased uptake of EVs, but it will likewise also result in South Africa reducing their carbon footprint, minimising the detrimental effects of climate change and constituting to other social benefits, including noise reduction

1.5 Research methodology

This research paper will include a literature study followed by a qualitative research study.

1.5.1 Literature study

The purpose of the literature study is to provide an international overview concerning the dynamics surrounding EVs and the factors that affect the development of EVs. The information obtained is then applied within a South African context. It is mainly to review historical research performed on the factors that influence the adoption of EVs and to ensure the researcher has a better understanding of these factors and how they are applied in cohesion with one another. Further literature reviews were conducted on different aspects surrounding EVs and aspects that are applicable to the South Africa market. The goal of the literature study was to identify all relevant factors that may affect the future of the global and South African automotive industry, all of which will have a direct, or indirect impact on the adoption of EVs in South Africa.

1.5.2 Empirical study

The qualitative research will be conducted in the form of semi-structured interviews with senior managers within the automotive industry in South Africa, as well as with role players along the value chain in the automotive industry and potential buyers of cars. According to Bryman and Bell (2014:225), semi-structured interviews contain specific

topics in which clarity is required; however, the respondent has ample flexibility to answer the questions posed to the respondent, which enables the researcher to add and/or change the questions on-hand based on the responses received. This flexibility will furthermore enable the interviewee to respond to questions that are viewed as important in explaining (Bryman & Bell 2014:225).

The goal of the research was to obtain the views and opinions of these senior managers concerning EVs pertaining to the global trends and forecasts, the future viability of EVs and the possibility of EVs being deployed in large quantities in South Africa.

Existing vehicle owners in South Africa were selected to be participants to represent the views of the market for electrical vehicles. Although the basic questions to be used for the different target groups will be identical, the way questions will be explained to vehicle owners will be stated such that technical terms would not confuse the participants.

Participants will be telephonically interviewed.

1.5.3 Research participants

The proposed research will focus on the insights from both the supply side of vehicles in South Africa, including both the manufacturing of vehicles and the retail of vehicles. Furthermore, the demand side of new EVs in South Africa will be represented by vehicle owners to elucidate the researcher on customer preferences. This approach will ensure that all parties involved in the South African automotive industry are included as participants in this research study.

The population of the qualitative research method will include senior managers in the South African automotive industry, working directly in the industry or working as consultants to the automotive industry. The population for the second part of the study will be South African vehicle owners and future vehicle owners as well as South African automotive industry experts.

In more detail, the following respondents will be utilised in this study, with an adequate description of each respondent that will follow:

- Consultants at international consulting and service providing firms
- Senior managers working in the South African automotive industry

- Individuals currently owning a vehicle and future new vehicle owners

Consultants working at international consultancy firms who specialises in the automotive industry. The consultants who will be interviewed will be the heads of department/leaders in the automotive industry at their respective consulting firms. These consultants will represent the supply side and the demand side of new vehicles in South Africa due to their expertise and experience in the broader automotive industry.

Senior managers working in the automotive industry will form part of the study. These management teams represent the retail supply side of new vehicles to South African customers. These management teams will provide a better understanding of their perception towards electrical vehicles, their views and opinions will be expressed concerning the future possibility of manufacturing EVs in South Africa, the factors they consider will increase the uptake of new EVs in South Africa.

Individuals currently owning vehicles in South Africa. These customers will represent the retail demand side of new vehicles in South Africa. These customers will provide insights into the different factors that will encourage them to increase the uptake and adoption of new electrical vehicles. These factors should convince customers to buy an electrical vehicle rather than the conventional internal combustion engine vehicles. Multiple different variables will be given to these customers to determine a correlation between factors that will encourage the uptake of electrical vehicles in South Africa. These individuals are important to provide insights into the retail supply side of new vehicles segment as these individuals make up the South African vehicle market. Emphasis should be placed on the data received from these respondents as it will determine the future landscape and environment of the South African vehicle industry.

Sampling will therefore be done through a stratified sampling strategy, with different stages in the automotive value chain representing the different strata. Sampling in each stratum will continue until saturation is achieved. It is envisaged that top management in the automotive industry might be too small a population to achieve saturation. In that case, interviews will continue until all available and willing participants have been exhausted.

1.5.4 Measuring instrument

The data will be collected for the research through interviews. The interviews will be of a semi-structured nature and will be conducted with senior managers in the automotive industry and with various role players along the value chain in the automotive industry, as well as with vehicle owners, representing potential buyers of electrical vehicles. The interviews will be utilised to obtain a better understanding of the views and opinions of these senior managers concerning the potential success of electrical vehicles in South Africa. According to Yang (2018:9), semi-structured interviews are an adequate process for explorative research as topics can be discussed in a free and flexible manner. An interview protocol will guide the interviews.

1.5.5 Ethical considerations

Demographic data is necessary to determine which section of the population is most likely to embrace electrical vehicles. Only demographic data that can be used for statistical analysis will be requested. Participants will complete an informed consent form and all responses will be confidential. Participants can withdraw at any stage during the research, and by participating in the interview they would give permission for their responses to be used for analysis purposes. The only ethical consideration is to determine what gender will be more inclined to purchase an EV, male or female. It is important to know the gender of customers who are more inclined to purchase EVs as it will influence the marketing strategies of vehicle manufacturing companies, should a situation exist where vehicle manufacturing companies want to market EVs to customers.

1.5.6 Data analysis

Data will be transcribed, coded and analysed using Atlas.ti qualitative research software. From this analysis, central themes will be identified to draw conclusions from.

1.6 Chapter division

Chapter 1: Introduction and problem statement, objectives and methodology

Chapter 1 will contain the introduction to the study, with an explanation regarding the problem statement, the primary and secondary objectives of the study, scope of the research and the research methodology. The purpose of this chapter is to provide an

adequate background and introduction to the study, as well as the objectives of the study and the significance of the study. This chapter will conclude with a brief outline of the proposed study.

Chapter 2: Discussion of the relevant literature

In Chapter 2, a brief explanation concerning the history surrounding EVs will be presented, in conjunction with the history of EVs in South Africa. The different EVs available on the market will be defined and the aim is to establish the general factors that will influence the adoption rate of electrical vehicles, the global demand forecast of electrical vehicles and the South African automotive industry. Literature review of appropriate market strategies to implement new technology to increase the market share of this technology will be discussed. Finally, the literature review will indicate the relationship between EVs and innovation and the factors that influence the adoption or non-adoption of innovation.

Chapter 3: Research methodology

The research process that will be followed in the study will be explained as well as the methods that are utilised to obtain the research data. Data analysis techniques used in the study will also be discussed

Chapter 4: Results and findings

The data obtained will be analysed and in-depth discussion of the results and findings will be performed in this chapter. The foremost results of the study are also summarised in this chapter.

Chapter 5: Conclusions and recommendations

The findings regarding the factors that will influence the adoption of electrical vehicles, specifically applied to the South African environment, will be dedicated to this final chapter.

The findings and results to the primary and secondary objectives will be discussed. Recommendations on appropriate marketing strategies that could be employed are made

to stakeholders of the automotive industry in South Africa to ensure greater adoption of electrical vehicles in South Africa. It will also include future research recommendations.

CHAPTER 2 CONCEPTUAL FOUNDATIONS: LITERATURE REVIEW

2.1 Introduction

The literature review is presented in nine sections. The opening section provides the history and development of normal internal combustion engine vehicles (ICEVs) and electrical vehicles (EVs). The following section examines what is meant by an EV and explores the different types of EVs, by means of defining EVs. The third section aims to provide an understanding of why there is a need in the automotive industry to change over from ICEVs to electrical vehicles (EVs). Section 4 explores the future development of EVs and the capital investment plans of major vehicle manufacturers to increase EV production. The goal of section 5 is to examine the current automotive chief executive officers' (CEOs) views regarding EVs and the future of mobility. Section 6 explores studies performed around the globe concerning factors that influence the adoption rate of EVs in specific countries. The aim of section 7 is to examine the major oil producing companies' views of the future regarding EVs, by means of identifying their strategies to capture future EV market share. The goal of section 8 is to prove that EVs can be classified as innovation and afterwards determine the adoption, or non-adoption factors that influence the uptake of innovation by consumers. The aim of the concluding section of this literature review is to provide an overview of the effect of globalisation and the resulting evolution of EVs on the automotive industry in South Africa. The final section will also include a framework of possible factors that might influence the adoption of EVs in South Africa, arising from the facts obtained through each section of the literature review.

2.2 The history of an internal combustion engine vehicle

The current retail automotive market in South Africa is dominated by conventional ICEVs. The automotive export manual reported in 2018 the total number of new vehicles, including passenger, light commercial vehicles, medium to heavy commercial vehicles and buses sold in South Africa amounted to 552 226, of which only 202 were electrical (AIEC, 2019:14, 16). ICEVs are therefore still very relevant to the South African vehicle market and this totally new vehicle market share domination is likely to continue in the nearby future up and until more EVs are introduced to the South African market, as likewise mentioned in the introduction to this research study. It is consequently important

to understand the history of ICEVs and to define ICEVs (section 2) as currently it remains a leading force in the South African automotive market. The table below is a representation of the early stages of design and development of ICEVs.

Table 1-1: Development timeline of the internal combustion engine vehicle

Timeline	Brief Discussion
1680	Christian Huygens designed an ICE that utilised gunpowder as a fuel source; this engine was, however, never manufactured.
1807	Francois Isaac de Rivaz developed an ICE that uses a combination of oxygen and hydrogen. Francois used this engine is his own vehicle, which is considered the world's first ICEV.
1824	English native, Samuel Brown, converted an old steam engine to burn fuel to power a vehicle.
1858	Jean Joseph Etienne Lenoir from Belgium developed an electrical spark-ignition ICE that used coal gas as the prime fuel source. This engine was patented in 1860 and an improved version of the engine was mounted to a three-wheel wagon that commenced and completed a 50-mile journey.
1862	Alphonse Beau de Rochas patented a four-stroke engine; nevertheless, the engine was never developed.
1864	Siegfried Marcus from Austria developed an engine with a carburettor and one cylinder. Several years later, Siegfried developed an ICEV that reached 10 miles per hour and this vehicle is considered as the forerunner of the current automobiles.
1866	Eugen Langen and Nikolaus August Otto improved Jean Joseph Etienne Lenoir and Alphonse Beau de Rochas' designs by developing a more efficient ICE.

1873	George Brayton designed a two-stroke ICE that used two external cylinders. Although unsuccessful, this ICE was considered as the world's first safe and practical ICE.
1876	Nikolaus August Otto developed and patented a successful four-stroke ICE, called the *Otto Cycle*. Otto developed this engine when he was 34 years old. The same year saw the successful development of a two-stroke ICE by Sir Dougald Clerk.
1883	Edouard Delamare-Debouteville produced a four-stroke, single-cylinder ICE that utilised stove gas as a fuel source.
1885	Gottlieb Daimler developed an ICE with a perpendicular cylinder, with fuel inoculated by means of a carburettor. This ICE was patented in 1887 and it is considered as an example of the present ICE.
1886	Karl Benz received the first patent for a gas-fuelled ICEV. Benz was the first individual to combine an ICE with a vehicle chassis.
1889	Gottlieb Daimler developed an improved four-stroke ICE with valves and V-shaped cylinders.
1890	Wilhelm Maybach developed the world's first four-stroke engine with four-cylinders.
1892	Rudolph Diesel, a German engineer, developed an ICE that utilises diesel as a fuel source. Diesel-source ICEs are more powerful than petrol engines and are utilised in heavy machinery including, large sea vessels and train engines.

Source: Compiled by the researcher, data gathered from RAŢIU (2003:146-147)

2.3 The History of the electrical vehicle

Contrary to popular belief, EVs were introduced to markets in the late 1880s when Thomas Parker designed and developed the world's first EV (Figure 1) (Sudhansu, 2017). ICEVs were presented to markets around the same time as EVs; however, EVs

dominated sales to customers over ICEVs in the early 1900s due to the following benefits (Department of Energy, 2014):

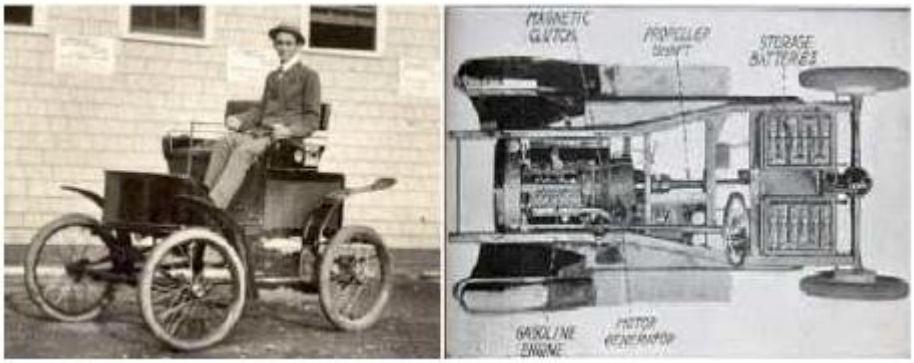
1. EVs could be operated with minimal effort and no hand-crank was needed to start the vehicle, and therefore these vehicles could also be driven by females;
2. EVs functioned silently and no harmful gases were emitted into the atmosphere; and
3. Superfluous people gained access to electricity – which increased the convenience to recharge EVs.

Chan (2012:209) maintains that further advantages that contributed to the domination of EVs over ICEVs were that no gears had to be changed and roads were not developed outside of towns and therefore EVs only had to travel short distances, which was a suitable environment for EVs due to their limited range capabilities.

Momentum shifted away from EVs to ICEVs when the United Stated of America developed a suitable road system that connected cities, which required vehicles with extended driving ranges, the unearthing of crude oil in the state of Texas reduced the price of fossil fuels and made the fuel more affordable for customers (Chan, 2012:210).

Another blow to EVs was when Henry Ford introduced the renowned Model T to customers in 1908; the Model T was mass-produced and therefore extensively available and affordable to customers. By 1912, the fossil-fuel based Model T was cheaper by 1 100 dollars compared to an EV (Department of Energy, 2014). Sudhansu (2017) supports this proclamation in which the advances in ICEs and the mass production of ICEVs caused the steep decline in EVs. The invention of the electric starter in 1912 by Charles Kettering eradicated the requirement to hand-crank ICEVs that made these vehicles easier and more convenient to start (Chan, 2012:210). Thomas *et al*. (2017:16) maintained that the batteries of EVs could not recharge timeously, compared to the refuelling of ICEVs with fossil fuels, which increased the level of convenience experienced by customers.

Figure 4-1: The world's first electrical vehicle developed by Thomas Parker



Source: Sudhansu (2017)

2.4 Defining internal combustion engine vehicles and electrical vehicles

“In an internal combustion engine vehicle, air and fuel are compressed using pistons in the combustion chamber (hence the term internal); ignited by the firing of spark plugs. The internal combustion engine transforms the thermal energy from burning the air-fuel mixture into mechanical energy” (Pilay, 2018:40). ICEVs are any vehicle with an engine that operates the explosive ignition of fuel (petrol or diesel) to propel a piston that rotates a crankshaft, which, in turn, propels the wheels of the vehicle with a drive train (RAŢIU, 2003:146).

In contrast to ICEVs that rely on the combustion of fossil-based fuel sources for thrust and propulsion, EVs utilise electricity to drive the vehicle and batteries are used for electricity stowage (Ellingsen *et al*., 2016:1). This research paper will focus on and define the four main types of EVs available, which are *battery electrical vehicles (BEVs), hybrid electrical vehicles (HEVs), plug-in hybrid electrical vehicles (PHEVs)* and *fuel cell electrical vehicles (FCEVs).*

According to Smit *et al.* (2018:1), BEVs are powered exclusively by an electric motor, which utilises electricity stowed in a battery and is plugged in to recharge the battery. This statement is supported by Todd *et al.* (2013a:10), who define BEVs as vehicles with no back-up fuel source and are exclusively powered with electricity. BEVs utilise electricity to power the electrical motor to propel the vehicle emissions free (UCSUSA, 2018).

Pilay (2018:36) maintained that HEVs includes an ICE (petrol or diesel) to propel the electrical drive motor and the additional electricity is stored in a battery. The battery used

to propel the electrical motor can, however, not be plugged in from an external source (UCSUSA, 2018). According to Todd *et al.* (2013b:10), HEVs utilise two power sources, i.e. electricity and a fuel-based source; the on-board battery assists the fuel-based source to be exploited more proficiently, while the fuel-based source is used to recharge the on-board battery. The refuelling process of HEVs is precisely the same as normal ICEVs; HEVs are not designed to be plugged in to an external source to recharge the battery pack; the battery pack is recharged by regenerative braking and all energy from HEVs is produced by the ICE (Thomas *et al*., 2017:16).

PHEVs are similar to HEVs, but with an added ability to recharge the battery with an external electricity source (Simpson, 2006:1). A subdivision of hybrids that permits the on-board batteries to be re-energised by plugging into a peripheral electricity source, these PHEVs can function on electricity and a fuel-based source (Todd *et al*., 2013c:10). PHEVs make use of electricity and fossil fuels for thrust and momentum; electricity is used for short driving distances, and fossil fuels are used for longer driving distances, which equate to a more eco-friendly vehicle (UCSUSA, 2018). The driving range of electric-only fluctuates significantly between different vehicle manufactures (Thomas *et al*., 2017:19). One major benefit of PHEVs is the fuel multiplicity these vehicles offer to customers as the electrical energy for the electrical motor can be exchanged for the fossil-based fuel of the ICE; the percentage of energy-type (electrical or fossil fuels) depends on the design of the PHEV and driving patterns (Thomas *et al*., 2017:19).

FCEVs utilise fuel cells to produce electricity from hydrogen; the electricity is generated from an isothermal process and not the burning of fuel, with zero emissions as a result and water as a by-product subsequent to the chemical process (Chan, 2007:705). The electricity produced is utilised to thrust the vehicle or, alternatively, the electricity is stored in tanks (Chan, 2007:705). FCEVs combine hydrogen with oxygen to fabricate electricity; FCEVs are exclusively powered by electricity, and therefore they are considered as EVs that only produce water and heat as a consequence (UCSUSA, 2018). FCEVs can drive emission-free and be timeously refuelled with hydrogen, parallel to refuelling conventional ICEVs with petrol or diesel (BMW Group, 2019).

2.5 The need for electrical vehicles as an alternative to internal combustion engine vehicles

Global warming is caused by an energy transformation procedure, which is basically the burning of fossil fuels including oil, coal and natural gas, which release greenhouse gas emissions into the atmosphere causing the earth's average temperature to increase by a predicted 3 degrees Celsius by the end of this century (Rueangphankun *et al*., 2018:1483; Di Lorenzo & Galassi, 2017:1; Oh & Jeon, 2017:828). It is maintained by Bradford (2017) that human activity is causing global warming a result of the burning of fossil fuels.

Greenhouse gases are a collective term for carbon dioxide (CO_2), chlorofluorocarbons (CFCs), nitrous oxide (N_2O), sulphur hexafluoride (SF_6) and methane (CH_4), and these gases are instigated from industrial processes and the global transport sector (Rueangphankun *et al*., 2018:1483).

Measurement of the earth's temperatures began in 1850 and 11 out of 12 times when the earth was at its highest temperatures were recorded in the last 12 years, a testament that global warming is accelerating (Oh & Jeon, 2017:828).

Climate change is a shift in global long-term weather patterns caused by a rise in global temperatures, resulting in more common and powerful weather damaging events including floods, winter storms, hurricanes, downpours and rising sea water levels due to ice glaciers melting at an increased rate (National Geographic, 2019).

Another worrying impact of global warming is the effect it has on African food production, as crops cultivated on this continent are primarily rain-fed and less predictable weather patterns and rainfall result in more risks arising in the African agricultural sector (Buhaug *et al*., 2015:2).

Australia has experienced catastrophic bushfires in recent months with 17 million acres of land and vegetation ruined, killing hundreds of millions of animals (Berwyn, 2020). Dr Richard Thorton stated that it is very difficult to pinpoint global warming to only one single event, like the bush fires, but he concluded that the current temperature in Australia is 1 degree Celsius warmer than the country's long-term average (BBC, 2019). More specifically, Australia's warmest year in history was recorded in 2019 with average temperatures 1.52 degrees Celsius beyond the national average recorded from 1961 to

1990 (The Guardian, 2020). According to Rott (2020), wildfires are occurring more regularly and burning more destructively due to climate change causing the expansion of areas by which these fires can burn, which, in turn, increases the length of time of these fires.

In recent years, South Africa has also been negatively affected by climate change. The City of Cape Town in South Africa experienced a three-year drought that peaked in 2018, whereby rainfall dropped between 50 and 70% from June 2015 to June 2018, and by January 2018, it was estimated that only three months of water supply was left for the residents of Cape Town (Joubert & Ziervogel, 2019). It was reported by Ellis (2019) on an observation made by Professor Alistair Clulow, residing at the University of KwaZulu-Natal, that the extreme weather experienced in South Africa's KwaZulu-Natal Province, which constituted substantial storms, floods, hail and tornadoes, is a result of climate change.

Global policy agendas are therefore geared toward reducing greenhouse gas emissions and as mentioned before, the transport sector is responsible for the fastest rising source of greenhouse gas emissions (Kawamoto *et al.,* 2019:1). A major concern with ICEVs is that energy produced by combustion is wasted and exhaust gases released by the burning of fuel in engines are harmful for humans, animals and the environment (Filip *et al*., 2019:1). Therefore, by taking these arguments into account, it can be debated that a change in the transport sector is consequently needed.

2.6 Future development strategies of major automotive companies to produce electrical vehicles

The sales of EVs are increasing and analysts are forecasting a bullish future market for EVs, as mentioned in the introduction to this research study. Major automotive manufacturing companies have developed strategies to increase the production of EVs not only for the current market, but also for future markets, in response to the growing EV market (Gustafsson & Nordström, 2017:22). The strategies for the development and employment of EVs by major vehicle manufacturers include:

2.6.1 Volkswagen

The Volkswagen group will increase the number of purely electrical vehicles from six to more than 50 vehicles by 2025 (Volkswagen AG, 2019).

2.6.2 Toyota Motor Corporation

Toyota Motor Corporation delivered the first mass-produced FCEV, the Mirai, in December 2014. Sales for the Mirai increased from 700 units in 2015 to 3 000 units in 2017 in Japan, the United States of America and several countries in Europe (Toyota Motor Corporation, 2018). Toyota aims to sell 30 000 units globally from 2020 by actively demonstrating the Mirai in numerous countries such as China, Canada and Australia and by supporting initiatives to promote the increased development of hydrogen infrastructure (Toyota Motor Corporation, 2018).

2.6.3 Ford Motor Company

The goal of Ford Motor Company is to have a total of 24 hybrid and 16 solely EVs in their portfolio by 2022 (Ford Motor Company, 2018). The Ford Motor Company is not only planning to increase the production of their own branded EVs, but it was reported by Naughton and Welsch (2019) that the company invested $500 million into Rivian, an EV manufacturing start-up company.

2.6.4 Mercedes-Benz

Over the upcoming years, Mercedes-Benz will invest 10 billion euros in the expansion of its electrical fleet (Mercedes-Benz, 2018).

2.6.5 BMW Group

The BMW group aims to have half a million electrified vehicles on the roads by the end of 2019 (BMW Group, 2019).

2.6.6 Nissan Motor Corporation

The Nissan Motor Corporation launched a plan called *Nissan M.O.V.E to 2022*. Part of this plan entails the development of eight new pure electrical vehicles, building on the

success of their predecessor electrical vehicle, the Nissan Leaf (Nissan Motor Corporation, 2018).

2.6.7 Volvo

Volvo's aim is to sell one million electrified vehicles by 2025, to expand the portfolio of electrified vehicles by offering two hybrid versions of every model, and to produce an all-electrical vehicle by 2019 (Volvo Car Group, 2016).

2.6.8 Opel

Customers can order Opel's first EV, the Corsa-e, which will be delivered to customers in 2020. Coincidently, Opel will launch another EV in the same year – the Grandland X Hybrid 4, which is a 4WD sports utility vehicle that can drive 52 kilometres on electricity (Opel, 2019). These two vehicles initiate Opel's electrical drive with two additional EVs; the Mokka-e and the Vivaro-e that will follow suit in the succeeding year and by 2024, Opel aims to offer all Opel models with an electrical drive system (Opel, 2019).

2.6.9 Porsche

Porsche announced their plans to invest in excess of six billion euros by 2022 with the emphasis being on PHEVs and pure EVs, the investment will be applied to expand vehicle production sites, to electrify current model ranges and to develop recharging infrastructures (Porsche, 2018).

2.6.10 Hyundai Motor Group

Hyundai Motor Group has announced a partnership with Rimac Automobili to co-develop EVs and FCEVs (Kia, 2019). Hyundai will invest 64 million euros and its subsidiary, Kia Motors, will invest 16 million euros; the investment will be applied to expand the research and development capabilities to enable the group to develop EV prototypes and to deploy 44 environmental friendly vehicles by 2025 (Kia, 2019).

It is worth mentioning that Tesla Motors, a vehicle manufacturing company that was established in 2003 and only produces EVs with no tailpipe carbon emissions is experiencing a market capitalisation double that of Fiat Chrysler and half that of Ford Motor Company and General Motors (Stringham *et al*., 2015:102; Tesla, 2019).

2.7 Capital expenditure plans of original equipment manufacturers to produce electrical vehicles

The strategies of the OEMs to increase the number of EVs on the roads should be accompanied with development plans to enable vehicle-manufacturing plants to produce EVs to satisfy the demand of customers. The development plans of foremost vehicle manufacturers to equip their vehicle manufacturing plants with machinery to produce EVs include:

2.7.1 Mercedes-Benz

Mercedes-Benz is investing nearby 500 million euros at their Hambach plant located in France. Hambach was chosen due to the years of experience the site has in producing EVs, and Mercedes-Benz wants to capitalise on this knowledge and expertise to produce a compact EV (Daimler, 2018).

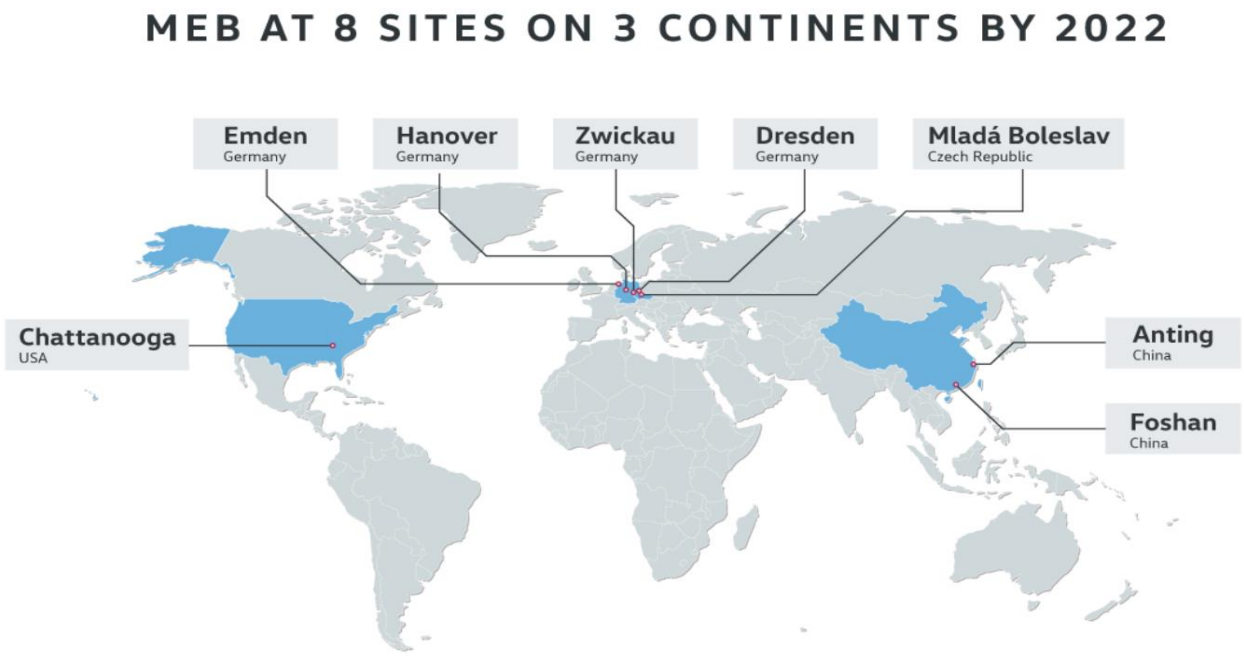
2.7.2 BMW Group

The BMW plant located in Leipzig commenced producing the completely electrical drive train BMW i3 in 2013. BMW is designing production processes to enable the group to produce partially or fully EVs and ICEVs on the same assembly line. To date, the BMW Group is producing ICEVs and PHEVs on the same assembly lines at ten locations worldwide (BMW Group, 2019).

2.7.3 Volkswagen

The Volkswagen Group plans to produce EVs at eight plants located on three continents by 2022; the most recent location selected is the Volkswagen plant located in Chattanooga in the United States of America. An investment of 690 million euros at this plant will result in the first EV to roll off this assembly line by 2022 (Volkswagen AG, 2019).

Figure 5-2: Volkswagen Group AG manufacturing plants to produce electrical vehicles on three continents by 2022



Source: Volkswagen AG (2019)

2.7.4 Toyota Motor Corporation

Toyota anticipates major growth in FCEVs with expected sales to reach 30 000 units subsequent from 2020, which resulted in the announcements that the company plans to build two new facilities: one brand-new facility that will be utilised to expand fuel cell (FC) stack mass production, and one to produce high-pressure hydrogen tanks (Toyota Motor Corporation, 2018). The on-board electricity produced by the FC is stored in the hydrogen tanks (Toyota Motor Corporation, 2018).

2.7.5 Groupe Renault

Renault has announced an investment greater than one billion euros to expand the company's production capabilities of electrical vehicles in France; the investment will be utilised for (Groupe Renault, 2018):

1. opening a second site that will manufacture electrical vehicles;
2. triplicating electrical vehicle production at the company's Cleon site; and

3. introducing a new electrical motor by 2021.

As mentioned before, the sales of EVs did increase; however, according to Statharas *et al.,* (2019:2), there is room for improvement and additional investments are required to enable the OEMs to deliver affordable substitute vehicles to ICEVs , especially to the European Union (EU) markets, if the EU wants to achieve their carbon dioxide reduction targets by 2030.

2.8 The views of captains of the automotive industry regarding the future of electrical vehicles and mobility

From the words of Dr Karl-Thomas Neumann, who is the current chief executive officer (CEO) of the Opel Motor Group, he believes that future vehicles will be driven by an electrical powertrain and the automotive industry will experience changes as never seen before due to electrical mobility (Neumann, 2017). The views from other CEOs of the automotive industry regarding the hype and future of EVs from their respective companies include:

2.8.1 Dr Johan van Zyl – CEO of Toyota Europe

Twenty years ago already, Toyota started to develop hybrid vehicles and the company wants to increase the development of EVs as they are aware of the trend of EVs and they believe the market for EVs will continue to grow and advance in the future in all EV categories, including BEVs, PHEVs and FCEVs (Bloomberg Markets and Finance, 2018a). Fifty percent of Toyota's revenue in Europe is from hybrid sales, and Toyota will continue to invest in EVs to enable the company to achieve the European CO_2 targets (Bloomberg Markets and Finance, 2018b).

2.8.2 Jim Hackett – CEO of Ford Motor Company

A total of 11 billion dollars will be invested in the development of EVs by 2022; the $11 billion will be funded from the current core business revenue streams and Hackett wants to ensure that the core business is running as efficiently as possible to ensure the full funding can be achieved (Bloomberg Markets and Finance, 2019). The arrival time of EVs should neither be overestimated, nor should the effect of these vehicles be underestimated (Bloomberg Markets and Finance, 2019a).

2.8.3 Hakan Samuelsson – CEO of Volvo

Samuelsson firmly believes that customers' demands will be directed towards EVs in the future and Volvo needs to develop EVs on a prompt pace to satisfy this demand (CNBC International TV, 2018). With that thought in mind, Volvo made the decision to prioritise the allocation of resources to the development of pure BEVs and hybrid vehicles and has made a commitment to ensure that 50% of their fleet be pure BEVs and the other half hybrid vehicles (CNBC International TV, 2018).

2.8.4 Harald Krueger – CEO of the BMW Group

Krueger confirmed that the BMW Group understands what their customers want and they are aware that their customers are leaning towards EVs. To satisfy their needs, BMW's plan to react to this new up and coming demand of customers is to introduce 25 new EVs by 2025 (AP Archive, 2018).

2.8.5 Dieter Zetsche – CEO of the Daimler Group

Zetsche confirmed that Daimler, with Mercedes Benz as their subsidiary, wants to introduce ten new EVs in the succeeding years, and the company is manufacturing their own battery technology that will provide customers with a 500 kilometre range and these batteries can be recharged within 30 minutes (Bloomberg Markets and Finance, 2016). One of the goals of this company is to be the leading premium brand of EVs by no later than 2025 (Bloomberg Markets and Finance, 2016).

2.8.6 Dietmar Exler – CEO of Mercedes Benz of the United States of America

Exler made the comment that automotive companies will continue to invest in the development of EVs as the inclination towards EVs is increasing (CNBC International TV, 2019).

2.8.7 Ralph Speth – CEO of Jaguar Land Rover

Speth is quite adamant that the future of the automotive industry will be the electrification of vehicles and, by 2020, Land Rover will have an electrical powertrain for all their vehicles (Bloomberg Markets and Finance, 2019b). The demand for EVs is increasing and the

company has already received 25 000 orders for their new E, the Jaguar I-Pace (Bloomberg Markets and Finance, 2019b).

2.9 Studies performed on the adoption of electrical vehicles around the globe

A study performed on literature review regarding general factors influencing the adoption of EVs and using the information to forecast EV sales in Hawaii was categorised into internal- and external factors. Internal factors are the features of the EV itself and include *charging time, battery costs, driving range* and *purchase price,* whereby external factors are those out of the control of vehicle manufactures and include *travel distances, fuel prices, consumer characteristics, charging stations, policy incentives, vehicle diversity* and *public visibility* (Coffman *et al*., 2015:2).

The total global EV fleet surpassed 5.1 million units in 2018, with the following three countries representing the largest EV markets (IEA, 2019:9):

1. The people's Republic of China, who had a total of 2.3 million EVs in 2018;
2. Europe had 1.2 million EVs at the end of 2018; and
3. The United States of America followed close with 1.1 million EVs.

The succeeding literature review under this section will be geared towards EV adoption studies performed on these three abovementioned countries, due to the success achieved by these countries with regard to the number of EVs sold. The factors that supported these countries to achieve the prolific number of EVs can serve as a framework for the development of factors that can help increase the uptake of EVs in South Africa and other nations.

2.9.1 China

The people's republic of China launched a programme in 2009 called, *Ten Cities, Thousand Vehicles* and the aim was to launch 1 000 EVs in each city; however, each city was given carte blanche to choose their own strategy to introduce these government fleet application vehicles into the city (Marquis *et al*., 2013:54-55 ; Du & Ouyang, 2013:3). The decision has since been made to expand the programme to a total of 25 cities and consumer encouragements are also included in five cities (Du & Ouyang, 2013:3).

The figure below represents the strategies and models followed of five of the ten cities selected in the programme to introduce EVs into the respected cities.

Table 2-2: Five Chinese cities and its unique electrical vehicle programmes

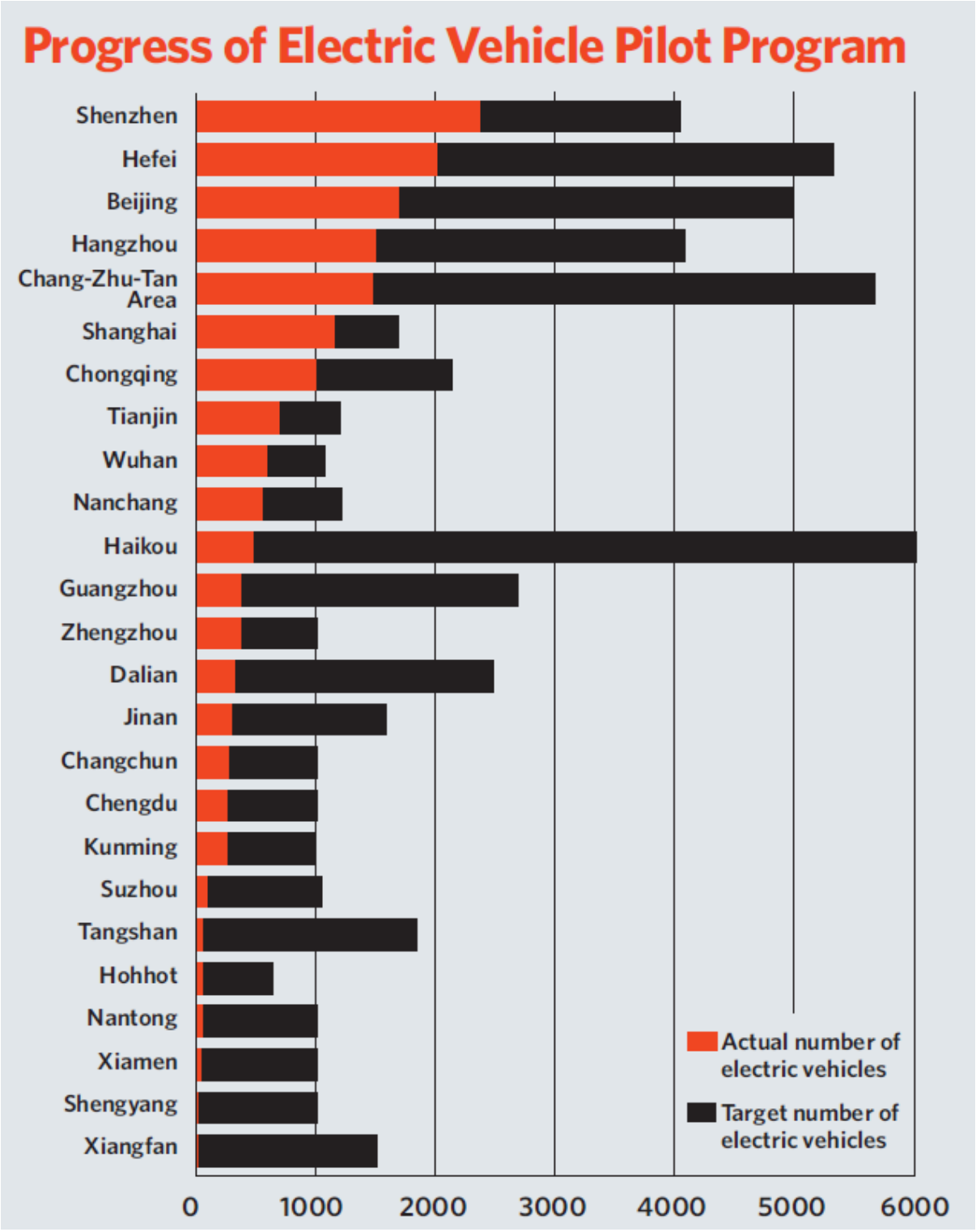
City	Model	Local strengths and geographical conditions
Beijing *State leadership model*	The government relies on preferential policies and makes a conscious effort to develop a strong EV industrial base. Foremost industry players cooperate actively	The capital city is good at regulations and is experienced in cooperating with public and private sectors. Beijing is strongly motivated to cultivate its image as an environmentally friendly city.
Shanghai *Platform-led business innovation model*	The EV international demonstration zone in Jiading provides a platform to promote EV development. Planners intend to spread EV rental business across the city	With deep roots as an international coastal city, the people are generally more open-minded. The investments originating from the private sector are strong. The ability to develop private business, including infrastructure, markets and human capital, is comprehensive.
Shenzhen *Cooperative commercialisation model*	Multiple industrial players participate actively. Potevio's financial leasing model reduces costs of purchasing an EV.	The city’s local government has wide experience in policy experiments and innovations. A vibrant private economy with many strong companies, such as BYD, can support the EV industry.

		Local government is determined to develop an EV industry and has already taken substantive steps.
Hangzhou *Flexible rental model*	Customers can choose to either rent the EV or the battery separately. This was the first city to adopt battery switching.	The local government gained a great deal of prior experience with the rental model when it developed a public bicycle rental system. One example is that a local manufacturer provides EVs that are propelled by Li-ion batteries that have a range of 100 km and a top speed of 70 km/h.
Chongqing *Fast charging model*	This is the only city pursuing fast-charging batteries	The location in a mountainous area with few flat lands made battery switching problematic. Nearby Three Gorges reservoir and the Three Gorges power grid are sources of large amounts of electrical power and a robust electrical grid.

Source: Compiled by the researcher, data gathered from Marquis *et al*. (2013:55)

The figure below indicates the targets that were set for EV deployment versus the actual number of EVs deployed in the 25 cities.

Figure 6-3: Results of the electrical vehicle program in China



Source: Marquis *et al*. (2013:56)

From the figure above, it is clear that Shanghai and Shenzhen are the two cities to date that performed the best in meeting the targets of EV deployment. The rental of EVs (Shanghai) and the cost reduction of EVs through a financial leasing model (Shenzhen) are therefore adequate factors for the private sector, government and other stakeholders to consider in other countries.

2.9.2 Europe

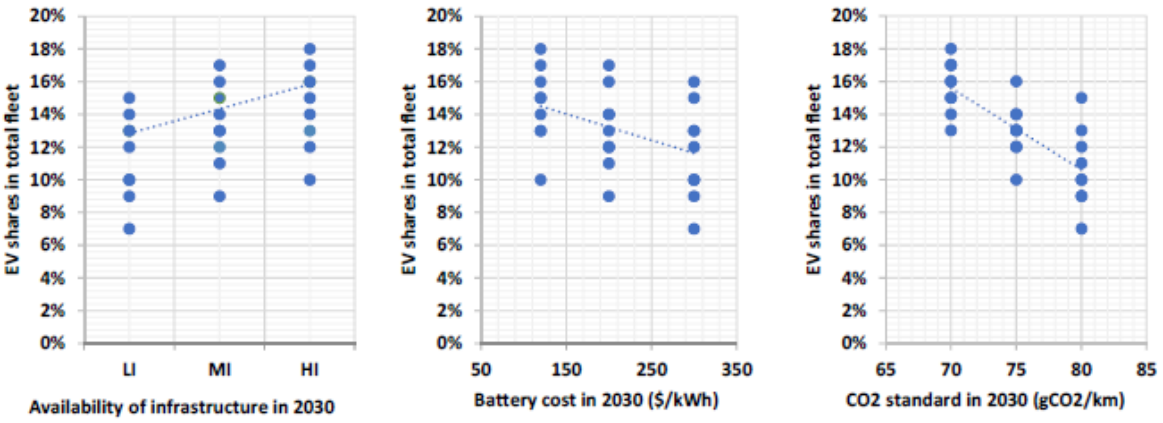
The European Commission employed a strategy to reduce GHG emissions in the transport sector to 60% by 2050, compared to the recorded levels in the year of 1990 (Statharas *et al*., 2019:1).

Statistical analyses performed in an EU study confirmed that the following three factors will undoubtedly influence the market share of EVs in the EU and the quantifiable impact on market shares as a result of these three factors will range from 7 to 18% in 2030 (Statharas *et al*., 2019:21):

1. Battery cost;
2. Battery recharging infrastructure network coverage; and
3. Carbon dioxide standards of the vehicles.

The figure presented underneath indicates the level of market share achieved by EVs when the factors are introduced in the market place.

Figure 7-4: Electrical market vehicle share fluctuations in the European Union



Source: Statharas *et al*. (2019:11)

The figures indicate that the high availability of recharging infrastructure, lowest possible battery costs and most stringent CO_2 vehicle standards will ensure the highest possible market share for EVs.

Another study performed in the EU established that the tendency to purchase an EV increased from 2014 to 2018 across all tested socio-economic groups and the researchers argued that this might be due to more members of the population using EVs, battery recharging infrastructure are gradually installed, the costs of EVs are decreasing and the market is shifting from the early adopters to the general public (Christidis & Focas, 2019:13).

2.9.3 The United States of America

A study performed in 2015 utilised statistical data from 19 different states spread across the United States and three major factors were identified that influence the uptake of EVs in these states; these factors are (Soltani-Sobh et al., 2017:4,10):

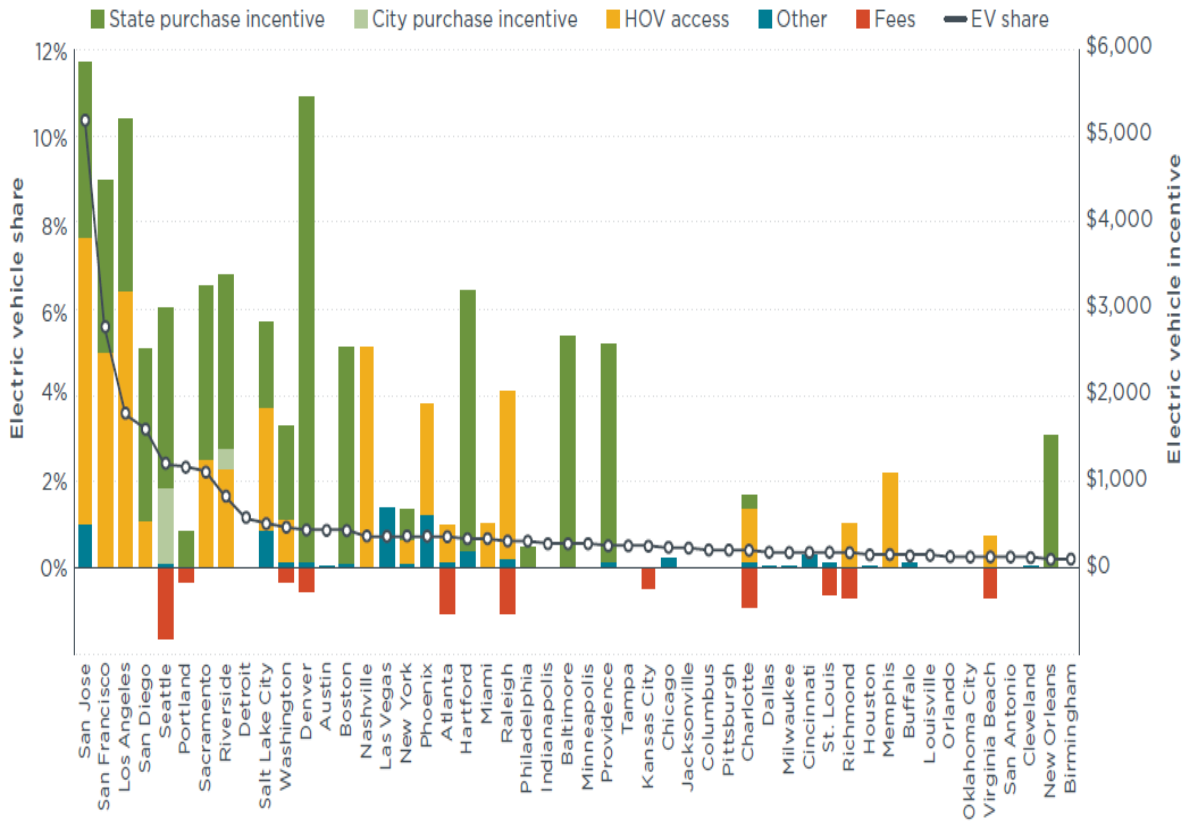
1. Decreasing electricity prices;
2. Increasing urban roads; and
3. Providing of incentives.

The study also found that the price of electricity is the most prominent factor in convincing customers to purchase an EV (Soltani-Sobh *et al*., 2017:10).

Apart from the three major factors identified by Soltani-Sobh et al. (2017), a study confirmed that many actions from various stakeholders are required to increase the market share of EVs and relationships play a vital role to increase the market share of EVs. The relationships identified are municipal charging infrastructures, consumer incentives, different models to choose from, office charging infrastructures, high ownership vehicle lane access and promotion initiatives (Slowik & Lutsey, 2018:28).

The figure below indicates the importance of the availability of incentives to encourage customers to purchase an EV rather than an ICEV. The figure highlights the market share of EVs from United States cities with sufficient incentives to states with a lack of incentives.

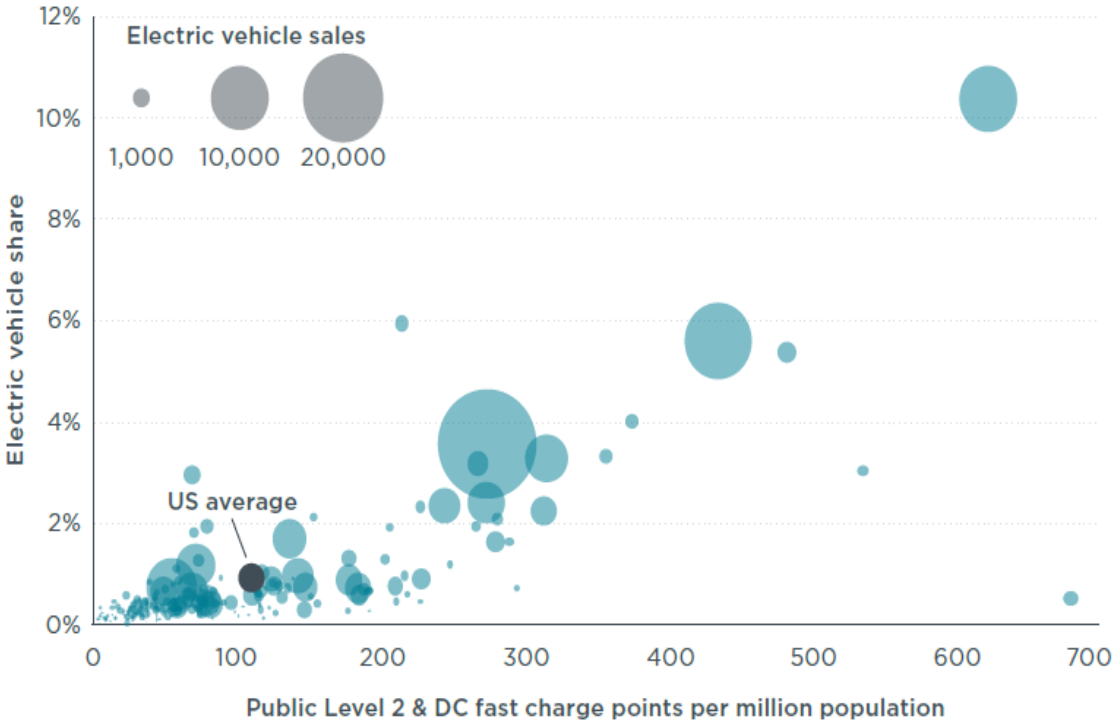
Figure 8-5: The United States market share of electrical vehicles of all new vehicles and the incentives available to customers



Source: Slowik & Lutsey (2017:22)

The following figure is a visual representation of the importance on having a sufficient battery-recharging infrastructure available for customers.

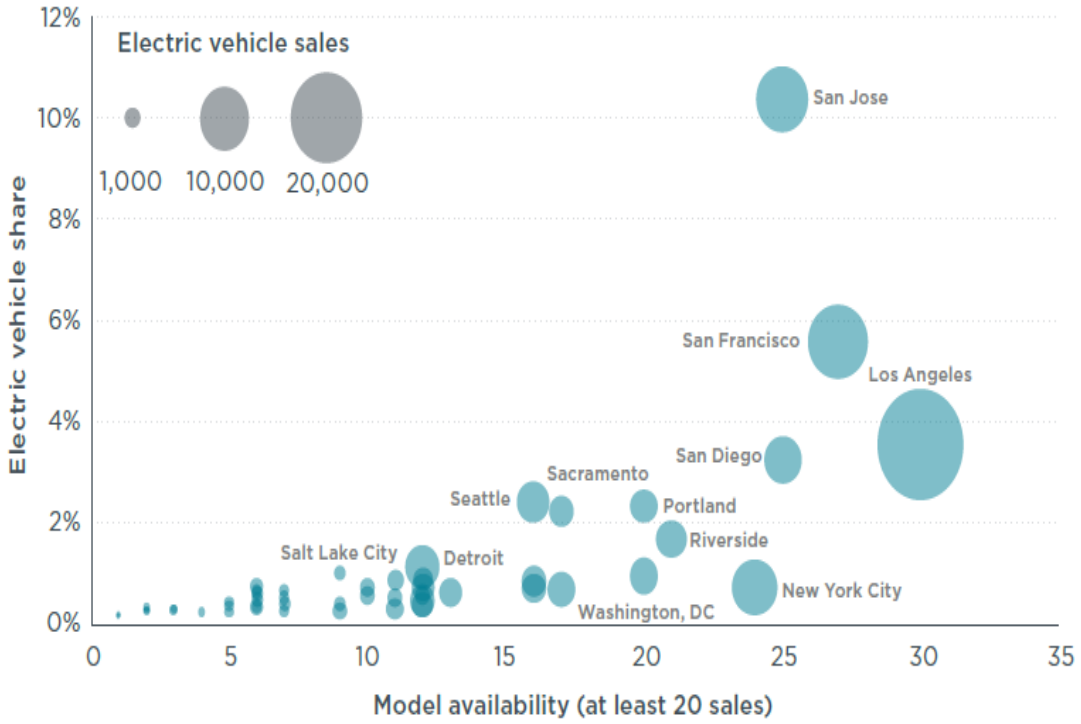
Figure 9-6: The United States electrical vehicle market share to total new vehicles versus public recharging points



Source: Slowik & Lutsey (2017:19)

The succeeding figure indicates the significance of different EV models available to customers and the increased market share of EV to new vehicle sales as a result of the model derivatives.

Figure 10-7: The United States electrical vehicle market share to total new vehicles versus electrical vehicle model availability



Source: Slowik & Lutsey (2017:21)

The figure underneath represents the promotional initiatives from various stakeholders to promote the uptake of EVs in the United States. As mentioned before, multiple stakeholders need to be involved to enable the development of support structures to increase the EV market share to the total new vehicle pool.

Figure 11-8: Electrical vehicle promotion from different stakeholders versus electrical vehicle uptake in the cities of the United States

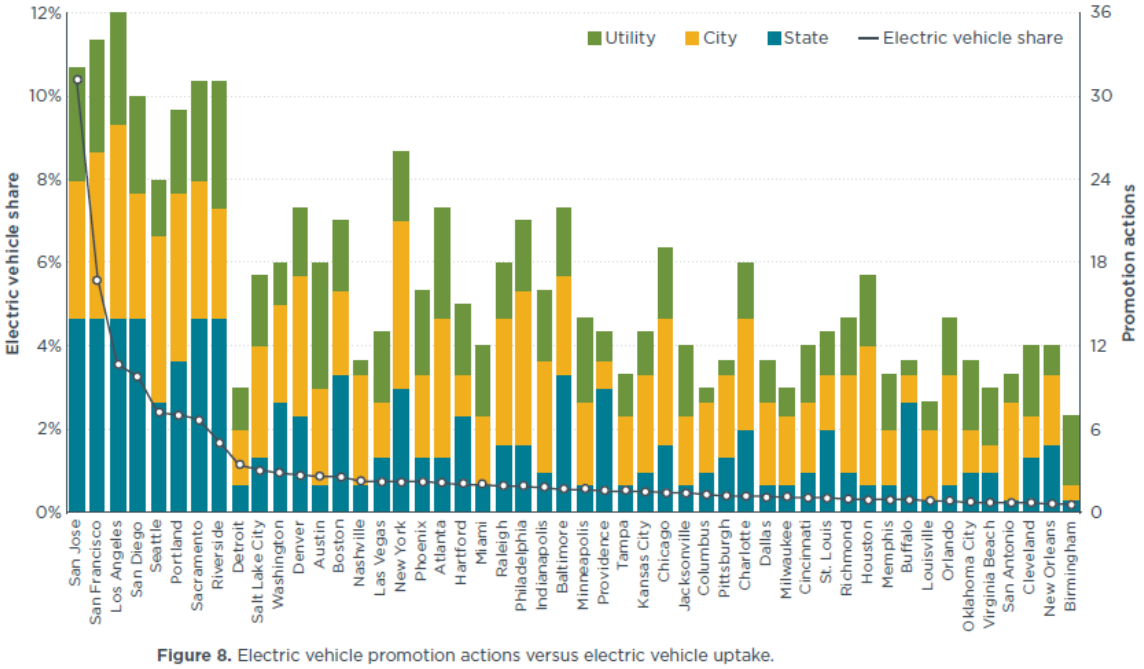
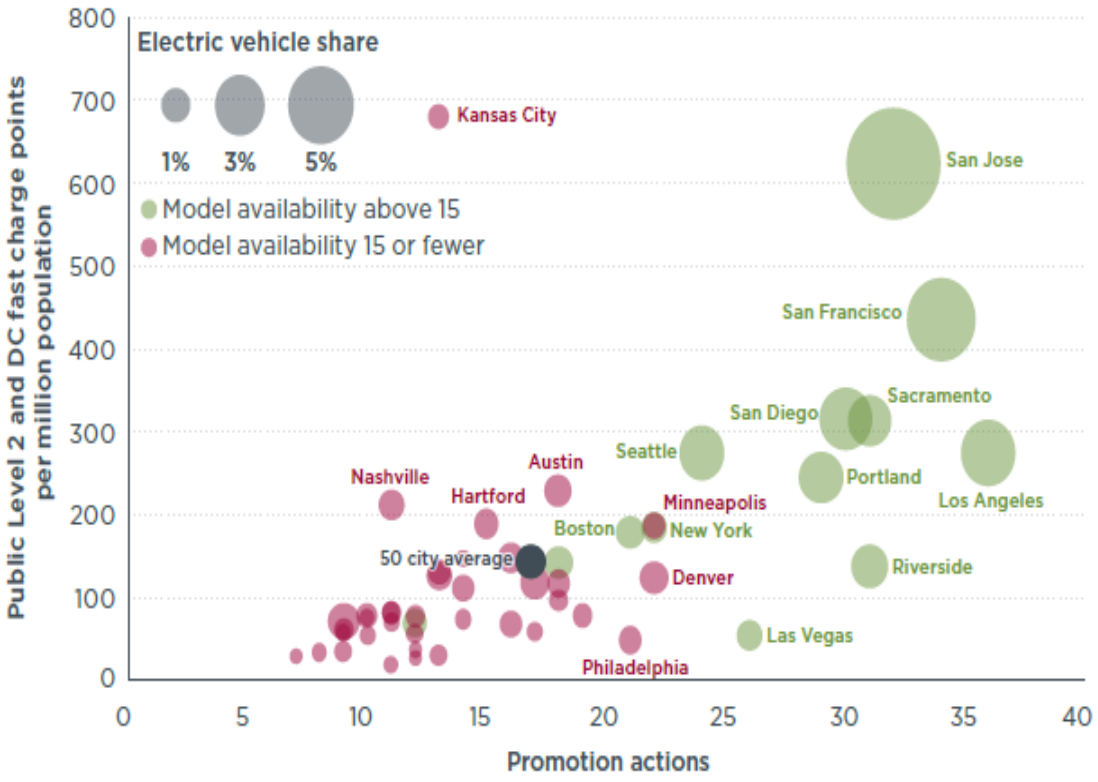


Figure 8. Electric vehicle promotion actions versus electric vehicle uptake.

Source: Slowik & Lutsey (2017:23)

Slowik and Lutsey (2017) emphasised the importance of the relationships between these underlying factors to even further increase the adoption of EVs among United States customers. The figure below indicates the market share of EV compared to new vehicles, when two factors are combined, namely battery recharging points and promotional activities from several stakeholders.

Figure 12-9: Public battery recharging points, combined with promotional activities and the electrical vehicle market share in the cities of the United States



Source: Slowik & Lutsey (2017:24)

From the above figure, it is evident that the market share of EVs increases when individual factors that encourage the uptake of EVs are employed; however, the market share of EVs compared to total new vehicles is increased even further when these factors are employed in combination with one another. The combination of the correct factors to increase the adoption of EVs as an alternative to conventional vehicles is therefore an important policy consideration in developing a framework to identify the most suitable combination of factors to increase the uptake of EVs in South Africa and other countries.

2.10 The hedging strategies of major oil producing companies to capture an emerging electrical vehicle market

A study concerning the transition from oil companies to energy companies has been performed on eight foremost oil producing companies, including Royal Dutch Shell, Chevron, BP, ExxonMobil, Total, Eni, Petrobras and Equinor, and the study concluded that the following five out of the eight companies commenced with substantial investments into renewable energy generation (Pickl, 2019:6):

1. Royal Dutch Shell;
2. BP;
3. Equinor;
4. Total; and
5. Eni

Although the findings from this research did not list Chevron and ExxonMobil as companies that started with investments into renewable energy, it is noted by Collier (2019) that these two companies are well aware of the future revolution of the energy industry and have joined the Oil and Gas Climate Initiative (OGCI), which is an association of universal organisations that pledged to invest 1 billion dollars in new technologies to combat climate change.

EVs in all forms, as defined under section 2.1, are a direct competitor for ICEVs, which utilise fossil-based fuel sources for propulsion. Fossil-based fuels are currently the central business activity for major oil extracting companies. These companies are aware of the international trend concerning EVs and the future uptake of EVs. The investment plans of these five main oil companies regarding EVs include:

2.10.1 Royal Dutch Shell

Royal Dutch Shell has reconnoitred ways in which it can serve the growing uptake of EVs, and to grow electrification to be a significant part of their business, this includes expanding electrical charging infrastructure and to supply electricity from cleaner renewable sources including wind and solar power (Shell, 2016).

2.10.2 BP

BP's energy outlook report issued in 2017 indicated that the number of EVs on international roads will be in the region of 100 million by 2035 (BP, 2017:47). The same annual report dispensed in 2018 showcased amended figures and the new number of EVs around the world is estimated at 190 million by 2035, with an increase to 320 million by 2040 (BP, 2018:113). These estimations were converted into strategies and BP wants to support the growing demand for EVs by providing a convenient charging network and to grow on BP's already established 6 500 charging points throughout the United Kingdom (BP, 2019).

2.10.3 Equinor

Up to 50% of Equinor's revenues are produced from satisfying the energy requirements of the transport industry. Consequently, in 2016, Equinor invested in Chargepoint, which sells EV charging equipment in the Unites States of America, where they maintain a 70% market share and are now aiming to increase their presence to both Europe and Asia (Equinor, 2019).

2.10.4 Total

EV charging points are present at approximately 100 Total fuel service stations in Europe and Total's goal is to increase these types of fuel service stations to 300 in the forthcoming years as well as 1 000 fast-charging points on highways (Total, 2019). Total is committed to manufacturing super-fast-charging points with a prerequisite for the vehicle to reach a range of 100 kilometres with only a ten-minute charge (Total, 2019).

2.10.5 Eni

Eni and Toyota Motor Italia announced their combined efforts on a project to increase the use of hydrogen mobility; the first stage of the project will be to build a hydrogen refuelling point at the new refuelling station of Eni located in Milan, and Eni will include additional hydrogen refuelling stations to more locations, should this project be successful (Eni, 2019).

Investments in renewable energy might not only include solar- and wind-based generation, but may also lead to the improvement and cost-reduction of batteries that can

preserve the electricity produced and then disperse the energy when there is a lack of wind and solar rays; this will benefit EVs as the batteries in a normal EV can amount to 20 000 dollars (Steffy, 2017).

The investments into various EV supporting networks, for instance the increased footprint of battery-recharging outlets at service stations by these oil companies and improvements made in battery technology, are further testament to the feasible future of EV around the globe.

It was argued by Fester (2019) that South Africa is still lagging behind other countries concerning EV adoption rates, but progress has been made by OEMs to introduce new EV in the country, coupled with disposable income reductions of customers and continuous fuel price increases that offer a convincing case for refuelling stations to invest in battery recharging infrastructure.

2.11 The adoption and rejection of innovativeness by customers

Greg Satell defines innovation as either the creation of something brand new and different or the utilisation of existing technology in a new manner (Satell, 2017:15). This is confirmed by Fruehauf *et al*. (2017:638), who performed a study and found that innovation is either the improvement or amendment to tangible products and processes.

According to Christensen *et al*. (2015), innovation is either defined as a disruptive innovation or a sustaining innovation, disruptive innovation originates in either a low-end or completely new market, whereby the low-end market is normally customers overlooked by established organisations, and sustaining innovation is where existing products are made better in the eyes of the incumbent's customers.

EVs can be classified as innovation, if Greg Satell's definition of innovation is applied to EVs, for example HEVs, PHEVs and FCEV are brand-new vehicle drivetrains that were developed and BEVs were already developed in the late 1880s (Section 1.1 History of EVs); however, the succeeding few years saw the increased improvement of BEVs.

Lithium-ion batteries, which propel EV powertrains, were initially discovered in 1979. By the early 1990s, these batteries had undergone sustaining innovation and, since then,

the energy capabilities of these batteries have increased by a factor of six and the cost reduced by a factor of ten (Satell, 2017:51). This is supported by Aggeri *et al*. (2009:124) and Carlucci *et al*. (2018:2), who maintained that EVs attract a broad range of innovativeness, starting firstly at the actual development of EVs to the emergence of new business concepts and the creation of new marketing strategies.

One can also argue that EVs are only sustaining innovation if Christensen *et al*.'s (2015) definition is applied to EVs, whereby EVs are neither aimed at creating a new market nor are they currently aimed at the low-end market of vehicle consumers; these vehicles are only improvements to normal conventional vehicles. However, EVs are still classified as innovation.

The creation of new products and services requires significant investments from companies and therefore they need to understand if and why consumers will adopt their brand new products or services or improvements to existing products and services (Nel, 2018:1; Claudy *et al*., 2015:528). As mentioned before, EVs can be determined as innovation, and management team members and various stakeholders need to be aware of the factors that will influence the adoption or non-adoption of innovation as it will contribute to the success of EVs.

The most cited innovation adoption research models, with the aim to determine the why and how consumers adopt innovation, include (Hasan *et al*., 2019:63) (Table 1):

- Rogers' (1962) diffusion of innovation (DOI) model,
- Davis' (1989) technology acceptance model (TAM); and
- Ajzen's (1991) theory of planned behaviour model (TPB).

The table below indicates how well documented and academically cited the above-mentioned innovation adoption models are.

Table 3-3: Innovation adoption models and the number of research citations

Model	Total number of Google Scholar citations (as of 2015)
DOI	62 330
TPB	30 507
TAM	22 597

Source: Compiled by the researcher, data gathered from Hasan *et al*. (2019:63)

Although the three models have been developed many years ago, the table below is indicative of the relevance of these models today.

The DOI process was defined by Rogers (1983:5) as: “the process by which an innovation is communicated through certain channels over time among the members of a social system.” The technology acceptance model foresees that a consumer’s adoption of innovation depends on whether consumers feel that the use of the innovation will lead to consumer benefits and whether the innovation is perceived to be easy to use (Nel, 2018:9; Hasan *et al*., 2019:63). The theory of planned behaviour model is an extension of the theory of reasoned action, which suggests that the behaviours of customers are determined by their intentions and customers’ intentions are determined by the subjective customs (Hasan *et al*., 2019:63).

It was described by Nel (2018:9) that the perceived usefulness and ease of use of an innovation of the technology acceptance model, as defined by Davis (1989), can be compared to Rogers’ ‘relative advantage’ and ‘complexity’ of an innovation.

Diffusions of innovations are debatably the most commonly known work concerning the adoption of innovations and have been applied to consumer and organisational areas (Hasan *et al*., 2019:63). Rogers (1983) identified five characteristics that influence the adoption of innovation, which is summarised in the table below:

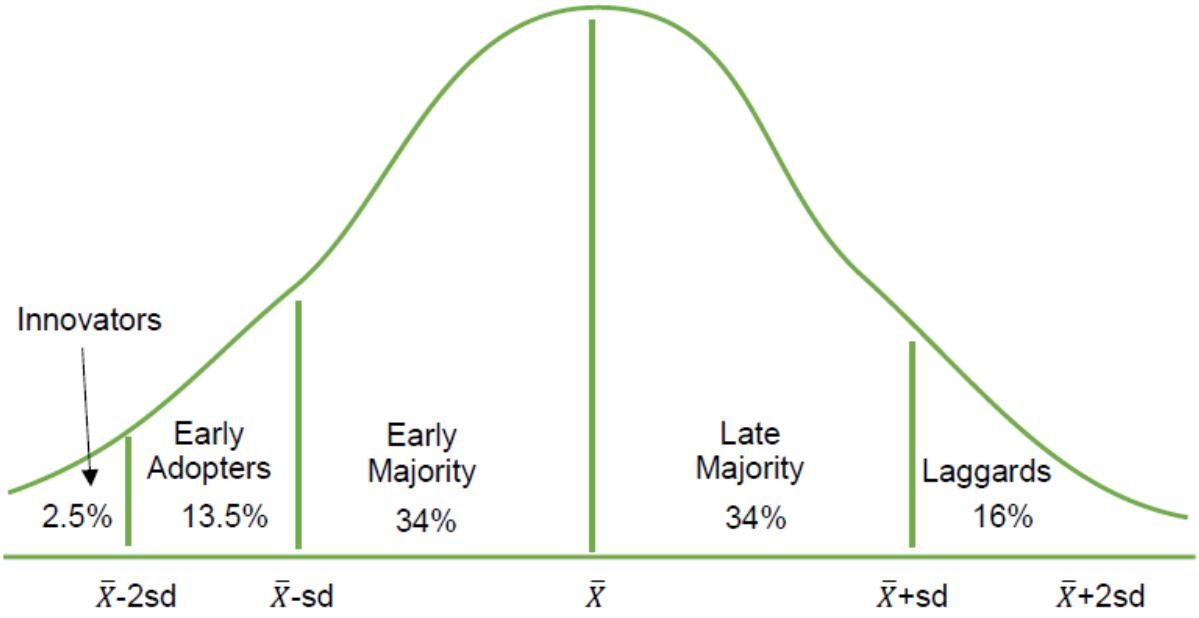
Table 4-4: Five characteristics influencing the adoption of innovation

Factor	Description
(1.) Relative advantage	The level to where the innovation is observed as superior than the idea/product or service it replaces.
(2.) Compatibility	The degree to which the innovation is received as consistent with the necessities of prospective adopters.
(3.) Complexity	The extent to which a new innovation is seen as challenging, demanding and difficult to understand and to use, which negatively affects the adoption of the innovation.
(4.) Trailability	Whether or not the innovation may be experimented with on a limited basis, innovations that are triable are perceived as less uncertain for adopters, which results in an increased adoption of the innovation.
(5.) Observability	The magnitude of whether the results of an innovation is visible for observation to potential adopters, which will simplify the decision-making process of potential adopters.

Source: Compiled by the researcher, data gathered from Rogers (1983:213-232)

Innovations are adopted by different members in a social system and include innovators, early adopters, early majority, late majority and laggards, all of which are illustrated in the figure below, but it is also noteworthy to include that non-adoptive members in a social system are not included in this categorisation (Nel, 2018:9).

Figure 13-10: Categories of different adopters in a social system based on innovativeness



Source: Nel (2018:8)

The factors that contribute to consumers adopting innovations are important to organisations when developing a new product, as it will assist organisations to understand the adoption behaviour of consumers (Nel, 2018:1). It is likewise important for organisations to understand the different adopter categories as it can be used as a management tool to ensure an organisation can persuade different levels of consumers to adopt and utilise an organisation's products or services (O'Connell, 2018).

2.12 The importance of marketing strategies to promote innovativeness

The innovation-decision process was developed by Rogers (1983), who defined the process as when an individual receives knowledge of the innovation, to developing an opinion of the innovation, followed by a decision whether or not to adopt or reject the innovation, to implementing the innovation and finally confirming the decision to adopt or to reject the innovation (Rogers, 1983:163).

An individual's decision to adopt or reject an innovation is not a singular event, but a process that transpires over time and consists of a succession of actions (Rogers, 1983:163-164). The succession of actions is highlighted in the table below.

Table 5-5: The different stages when an individual decides to adopt or to reject and innovation

Innovation Decision Stage	Description
Knowledge	This stage occurs when an individual is made aware of the innovation's existence and receives some understanding of the innovation
Persuasion	This is the stage whereby an individual forms an attitude towards the innovation and the attitude is either in favour of the innovation or unfavourable towards the innovation
Decision	This stage transpires when an individual participates in activities that result in either deciding to adopt the innovation or deciding to reject the innovation
Implementation	This stage occurs when an individual commences to utilise an innovation
Confirmation	Reinforcement is sought after in this stage, for an innovation decision, which has already been made by the individual. A previous innovation decision can be reversed at this stage

Source: Compiled by the researcher, data gathered from Rogers 1983:164)

Innovations are crucial for organisations to achieve sustainable development, but the marketing strategies implemented to market an innovation are likewise important to ensure the diffusion of the innovation (Kharchuk *et al*., 2014:49). This is supported by

Kozlovskyi *et al*. (2019:42), who maintain that the development of a marketing strategy within the EV market is a key consideration to ensure innovative changes.

According to Kharchuk *et al.* (2014:51, 53-54), innovations require exceptional marketing strategies, with the objective to foresee the time of mass-market adoption of the innovation, perform market segmentation to identify the potential early adopters of the innovation, to overcome the known barriers of adopting the innovation, and to determine a way to commercialise the innovation.

According to Oliveira (2014), there are five steps to consider when developing a marketing strategy to promote EVs:

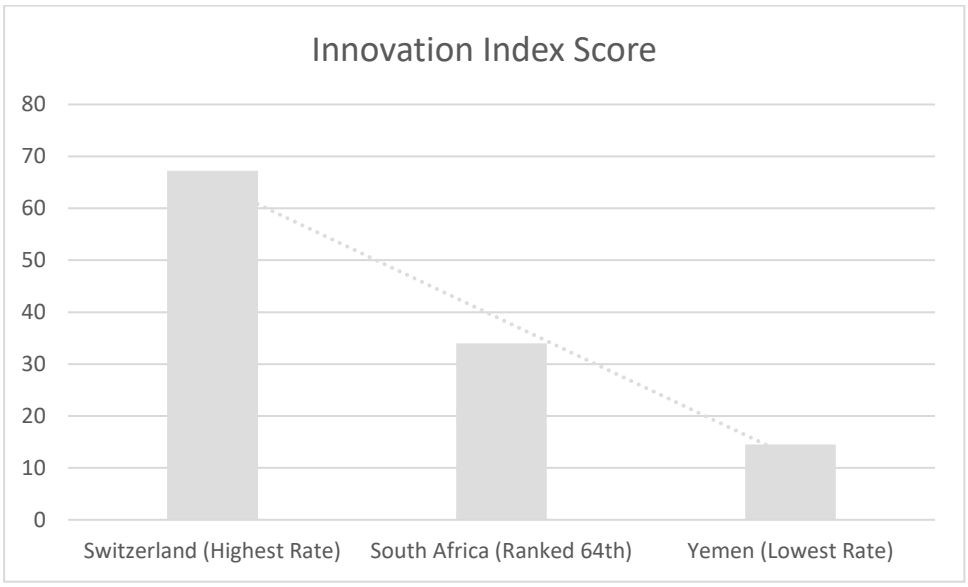
2 Customer communication: Explain the advantages of an EV to potential customers;
3 Avoid commercial pressure: Do not use traditional selling techniques to persuade potential customers; be innovative in the approach to convince customers to purchase an EV;
4 Utilise social media: Sales consultants should utilise social media to explain the product features and advantages of an EV by means of videos and images;
5 Employ novelty as a selling point: EVs are fresh, innovative and new, which should be used as a selling point to customers; and
6 Maintain an open mind: EVs are very different from what customers are used to, try to encourage customers to have an open mind-set.

2.13 Innovation index by country

The global innovation index includes two categories per country; the first category is an innovation input sub-index, which is based on five elements, including human capital and research, institutions, market sophistication, business sophistication and infrastructure, the second category is an innovation output sub-index, which is based on knowledge, technology outputs and creative outputs (The Global Economy.com, 2020).

A total of 129 countries were measured based on the criteria as mentioned above out of a total of a 100 with Switzerland achieving the highest score of 67.20 and Yemen attaining the lowest score with 14.50, South Africa ranked 64th with a score of 34.00 (Figure AB) (The Global Economy.com, 2020).

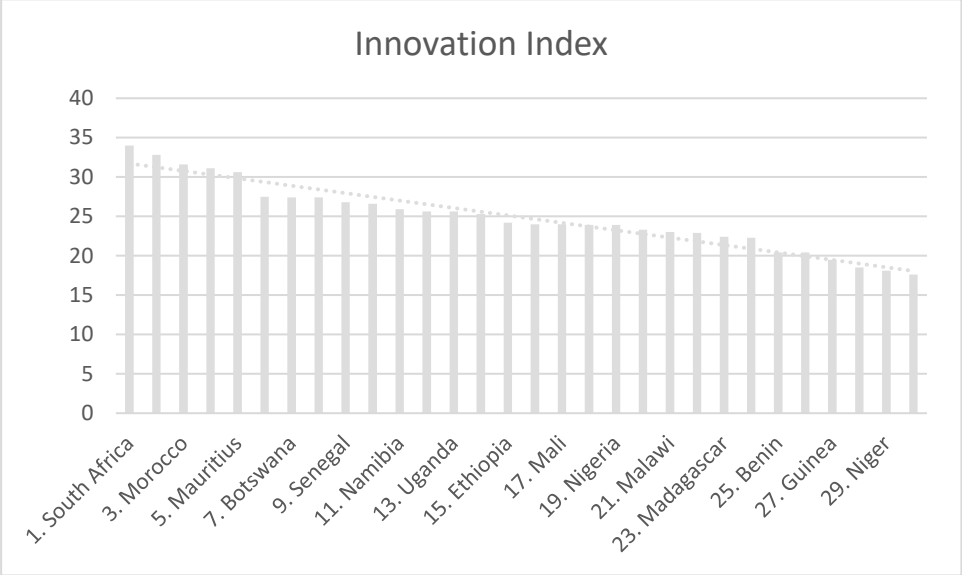
Figure 14-11: Innovation index scoring spread from Switzerland (highest score) to Yemen (lowest) and South Africa's position



Source: Compiled by the researcher, data gathered from The Global Economy.com (2020)

Although South Africa only achieved 64th place on the global rankings, they are the country placed 1st on the African continent concerning the Innovation Index (Figure AC) (The Global Economy.com, 2020).

Figure 15-12: Rating of African countries innovation index



Source: Compiled by the researcher, data gathered from The Global Economy.com (2020)

It is evident from the global innovation index ratings that South Africa needs to focus on improving the level of innovation in the country. It was reported by Burger (2017) that innovation has the ability to change the lives of millions of less-fortunate people, by enhancing the quality of products and services and there are profuse opportunities in South Africa to incorporate the country's academic superiority and innovation strengths into the broader economy.

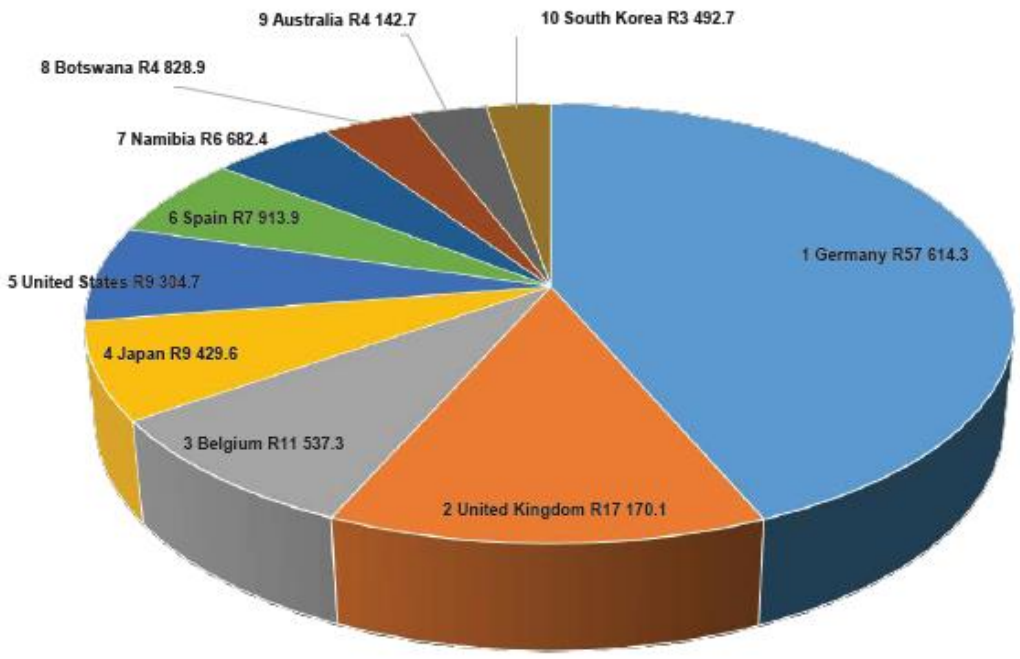
2.14 An overview of globalisation and the vehicle industry in South Africa

Foremost vehicle manufacturers are spread across the globe with their instantaneous distinguishable brands producing vehicles at an assortment of manufacturing plants located on several continents (AIEC, 2018:11). The automotive industry is a leading example of globalisation as national governments are aware of the profuse economic advantages of vehicle manufacturing concerning vehicle production plants, which led to increased competition between governments to obtain new manufacturing facilities from major OEMs; this led to the increased global footprint of major vehicle manufacturers in the preceding decade (AIEC, 2018:11). Programmes implemented by the South African

government established South Africa as a noteworthy vehicle exporter and part of the global automotive supply chain (TSAM, 2016:7).

South Africa produced 601 178 vehicles in 2017 and ranked 22nd in the global vehicle production ranking, with a global market share of 0.62% (AIEC, 2018:11). In 2017, a combined total of 338 093 vehicles were exported from South Africa to 110 countries around the world (AIEC, 2018:60). The same year saw the importation of 294 616 vehicles from 25 different countries (AIEC, 2018:88). Europe remained the most important trading partner for the South African vehicle industry, equating for R105.2 billion or 58.8% of total automotive exports in 2018 (AIEC, 2019:42). The figure below indicates the top ten export destinations of South Africa's automotive industry for 2018.

Figure 16-13: South Africa's top ten countries regarding automotive exports ('000)



Source: AIEC (2019:64)

The market leaders in the EV evolution are furthermore operating in a manufacturing capacity in South Africa. The OEMs present in South Africa manufacturers vehicles not

only for local customers, but also to satisfy the demands of numerous international markets. The manufacturing and assembly environment of major vehicle manufacturers in South Africa include:

2.14.1 Toyota South African Motors

Toyota South Africa manufactures the following five Toyota vehicle models at their plant located in Prospection, Durban, KwaZulu-Natal, South Africa; Hilux, Fortuner, Ses'fikile, Corolla and Corolla Quest, these vehicles are manufactured from individual components entirely on-site, better known as complete knock down (CKD) vehicles (TSAM, 2016:8). Four Hino model ranges are furthermore assembled at the same plant, and these models include the Hino 300, 500 and 700-series models. These vehicles are constructed from partially assembled vehicle kits, more commonly known as semi-knock-down (SKD) vehicles (TSAM, 2016:8). The vehicles manufactured in South Africa are utilised to satisfy the local South African market and the exportation to 72 countries throughout Europe, Africa and Latin America (TSAM, 2016:9).

Toyota South Africa Motors (TSAM) is also planning to produce another passenger vehicle as reported by Droppa (2020), whereby the vehicle manufacturer pledged an investment in excess of R4 billion to produce a vehicle with Toyota's hybrid synergy drive vehicle powertrain, which is a first on the African continent. This vehicle will replace the Corolla model.

2.14.2 BMW Group

The BMW group plant operating in Rosslyn, Pretoria, Gauteng, South Africa evolved from assembling CKD vehicles for the local South African market, with restricted customisation opportunities, to a world-renowned plant capable of manufacturing customised vehicles for discerning customers around the globe. (BMW Group, 2019)

"This evolution is largely due to BMW's billion rand investment in the Rosslyn plant in the mid 90's. The investment, used to upgrade the production facility into one of the most modern in the world, brought Rosslyn in line with other BMW group plants across the world and earned the title of BMW Group Plant Rosslyn" (BMW Group, 2019). The BMW group plant in Rosslyn is producing the sixth generation of the 3 series and more than 85% of the 3 series vehicles produced in Rosslyn are destined for BMW markets in the

United States of America, New Zealand, Hong Kong, Australia and Canada (BMW Group, 2019)

2.14.3 Mercedes-Benz

The Mercedes-Benz manufacturing plant located in East London, Eastern Cape, South Africa received an investment of 600 million euro to expand the current capabilities of the plant and to build the new generation of C-Class Mercedes-Benz vehicles (Daimler, 2018). The C-Class vehicles produced in East London are destined for the left-hand drive and right-hand drive export markets, and this specific plant has been producing the fourth generation of C-Class sedans since May 2014 and the plant has been producing a PHEV model since 2016 (Daimler, 2018).

2.14.4 Ford Motor Company

R3 billion were invested in South African operations in 2011 to cater for the introduction of the new Ford Ranger models for the South African market and exports to virtually 150 markets in Europe, Africa and the Middle East, which equated to an additional investment of R3 billion in 2017 to increase production capabilities to satisfy the worldwide demand for rangers (Ford Motor Company, 2018a).

“This reaffirms our role as an integral part of Ford’s global manufacturing network with world-class operations at the Silverton assembly plant in Pretoria, and at the struandale engine plant in Port Elizabeth which produces the duratorq TDCi engines for the ranger” (Ford Motor Company, 2018b).

2.14.5 Volkswagen South Africa

The Volkswagen plant located in Uitenhage, Eastern Cape, South Africa manufactures the Polo and Cross Polo models. In 2016, the plant produced a total of 123 854 vehicles and 122 222 engines, of which 69 192 vehicles were exported (Volkswagen Group South Africa, 2019).

2.14.6 Nissan South Africa

It was reported by Venter (2019) that Nissan South Africa will invest R3 billion to increase the capabilities of their plant located in South Africa to not only produce the NP 200 and

NP 300 hardbody, but also to produce an estimate of 30 000 Nissan Navara units, of which 12 000 will be exported to the sub-Saharan African market.

2.14.7 Isuzu Motors South Africa

Isuzu Motors Limited of Japan confirmed an investment of R1.2 billion to manufacture the next generation Isuzu D-MAX pickup destined for the local and sub-Saharan African market. This generation of D-MAX will be the seventh generation produced in South Africa (Isuzu South Africa, 2020).

The table below provided a summarised view of the different passenger- and light commercial vehicles produced in South Africa by the different OEMs operating in the country.

Table 6-6: Different vehicle models produced by vehicle manufacturers in South Africa

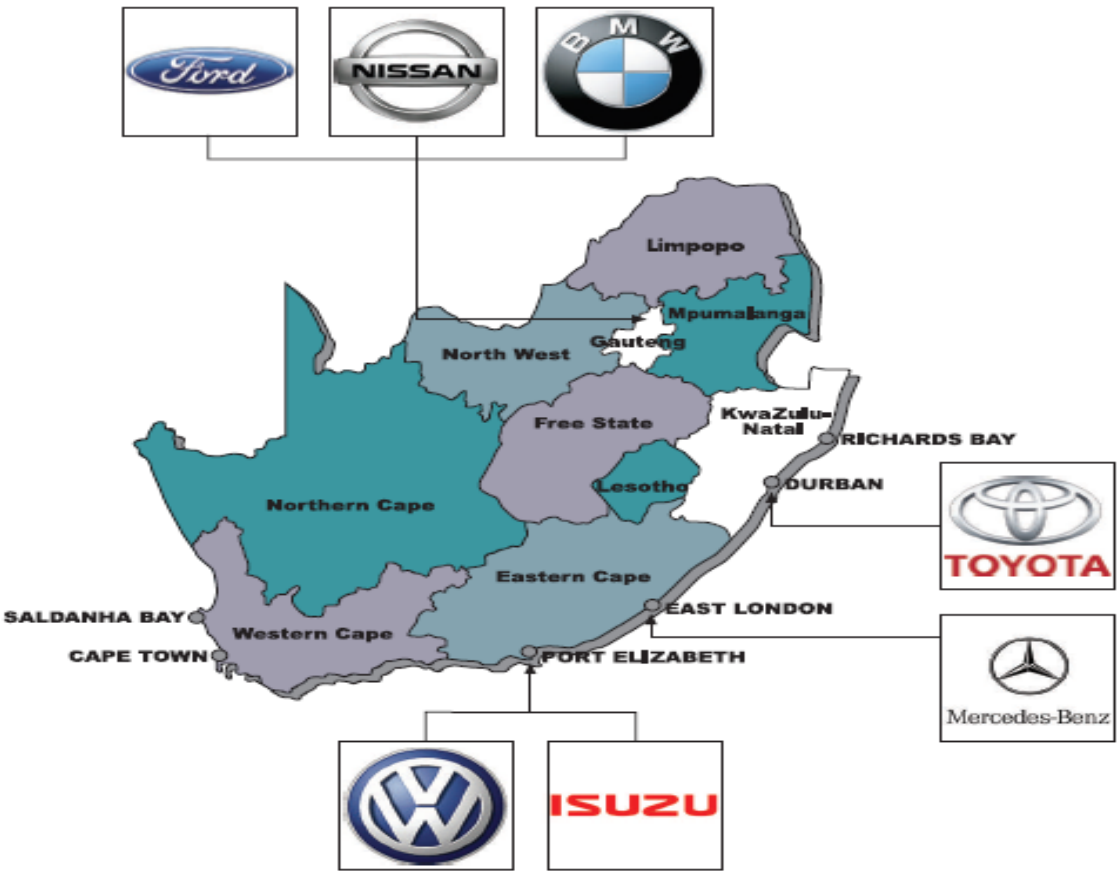
Original equipment manufacturer	Passenger vehicles	Light commercial vehicles
BMW	3-series, 4-door and the X3, manufactured from 2018	-
Ford	Everest	Ranger
Isuzu Motors	-	KB and D-Max
Mercedes-Benz	C-Class, 4-door	-
Nissan	-	NP200 and NP300 Hardbody
Toyota	Corolla, 4-door and Fortuner	Hilux and Quantum

Volkswagen	Polo	-

Source: Compiled by the researcher, data gathered from AIEC (2019:15)

The OEMs manufacturing these passenger and light commercial vehicles are spread across South Africa. The figure below indicates the provincial manufacturing presence of these OEMs.

Figure 17-14: Automotive manufacturing presence in South Africa



Source: AIEC (2019:25)

The automotive industry is not only important for South Africa, but also contributes to economic development of the provinces within which these OEMs are operating.

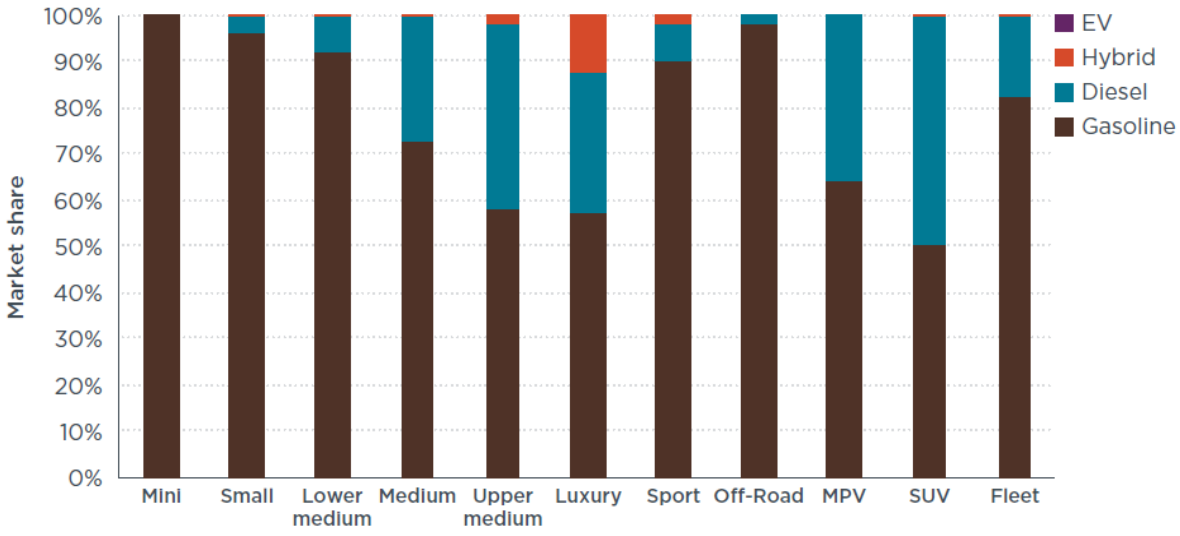
2.15 Oil refineries landscape in South Africa (current supporting infrastructure to ICEVs)

A study performed by Ahjum *et al.* (2018:39) concluded that ICEVs dominate the South African market. A more recent study concluded that currently, South African customers prefer vehicles powered by gasoline engines, followed by vehicles propelled by diesel engines (Posada, 2018:5).

The total number of new passenger and light commercial vehicles amounted to 524 691 in 2018, the number of diesel vehicles sold, including passenger and light commercial vehicles equated to 188 284, representing 35.88%, the number of petrol passenger and light commercial vehicles sold amounted to 336 286, representing 64.09% of the passenger and light commercial vehicle market (AIEC, 2019:16).

The figure below represents the fuel type distribution by vehicle segment in South Africa.

Figure 18-15: Fuel type distribution by vehicle segment



Source: Posada (2018:5)

Gasoline- and diesel-powered vehicles are dominating the South African vehicle landscape, as evident from the figure above. Petrol and diesel are also the liquid fuels that are consumed the most by South African customers, and South Africa is the largest consumer of petrol on the African continent, consuming approximately 11.7 billion litres

of fuel per annum (SAPIA, 2020; Thompson, 2019). It was reported by Page (2018) on an announcement made by Volkswagen's technical head, Frank Welsch, that the carmaker will continue to produce ICEVs post-2026 and the demand towards petrol- and diesel-powered vehicles will probably continue in developing countries with a lack of battery recharging infrastructure.

The Automobile Association (AA) has furthermore pointed out that there has not been a proposition from the South African government to prohibit the sale of ICEVs (Business Tech, 2017). It was also reported by Oberholzer (2019) that although EVs might be the future, it does not appear that these vehicles will be a realisable possibility in South Africa's immediate future due to the non-existence of a battery recharging infrastructure, the inconsistent- and problematic electricity supply and the price of EVs.

To summarise, the South African new vehicle market is currently dominated by ICEVs using petrol and diesel as fuel source and the same level of domination can be expected in the future if the announcement by Frank Welsch is taken into account. It can therefore be argued that it is important to analyse and understand the current supporting environment and infrastructure available to ICEVs within a South African context. The aim of the succeeding information will be to sketch the current environment concerning the petrol- and diesel fuel landscape in South Africa and the underlying problems of this landscape.

The global oil industry is divided into two categories, namely upstream and downstream activities; upstream activities include all participants involved with the production of oil, and downstream activities are participants who refine crude oil. South Africa has no oil reserves and partake in the refining of oil, imported from other countries (SAPIA, 2020).

There are six established refineries in South Africa, which are *Chevref, Enref, Natref, Sapref, Sasol Secunda* and *PetroSA.* The first four refineries are known as crude oil refineries, with the preceding two being synthetic refineries whereby coal is refined to liquid fuels (Sasol Secunda) and natural gas is cultivated to liquid fuels (PetroSA) (SAPIA, 2020). The refined oil is distributed to approximately 4 600 retail petrol- and diesel refuelling stations throughout South Africa (SAPIA, 2020). However, the refined fuel for ICEVs in South Africa is, however, not up to international standards, as prescribed below.

Modern vehicle engines require Clean Fuels 2 stipulations to increase efficiency and reduce greenhouse gas emissions from vehicles; however, South African refineries are not equipped to produce these fuels and an estimated R40 billion are required to meet the Clean Fuels 2 specifications (SAPIA, 2018:4, 6). It was maintained by Droppa (2017) that the euro 2 quality fuel produced in South Africa is not only dirty, but requires the adaption of new vehicle engine technology to enable them to operate on this sub-par fuel source, as adjustments to engine management systems, exhaust systems and drivetrains are required.

It was described by Stead and Moldan (2009:1) that South Africa is far behind first-world countries such as the USA and Europe who are implementing more rigorous fuel quality standards. A more recent study performed by Brown (2016) indicated that South African oil refineries are only producing fuel up to Euro 2 standards and are facing the threat of cleaner, Euro 5 standard, fuel imports, which will arguably result in a reduction in demand for local less-clean fuel and shrinking profits. This is supported by Bhowan (2019), who reported on a statement by Christopher Judd, the service engineering leader of Cummins, who maintained that Canada, the USA and Europe are already supporting Euro 6 emission standard engines, but South Africa neither has the legislation nor the fuel quality to support these stringent emission regulations.

Not only is the air quality compromised by the locally produced fuel, but the disposable income of South African customers is negatively affected, as the importation of new vehicle engine technology into South African might be denied by vehicle OEMs, or alternatively customers will have to pay for the vehicle adjustments, as mentioned above (Droppa, 2017). It was indicated by Mahotas (2019:13) that South African oil refineries are reluctant to invest in refinery upgrades as there are no guarantees that their investments will be recovered as a whole and the refineries are proposing an additional fuel levy on top of the fuel prices to recover their investments, which will also diminish the disposable income of customers.

Droppa (2017) further reported that South Africa exports vehicles to numerous developed countries and to manufacture vehicles for these first-world markets as well as vehicles for the domestic market characterised by low technology vehicles operating on Euro 2 quality fuels are not only inefficient, but negatively affect the global competiveness of South Africa’s vehicle manufacturing sector.

Abraham (2018) maintained that the increased utilisation of cleaner energy, including solar- and wind power, is a step in the right direction to reduce global warming; however, in the meanwhile, the need for liquid fuels still persists and decisions regarding the most environmentally friendly fuels need to be made. This statement is also true for South Africa, concerning the demand for ICEVs and evidently the liquid fuels powering these vehicles, as witnessed above. However, as evident from the above, investments in local oil refineries and improvements in the quality of local fuel are required not only to reduce carbon emissions, but also for the local automotive industry to remain internationally competitive and to avoid the cost escalation of adapting new engine vehicle technology onto South Africa customers.

Therefore, it was argued underneath the problem statement of this research study that the South African automotive industry is crucial for the economy of the country in the form of vehicle exports and GDP contributions. However, as evident from the preceding information, the lack of development in local oil refineries might be counterproductive for the development of the South African economy as higher quality fuels might be imported as a substitute for domestic, lower-quality fuel, resulting in a reduction of GDP. Furthermore, the disposable income of South African consumers might be reduced if the investment cost of new refineries is transferred to local customers, which may result in less domestic spending by South African residents, resulting in lower economic growth.

2.16 Carbon taxation on internal combustion engine vehicles

It can be argued that it is important to understand the different taxations imposed on new vehicles sold in South Africa, as it increases the cost of new vehicles. It was reported by Brothwell (2020) on an announcement made by NAAMSA that carbon taxation increases and the lowering of the carbon emission thresholds on passenger vehicles increases the prices of new vehicles throughout a continued market decline.

Carbon taxation is only imposed on ICEVs in South Africa and not on EVs sold in the country. It is an essential consideration as carbon taxation may encourage customers to consider alternative vehicles to ICEVs, and an alternative is EVs.

Carbon taxation is defined as a policy to impose a fee to decrease and even eliminate the utilization of fossil fuels including coal, oil and gas who’s burning therefore is disrupting and abolishing the global climate (Carbon Tax Centre, 2019). The South

African Revenue Service (SARS) defines carbon tax as a new taxation in response to climate change, which is designed to decrease greenhouse gas emissions in a cost effective and sustainable fashion (SARS, 2019).

Van Heerden *et al*. (2016:715) argued that South Africa needs to successfully manage the trade-offs between transitioning to a low-carbon economy and poverty reduction, developing job opportunities and creating inclusive growth, and one approach is to progressively implement carbon tax into the South African economy. Progressively implementing the carbon tax was the approach followed by the South African government, as reported by Duncan (2019), when the South African carbon taxation was accepted in parliament on 19 February 2019. The first stage of implementation will range from June 2019 to December 2021, increasing at 2% above the consumer price index (CPI). The introduction of carbon taxation on liquid fuels will increase the petrol price by 9 cents per litre and diesel by 10 cents per litre (Gous, 2019; Persens 2019).

According to Oxford (2019), the introduction of the carbon taxation is a step in the right direction, if South Africa is committed to the goals set out by the Paris agreement to reduce greenhouse gas emissions. However, contrastingly, it was reported by Omarjee (2019), on a proclamation made by the Organization Undoing Tax Abuse (OUTA), that carbon taxation is disingenuous as there is no evidence linking behavioural changes as a result of carbon taxation. In the proclamation, OUTA utilised the example that plastic bag taxation did not reduce pollution in South Africa.

It was reported by Cokayne (2019) on a statement made by the President and chief executive officer of Toyota South African Motors (TSAM), Andrew Kirby, that the total price of a new vehicle includes taxes of up to 42% for prices of vehicles ranging between R200 000 and R900 000, and carbon taxation is included in this aggregated taxation amount. However, Gosling (2019) reported on a statement made by Harhald Winkler and Andrew Marquard of the University of Cape Town's energy research centre, who argued that the carbon taxation in South Africa is too low to reduce carbon emissions to the scale required. This statement is supported by Oxford (2019) who reported on an announcement made by Kevin James, who is the chief executive officer and founder of a sustainability-consulting firm called GCX, that the carbon taxation imposed in South Africa is too low.

There are two possible scenarios concerning carbon taxation in South Africa. According to Mileham (2019), carbon taxation will not reduce emissions, but rather cost jobs and increase the cost of living, or the carbon tax will decrease emissions, but likewise reduce economic behaviour also resulting in job losses and an increase in the cost of living.

A study performed in 2015 indicated that 92% of people living in Switzerland rejected the taxation on fossil-fuel-based energy sources and a study performed in Washington in 2016 and 2018 indicated that voters in this state are against carbon tax (Carattini *et al*., 2019). The same sentiment is experienced in South Africa, as reported by Omarjee (2019) on an announcement made by the Automobile Association (AA), that it is unfair for South Africans to pay carbon taxation on substandard fuel quality, without access to more sophisticated fuel quality, which is available in numerous other countries around the globe.

Therefore, it can be argued that carbon taxation is further reducing the disposable income of South African customers. The prices of new vehicles are highly inflated with taxes, of which carbon taxations are part of, if the statement of Andrew Kirby is taken into account. Local spending is affected as a result of lower disposable income available to South African customers, which contributes to a shrinking economy.

2.17 Literature study conclusion

Per conclusion, the global automotive industry is experiencing change, and one major change is the investment of major OEMs in the development of EVs. This is due to the customer preferences changing and pressures from national governments regarding global warming. This development and push towards EVs will undoubtedly have an impact on South Africa. Firstly, on South African vehicle exports, as mentioned before under Figure 2, the top five export destinations for South African automotive products include Germany, the United Kingdom, Belgium, Japan and the United States of America.

Two of the three leading countries in the world concerning EV sales are Europe and the United States of America; the top three export countries of South Africa are all European countries and the United States of America is the fifth largest export destinations for South African-built vehicles. As mentioned under the introduction of this study, the United Kingdom, in conjunction with France, also indicated that petrol and diesel vehicles will be barred by 2040, which is only 20 years away.

The literature study acknowledged the importance of the South African automotive industry, with locally produced vehicles being exported to a vast number of countries located all over the globe. Automotive products exported from South Africa equated to R178.8 billion, accumulating 14.3% of the total value of South African exports, contributing 6.8% to South Africa's gross domestic product (GDP) (AIEC, 2019:5). It is consequently imperative for South Africa to produce globally demanded vehicles. The study highlighted the increase in global EV sales and the foremost vehicle manufacturers' development plans to produce EVs, which is an indication that the future of mobility might arguably be driven by electrical powertrains.

The interaction between South Africa and the current market leaders in the EV evolution will arguably result in a similar movement trend from ICEVs to EVs being witnessed in South Africa in the not so distant future concerning a shift in vehicle production from predominantly producing ICEVs to manufacturing EVs. Primarily because, as stated under the research problem of this study, vehicle manufacturers operating in South Africa would not want to lose exporting locally produced vehicles.

The second consideration that cannot be ignored is the type of vehicles that will be driven by the local South African market. It was mentioned that the economies of scale are of the utmost importance to the South African vehicle industry, which is achieved by the exporting of vehicles, and this scale will debatably only be maintained if the major OEMs are focusing on one type of vehicle. The possibility of additional, locally produced EVs being offered to local South African customers is arguable real; contrastingly, conventional ICEVs would need to be imported if the South African market conditions and infrastructure only support ICEVs and not EVs. However, the majority of new vehicles being sold in South Africa are locally produced, as there were 524 691 new passenger and light commercial vehicles (LCVs) sold in 2018, whereby South Africa produced 610 854 vehicles and only 291 402 passenger and LCVs were imported to South Africa.

One of the factors identified through the DOI process, which will lead to customers adopting innovation, is the relative advantage that customers will experience. Similarly, the TAM identified that a high perceived usefulness would lead to customers accepting the technology. Light commercial vehicles (LCVs) are South Africa's most popular sold vehicles with the Toyota Hilux leading the way with 40 022 units sold, followed by the Ford Ranger with 30 135 units sold in 2018 (AIEC, 2019:15). This is an indication that

South African customers arguably view LCVs as rather useful and advantageous and it is unlikely that customers will substitute conventional LCVs with passenger EVs. An electrical LCV should debatably be available and marketed to this market segment, if vehicle manufactures want to enjoy a high market share of EVs.

The carbon taxation environment in South Africa was described, which could lead to a contributing adoption factor of EVs for consumers if these costs escalate and increase the cost of ICEVs. The current oil refinery situation in South Africa was defined together with the difficulties surrounding the fuel industry in South Africa, which can likewise result in consumers deciding to purchase EVs instead of the conventional ICEVs. The carbon taxation and oil refinery landscape can in fact likewise lead to customers continuing to adopt ICEVs, if the South African government decides to either assist the local oil refinery industry with investments to enable this industry to produce quality fuel or reduce, or eliminate the carbon taxations on ICEVs to reduce the pressures felt by local consumers.

Non-renewable energy sources, including oil, coal and natural gas are only available in limited quantities and can be depleted; these energy sources are also found in specific areas of the world and are not widely available (Shinn, 2018). Therefore, oil utilised by ICEVs will be depleted in the future and it was reported by Slav (2019) on an estimation made by BP, that the world has only 1.7297 trillion barrels of crude oil in reserves and these reserves will only last for another 50 years.

Although 50 years is long into the future, the depleting availability of oil reserves around the world will act as a positive adoption factor for customers to choose an EV over an ICEV.

It was noted that appropriate marketing strategies to assist with the DOI are important to ensure customers adopt innovations. Therefore, OEMs need give a great deal of thought when developing marketing strategies that will be appealing, firstly to early adopters of EVs as well as the succeeding customer segments to convince them to purchase EVs instead of ICEVs.

The literature review identified that a battery-recharging network is crucial for the increased uptake of EVs, and a sufficient, uninterrupted electricity supply to these stations is critical. The study also found that government taxation incentives led to an increased uptake of EVs by customers, as it reduces the cost price of EVs. The current debt liability

of South Africa is more than 50% of our GDP (Mutize, 2017). Therefore, taxation incentives need to be reviewed within a South African context to determine whether the South African government has disposable funds available to assist customers to purchase EVs rather than ICEVs.

Determining the factors that will increase the adoption of EVs in South Africa is important, but it is likewise important to perform a country analysis to determine the strengths and weaknesses of a country, which will either encourage or discourage international investors to invest in a country.

PESTLE analysis is defined by Frue (2016) as a strategic planning technique examining the political, economic, social, technological, legal and environmental factors, which will result in advantages for organisations concerning new product ideas, development, launching and marketing of the products to ensure success. Furthermore, PESTLE analysis can be used as an investigative tool to identify external factors and to determine the potential impacts; it can likewise be utilised as a method for forecasting, presenting and report writing (Tan *et al*., 2012:1).

The table below highlights a summarised view of a PESTLE analysis performed on South Africa concerning current challenges and future risks concerning each factor of the PESTLE analysis.

Table 7-7: PESTLE analysis of South Africa

Factor	Current Challenges	Future Risks
Political	High levels of government corruption and high levels of crime	Failing confidence in the South African government, both locally and internationally
Economical	Policy uncertainty and low economic growth	Investment rating downgrade and increased public debt
Social	Failing public educational system	High levels of poverty and income inequality

Technological	Reduced research and development spending	Less patents being registered
Legal	Market regulation, red tape and bureaucracy	Biased foreign investment policy
Environment	Neglect of the environment, for example, acid main drainage	Wildlife poaching

Source: Compiled by the researcher, data gathered from (Market Line, 2016)

The South African automotive industry is privileged to not only be dependent on domestic vehicle sales, but the industry can also place vast reliance on vehicle exports; however, government interference and trade union strikes might harm the vehicle industry and be an obstacle for future growth (Janse van Rensburg, 2020).

Universally, there is an interdependent relationship between governments and the automotive industry, whereby the automotive industry is dependent on government incentives, which, in turn, contributes to economic development (Deloitte, 2019). It is consequently important for the South African government to establish an investment friendly landscape within South Africa to ensure the country firstly remains a vehicle-producing hub for international markets; and secondly, it is likewise imperative to identify the possible factors that might have an impact on the adoption of EVs in South Africa, as it will not only benefit local vehicle customers, by continuing to purchase locally-produced vehicles in South Africa, but also the local vehicle industry and South Africa as a whole concerning the exporting of vehicles produced locally.

CHAPTER 3 DATA GATHERING AND DATA ANALYSIS

3.1 Introduction

The purpose of this chapter is to provide information regarding the method employed to select different respondents who contributed to this study with meaningful data to enable the researcher to answer the primary- and secondary research questions. A detailed discussion pertaining to the sampling for this research study will likewise be included in this chapter as well as a discussion concerning the ethical considerations of this study and the utilisation of qualitative data-analysis software.

Two sources of data were gathered for this research study. Firstly, primary data was attained by means of semi-structured interviews. Furthermore, secondary data was likewise utilised, as specific information, which will be discussed further in this chapter, could not be acquired through conventional primary data collection procedures. Recognition was given to all sources used as secondary data.

1.7 3.2 Ethical considerations

The NWU consent form was utilised for all semi-structured interviews performed to gather primary data. The form included the following information for the perusal of the participants:

- The permitted title of this research study.
- The researcher's name, surname and contact details, which included the researcher's cell phone number and email address.
- A short, but informative explanation of the purpose of this research study.
- An explanation pertaining to the research method followed, and that the views and opinions of the participants would be gathered by performing semi-structured interviews, by posing open-ended questions to the participants.
- A notification that the researcher might ask basic information of the participants, including, for example, the name, surname and academic qualifications of the participants.
- The maximum time for the interview will not surpass two hours.

- A notification that participation in this research is on a voluntary basis and should the participants want, they are allowed to end their participation in the research study immediately.
- Assurance that the data gathered for this research will remain confidential and anonymity will be guaranteed when statements are quoted in this research study and the data gathered will only be utilised for research purposes.
- A notification that participants are permitted to request a summarised copy of the final mini-dissertation.

A copy of the ethical clearance form, which indicates that this research study has been approved, was attached to the informed consent form, distributed to all participants. The ethical clearance form is also attached as Annexure A to this research study.

Participants who gave their approval to contribute to this research study were requested by the researcher to provide their name, surname, date of the interview and to sign the consent form.

3.3 Main sampling strategy

A stratified sampling strategy was the main strategy employed in this research study. The main objective for this stratified strategy was to obtain data from respondents representing the full spectrum of the automotive industry. The automotive industry was therefore stratified into two main categories, including the *retail side of the automotive industry* (South African vehicle customers) and the *supply side of the automotive industry* (manufacturing of vehicles). The supply side of the automotive industry was stratified even further into an international vehicle supply perspective and into a local vehicle supply perspective due to globalisation of the global automotive industry and manufacturing of vehicles not only for domestic markets, but also for international markets.

The researcher deemed this sample strategy as important to possibly determine the relationship between factors originating from the supply side of the automotive industry as well as from the *retail side of the automotive industry*.

3.3.1 Sampling strategy and method employed pertaining to primary data collected

Semi-structured interviews were conducted with individuals representing the South African *retail side* of the sample stratosphere.

Convenience sampling was used to interview respondents, representing the local *retail side of* the local automotive industry. Sampling continued until saturation was achieved. According to Bryman *et al.* (2014:178), convenience sampling can be utilised by the researcher if the respondents are easily accessible to the researcher and although representation difficulties are associated with convenience sampling, Bryman et al. (2014) maintained that convenience sampling should not be excluded from research, especially if an opportunity presents itself to obtain meaningful data. All of the respondents are vehicle owners in South Africa and this was the only prerequisite to form part of the target sample; the reason for this prerequisite is that these respondents have experienced the process of purchasing a vehicle as well as driving a vehicle and personal preferences regarding vehicles have been established.

It was difficult to recruit enough willing participants with sufficient knowledge of the electrical vehicle industry from the *local supply side* of the automotive industry especially with restrictions that were in place due to the Covid-19 pandemic. Purposive sampling was employed and finally two respondents were willing to form part of the sample pertaining to the *local supply side* of the automotive industry. Purposive sampling is defined by Bryman *et al.* (2014:186) as the process of sampling respondents in a strategic manner to ensure the chosen respondents are relevant to the research questions, and Bryman *et al.* (2014) maintained further that most sampling of respondents for qualitative research involves some form of purposive sampling. Semi-structured interviews were likewise utilised to obtain data from these purposefully selected individuals.

These respondents were selected due to their knowledge, expertise and experience in the South African automotive industry. Details of these two respondents are presented below:

Respondent 1: A male respondent with 30 years of experience in the South African automotive industry. The respondent has been with a leading South African association for the past 14 years, currently being the executive manager of this association. This

association represents the interests of the vehicle manufacturing industry in South Africa. The respondent has a master's degree and doctorate with a specific focus on the South African automotive industry.

Respondent 2: A male respondent who is the managing director of a division within one of the large, big four, international audit and advisory firms as well as the automotive industry leader within the same firm. The respondent has a master's- and PhD degree in international relations.

The respondents in the sample pertaining to the *retail side of the automotive industry* and the two purposefully selected respondents as described above, for the domestic supply side of the automotive industry, were all interviewed and the semi-structured interviews were audio-recorded, transcribed and coded, which will be utilised in the data analysis process.

According to Bryman *et al*. (2014:231), reviewing of recordings and transcripts ensures a comprehensive analysis of the interviewees' answers and this allows for the data gathered to be reused by other researchers.

3.3.2 Semi-structured interviews

Semi-structured interviews were performed to obtain primary data from the *retail side of* the South African automotive industry as well as a portion of the *local supply side* of the South African automotive industry. The preceding questions were posed to the interviewees representing the *retail side of* the South African automotive industry:

- ***Question 1:*** What vehicle are you currently driving and does your vehicle have a manual or automatic gearbox and is your vehicle powered by a petrol or diesel engine?
- ***Question 2:*** What is your understanding of electrical vehicles?
- ***Question 3:*** In your opinion, what is the future of electrical vehicles?
- ***Question 4****:* In your opinion what is the future of normal, conventional internal combustion engine vehicle?
- ***Question 5:*** What do you think is the future demand for electrical vehicles and internal combustion engine vehicles within a South African context?

- ***Question 6:*** South Africa obtains export credits for vehicles locally produced and exported, and currently approximately 70% of locally produced vehicles are exported. What do you think is the opportunity for South Africa to produce electrical vehicles in the future?
- ***Question 7:*** What assistance can the South African government provide for South African vehicle manufacturers to produce electrical vehicles?
- ***Question 8:*** In your opinion, what infrastructure is required to increase the adoption of electrical vehicles in South Africa?
- ***Question 9:*** What assistance can the South African government provide to increase the adoption of electrical vehicles in South Africa?
- ***Question 10:*** Let us assume South African customers demand electrical vehicles instead of conventional ICEVs; will it be the responsibility of the private sector or the South African government to develop the infrastructure to support electrical vehicles?
- ***Question 11:*** Will you consider purchasing an electrical vehicle in the future and personally, what factors will convince you to purchase an electrical vehicle instead of an internal combustion engine vehicle and lastly, what timeframe will you decide to purchase an electrical vehicle?
- ***Question 12:*** Would you prefer having a battery recharging point at your home and work place/office?
- ***Question 13:*** Would you consider sharing a battery recharging point with your neighbour, to keep the cost of an electrical vehicle down?

Identical questions were posed to the two purposefully selected respondents forming part of the *local supply side* sample of the South African Automotive industry, except for questions 1 and 2 and questions 11 to 13. The purpose of questions 11 to 13 is to determine the preferences of retail customers and does not concern the manufacturing of vehicles (supply side of the automotive industry). Questions 1 and 2 were replaced by a single question, posed to the two individuals, which is:

- ***Question 1:*** What is your experience in the automotive industry?

The basic structure of the interview schedule was kept unchanged for both strata of the population, the retail side and the local demand side of the automotive industry to enable the researcher to draw comparisons between the two strata.

3.3.3 Sampling strategy and method employed pertaining to secondary data collected

The collection of secondary data involved the exploitation of existing online interview recordings made with international chief executive officers of the foremost automotive companies in the world as well as domestic chief executive officers managing the South African operation of these major international automotive companies. Major automotive manufacturing companies' websites were also utilised to obtain company information regarding the supply of future vehicles. The information obtained from these recorded interviews and company websites represented the local, as well as the *international supply side* of the sample stratosphere.

The decision to utilise these pre-recorded interviews and company websites was due to the lack of personal accessibility of the researcher to international and local chief executive officers of automotive companies and to information pertaining to the future strategies involving the production of new-aged vehicles. The importance of the data obtained from these interviews and websites was deemed too valuable to not include in this research study.

Purposive sampling was again utilised to sample automotive companies pertaining to the *international supply side* of the automotive industry and was selected in accordance with South African automotive companies manufacturing vehicles in the country. For ease of reference, as mentioned under the literature review of the study, the automotive companies manufacturing vehicles in South Africa are Toyota South Africa Motors, Volkswagen South Africa, Nissan South Africa, BMW South Africa, Mercedes-Benz South Africa, Ford Company of Southern Africa and Isuzu Motors South Africa. Data was gathered pertaining to the future direction of the automotive industry and more specifically the future of EVs.

Secondary data in the form of online interviews and company websites was similarly gathered concerning the *local supply side* of the South African automotive industry. The data gathered from these interviews and company information led to the understanding

of the future of EVs in South Africa, the future production plans of the automotive companies operating in the country, and the future direction of South African automotive companies.

All of the online interviews were furthermore transcribed and coded, as were the case of the primary data, which will be utilised for data analysis.

3.4 Validity and reliability

3.4.1 Validity

According to Bryman *et al*. (2014:38), the concept of validity determines whether a measurement developed to determine a notion, actually determines the notion of a research study.

Leung (2015:325) maintained that a series of questions could be posed to determine validity and if the answers to these questions form a comprehensible unit, then the researcher may be comfortable pertaining to the validity of the research. These questions are posed below in *italic,* with the researcher answers following each question. The researcher will subsequently make a judgement call pertaining to the validity of this research study.

Ontology: What is the view of the researcher pertaining to who is being studied?

The purpose of this study is to determine the factors that will influence South African customers to adopt EVs. Therefore, the view of the researcher pertaining to the participants is that they are all adults who are permitted by South African law to own and operate a vehicle. The prerequisite for potential participants representing the *retail side of the automotive industry* is that all participants should at least own a vehicle. This ensures that the participants are well informed to provide information regarding their experiences and knowledge of vehicles. The two purposefully selected participants representing the *local supply side* of the automotive industry have vast experience in the automotive industry and both have PhD degrees.

Epistemology: Relating the educational view of participants, does this view fit the ontology?

This research study is based on constructionism, which is defined by Bryman *et al.* (2014:17) as “social phenomena and their meanings are being produced continually by social factors, individually and collectively, through social interaction.” As mentioned above, the participants are all vehicle owners and employed in the automotive environment, meaning they are adults, who can developed their own knowledge, and therefore the epistemology supports the ontology.

What is the sought-after outcome of the research study?

The desired outcome of this study is to determine what factors should be incorporated to ensure South African customers adopt EVs, as well as to possibly determine the factors that will lead to the non-adoption of electrical vehicles by South African customers. The desired outcome of this research is therefore adequate for the ontology and epistemology.

Is the research objective valid to obtain the sought-after outcome?

The primary research question, as stated in Chapter 1, is to determine the factors that could lead to the adoption of electrical vehicles by South African customers. Obtaining the views and opinions from participants representing the supply side of the automotive industry and the *retail side of the automotive industry* would achieve the sought-after outcome.

Is the methodology chosen appropriate to obtain the research objective?

The research design chosen for this research study is qualitative based, whereby primary- and secondary data is gathered. This method ensures that the most relevant and suitable information is obtained to ensure the primary research objective is achieved.

Is the research design effective for the methodology?

The design incorporated semi-structured interviews to gather primary data and the utilisation of secondary data including existing online interviews and automotive company websites to obtain valuable information pertaining to the development of electrical vehicles. It can therefore be concluded that the design described above is suitable for the methodology chosen.

Is the data analysis appropriate for the research design?

The process employed pertaining to data analysis was to transcribe all data gathered, including primary- and secondary data. The transcripts were uploaded to Atlas.ti, a qualitative data analysis software program. Codes were assigned to the transcripts by using the functionalities of Atlas.ti. Detailed information pertaining to the data analysis of this research study are also described in this chapter.

Are the results and conclusions valid for the entire context?

The findings are supported by quotes documented from the semi-structured interviews performed and information obtained from the secondary data. All of the conclusions can be traced back to the primary research objective.

The answers provided to the questions posed ensures a logical flow of events and sequence, and therefore it can be concluded that the research design would supply valid results.

3.4.2 Reliability

Bryman *et al*. (2014:36) define reliability as “the consistency of a measure of a concept”. The researcher personally transcribed the responses received to the semi-structured interviews held and all secondary data obtained. The researcher likewise personally performed all of the coding on the qualitative data, which yields consistency and reliability of the data gathered. The academic research supervisor for this research study likewise reviewed all of the codes utilised. The process employed to code all of the data obtained is also discussed in this chapter.

According to Jordaan (2019:206), the reliability of qualitative data is improved if all data is captured and coded, well after saturation has been achieved. This process has been implemented with this research study, whereby all primary- and secondary data has been transcribed and coded, subsequent to saturation being achieved.

3.5 Data analysis

The steps followed in the process of data analysis concerning the primary- and secondary gathered data were:

3.5.1 Primary data

- The researcher conducted the interviews with the respondents,
- The data obtained from the interviews was transcribed,
- The transcripts were uploaded into Atlas.ti and;
- The data was encoded by using Atlas.ti.

3.5.2 Secondary data

- The researcher identified online interviews and company websites, which can be utilised by adhering to the sample criteria,
- The data obtained from the online interviews and company websites was transcribed,
- The transcripts were uploaded into the software programme, Atlas.ti, and;
- The data was encoded by using Atlas.ti.

Atlas.ti is a software program utilised by researchers to conduct qualitative data analysis by encoding transcripts of data. This software program has the capability to highlight the relationships between different codes assigned to the transcripts (Silver & Lewins, 2014:210).

CHAPTER 4 RESULTS OF EMPIRICAL STUDY

4.1 Introduction

The data gathered and presented in Chapter 3 is analysed and discussed in this chapter.

4.2 Prominent codes identified

The researcher read all the transcripts of data gathered to identify important concepts in the transcripts, which could be used to code the data. The transcripts of all interviews and company information were encoded with the main concepts identified by utilising a function in Atlas.ti called “open coding”.

Open coding was utilised on the first five primary data transcripts, which yielded 165 initial codes. These codes were assigned to the remaining data transcripts in Atlas.ti.

The initial 165 codes were scrutinised by the researcher and arranged into code groups. This process resulted in the identification of 11 imperative code groups to assist in answering the research questions. These code group are:

- Code 1: Trust
- Code 2: Insufficient electricity
- Code 3: Recharging infrastructure
- Code 4: Cost of EVs
- Code 5: Taxation incentives
- Code 6: Long travel distance required in South Africa
- Code 7: Timeframe
- Code 8: Willingness to adopt electrical vehicles
- Code 9: Future international supply of electrical vehicles
- Code 10: Opportunity to manufacture electrical vehicles in South Africa
- Code 11: Future need for internal combustion vehicle engines

4.3 Discussion of significant codes identified

The ten identified codes, as mentioned above, will now be described by the researcher. This will include a discussion of the different relationships between the codes identified with the use of Atlas.ti.

The codes will be supported by quotes, which are information obtained from the participants (primary data) and from secondary data. The responses received from participants representing the *retail side of the automotive industry* in South Africa are given as **P01 to P10**. The responses received from the two individuals purposefully selected to represent the *local supply side* of the South African automotive due to their vast majority in the automotive industry are marked as **P11 to P12**. The secondary data utilised to obtain the opinion of the CEO's of the world's foremost vehicle manufacturers, which represents the *international supply side* of the automotive industry, is marked with their name and the companies they represent. Recognition is given to all online videos utilised under the references list.

4.3.1 Trust

Trust as a relation to other codes was a strong theme identified in the data. Customers are not comfortable that sufficient electricity can be produced for EVs and the lack of battery recharging points is contributing to the uncomfortableness of customers and subsequently their lack of trust. Customers are willing to trust new aged vehicles, including EVs, as will be discussed in the final theme identified in this study; however, customers do not trust the supporting infrastructure for the operating of EVs. Trust is important for customers to make the change from well-known ICEVs to EVs.

"Eskom problems, is also a problem for the adoption of EVs. This negatively influences customers mind set of EVs" – **P12**

4.3.2 Insufficient electricity

South Africa's electricity power utility/generator is currently experiencing electricity output challenges resulting in rolling electricity loadshedding schedules being implemented countrywide. Loadshedding is making customers uncomfortable to consider purchasing an EV. It was reported by Mjo (2018) that loadshedding is caused by mismanagement, incurring high debts and the failing of electricity generating plants. Insufficient electricity is contributing to the non-adoption of EVs. Insufficient electricity production increases the lack of trust customers are experiencing in the supporting infrastructures to EVs.

"It will definitely take longer for EVs to be adopted in South Africa, for the main reason being is that the electricity infrastructure will not be able to cope with the added pressures

on the grid. Eskom needs to be upgraded to supply quality and uninterrupted electricity to consumers. Currently South Africa cannot produce sufficient electricity to meet the demand of households, never mind to charge batteries for EVs." – **P01**

"Eskom will need to produce more electricity. Uninterrupted good quality electricity is required and it will encourage more customers to purchase EVs." – **P03**

"South Africa is far along from adopting EV, with the problems facing Eskom." – **P06**

4.3.3 Recharging infrastructure

International studies, as discussed under the literature review of this study, indicated that sufficient battery recharging points increase the adoption of EVs. The data gathered indicated a similar relationship of South African customers, in which the probability of local customers to consider purchasing an EV is higher when a sufficient battery-recharging infrastructure is present in the market. Another strong theme that appeared from the data is that convenient recharging would be beneficial to the adoption of EVs. This includes office- and home-based battery-recharging points. Sharing of battery recharging points with neighbours and the installation of battery recharging points in residential property- and complex estates could contribute to the reduction of EV costs, which can lead to an increase in EV adoption.

"I am sceptical whether the South African government will invest into supporting structures of EVs like the battery recharging infrastructure." – **P12**

"South Africa's infrastructure is also not ready for EVs, there might be a possibility in the future, but for now it will be difficult for widespread use of EVs." – **P03**

"More battery recharging stations are required to encourage people to purchase vehicles." – **P02**

"Current infrastructure is not up to date in South Africa; more recharging points are required to recharge the batteries of the EVs." – **P06**

4.3.4 Cost of EVs

A major concern for local customers are the high costs of EVs currently on offer to customers. The majority of participants indicated that a lower priced EV would increase

the adoption rate of EVs in South Africa. According to Theron (2019), the top five least expensive hybrid vehicles on offer in South Africa range from R490 000 to R846 800. It was reported by Lilleika (2020) that the top five cheapest new vehicles on sale in South Africa range from R142 900 to R159 900. The high purchase cost of EVs will contribute to the non-adoption of EVs.

"The chances of lower income individuals buying EVs are slim, due to the cost of EVs. A cheaper, more affordable EV will have to be produced, because currently the prices of EVs are so expensive that the normal customers and the-man-on-the-street will not be able to afford these vehicles." – **P01**

"EVs are also expensive and South Africa's market is dominated by smaller Sports Utility Vehicles (SUVs) and small hatchback passenger vehicles, dominated by smaller petrol turbo displacement markets. The current EVs of offer to South African customers are too expensive" – **P12**

"The solution will be for OEMs to offer more affordable electrical vehicles to South African customers. Customer's perceptions of electrical vehicles, that it is expensive vehicles, needs to be changed." – **P11**

4.3.5 Taxation incentives

Taxation incentives are another strong theme identified in the data gathered. It concerns the involvement of the South African government to help reduce the cost price of the EVs. Taxation incentives can be utilised to reduce the cost price of EVs; as mentioned above, the cost of EVs is significantly more than the top five most inexpensive new vehicles on offer to South African customers and South African customers' disposal income is under pressure as mentioned under the literature review of this research study. Therefore, incentives aimed at reducing the cost price of EV on offer to customers will lead to more EV being adopted.

"The government can implement tax grants whereby for example, 10% of the purchase cost of an EV can be given back to the customer in the form of a tax rebate; this will encourage customers to purchase an EV." – **P01**

"The South African Government will never stimulate EV sales by means of financial incentives, because they are saying EVs are three times the price, compared to a normal ICEV counterpart. Rich - fortunate people can afford these vehicles. So there question is, who are actually benefitting from these incentives? Cash grants and financial incentives are not available; however, other multiple services and products can be implemented to stimulate demand for EVs. This includes offering free parking and in other countries EV can enter certain cities in which ICEVs are not allowed." – **P11**

"I am sceptical surrounding EVs in South Africa. Currently the numbers are low, there is no tax incentives." – **P12**

4.3.6 Long distance of traveling required in South Africa

This code pertains to the participants recognising the risk of long distances travelled in South Africa and contributes to the lack of trust current customers have in the range of EVs. Current customers have range anxiety and do not feel comfortable with the lack of a battery recharging infrastructure and -network.

"I think that South Africa is not ready for EVs. Just with regards to the geographical landscape of South Africa, people live far away from each other, cities are far from one another. Long distances needs to be travelled." – **P03**

"With regards to electrical vehicles, there will be a future for EVs, but it might still be far away and in the very long term. One reason being is that the cities in South Africa is far away from each other. EVs used only in cities would be great and more widely used. EVs would be perfect for people that does not drive to far to work and back home, but it would not be great for people driving further than the average individuals." – **P04**

"South Africa is also a big country, like the US and Australia, Australia is a bit different as where people do not drive between large cities, they fly." – **P12**

"In the United Kingdom for example, every second service stations is equipped for electrical vehicles to be recharged. In South Africa, to only charge vehicles at home will not be sufficient, especially for customers who are travelling farther distances." – **P01**

4.3.7 Timeframe

The period applicable to this research study relates to when customers would consider purchasing an EV instead of an ICEV. The timeframe is a representation of the opinion of customers on when the required supporting infrastructure would be developed and implemented for customers to seriously consider purchasing an EV. This include customers' perceived timeframe in which sufficient electricity would be produced, the development and the implementation of an adequate battery recharging infrastructure and when EVs will be more affordable to customers. The majority of participants indicated that they would consider purchasing an EV within a period of 10 years, with a small percentage indicating that they would purchase an EV within the next ten to 15 years.

4.3.8 Willingness to adopt EVs

The willingness to adopt EVs is a code representing whether South African customers would consider purchasing EVs instead of ICEVs. The researcher assumed that should a respondent provide a timeframe of when they will consider adopting an EV, then those respondents are in fact willing to adopt an EV.

"I will consider purchasing a hybrid vehicle in the next 5 years and a full electrical vehicle in 10 to 15 years' time." – **P01**

"The timeframe to purchase an EV will be in 10 years." – **P06**

"The timeframe would be in the next 15 years." – **P05**

"I will purchase a hybrid or an EV, in the next 10 years." – **P04**

4.3.9 Future international supply of EVs

All of the data gathered revealed that the major vehicle manufactures are planning to upscale the production of EVs, which is highlighted in the literature review study performed. These vehicle manufacturers are aware of the trends concerning EVs and believe the future of vehicles will be electrification. Substantial funds are invested to enable these manufacturers to produce EVs.

"Electrification is an absolute requirement for the future. Toyota will continue to invest in hybrid vehicles, plug in hybrid vehicles, full battery electrical vehicles and fuel cell

vehicles. The trend is there the market is there for electrification to develop. Toyota believes it will be a mix of EVs, Hybrid, Plug in Hybrid, Battery EV and Hydrogen. The trend is quite clear and Toyota sees what is happening. Electrification is going to happen." – **Johan Van Zyl, CEO of Toyota Europe**

"The sales and the cost of sales of electrification is moving in the right direction very fast, which is a good indication. Daimler Chrysler builds their own batteries, which allows them to ensure that their EVs battery range is 500 KMs, in real driving conditions. These batteries also allows the vehicles to be recharged in less than half an hour. This allows customers a free choice to choose between an ICEVs or an EV. A goal has been set by DC to be the leader in premium EV by 2025." – **Dieter Zetsche, CEO Daimler Chrysler**

"New gaps will be created, with EVs. EVs will be very attractive for customers and Volvo needs to very rapidly develop cars for Electrical drive, to full the future market, which will definitely come. Volvo has therefore taken the decision to prioritise hybrid vehicles with Diesel Engines and to allocate the resources to develop full battery electrical vehicles as fast as possible." Volvo plans to have half of their vehicle battery electrical vehicles by 2025 and the other half will be hybrid vehicles." – **Hakan Samuelsson, CEO of Volvo**

4.3.10 Opportunity to manufacture EVs in South Africa

The literature review highlighted the vehicle manufacturing capabilities of South Africa and the different vehicles produced in the country. Emphasis on the revenues obtained by exporting locally produced vehicles to a vast majority of international markets was likewise highlighted in both the problem statement and literature review of this research study, especially the European markets. Many participants indicated that the opportunity to produce EVs is viable if South Africa has established vehicle plants. One participant purposefully selected for the research indicated that the South African OEMs operating in the country would need to adapt to produce the vehicles demanded by the markets to which locally produced vehicles are being exported. This same participant indicated that Europe was the largest customer for South African-produced vehicles and this trend will more than likely continue into the long-term future; therefore, the importance for South African OEMs to produce vehicles demanded by the European markets.

"There is a possibility of South Africa producing Electrical vehicles. There is already multiple different OEMs operating in South Africa with the necessary infrastructure and facilities, Electrical Vehicle Technology just needs to be incorporated into these plants and facilities. An additional Line can be included in these factories to produce Electrical Vehicles. For example, Ford, BMW and Mercedes - Benz all have existing plants in South Africa, all that might be required is a restructuring of these plants to produce Electrical vehicles. It will be cheaper and faster oppose the building a new plant." – **P01**

"I definitely thinks there is an opportunity to produce EVs in South Africa. The infrastructure to produce vehicles in South Africa is already established, and petrol and diesel vehicles are already being manufactured in South Africa. The country has the knowledge and expertise to build vehicles." – **P03**

"I think that there is a high possibility of South Africa manufacturing EVs in the future. For example BMW is manufacturing and assembling vehicles in South Africa and the respondent thinks that South Africa has the infrastructure to manufacture EVs." – **P05**

"If there is a demand for EVs, then yes there is an opportunity for South Africa to produce EVs. Another concern is whether South Africa has the skills to produce EVs. Workers will have to be upskilled, because of there is a demand for EVs, then my all means yes, but the skills needs to be improved." – **P02**

The opinion of P02 is supported by the opinion of the participant purposefully selected to represent the *local supply side* of the automotive industry:

"Training is also required to ensure there are sufficient people equipped to work on EVs. The best technicians around the world was tested and they has no idea how to work on an EV." – **P11**

The majority of the participants interviewed are of the opinion that South Africa has the opportunity to manufacture EVs, due to the established vehicle producing capabilities of numerous OEMs operating in South Africa.

However, the two participants purposefully selected to represent the *local supply side* of the automotive industry, participants P11 and P12, likewise provided the opinion that

South Africa can indeed manufacture EVs in the future, but added that convincing might be required to ensure the headquarters of OEMs to allow South Africa to produce EVs.

The participants highlighted the fact that South Africa needs to improve the quality of locally produced fuel and a strong local market concerning the adoption of EVs is required.

"South Africa does not produce clean, good quality fuels for new vehicle engine technology. This is not the message that a country wants to send into the international space, because if we cannot even produce quality fuels for the current vehicle parc, how are we going to produce EVs. It is not a good message to follow. It is important for South Africa to come onto par with international fuel producing counter parts. If we are going to be considered to produce EVs in the future." – **P11**

"South African OEMs are already experiencing higher manufacturing cost due to adaptions and to down spec the engines to run on low-quality fuel available in South Africa. Europe has already Euro quality 6 fuel and South Africa is on Euro-level 2. The lag of progressive regulation convinces the industry to low-technology products or old-technology products. I am also of the opinion that this will eventually happen with EVs as well. The possibility of South Africa to produce EVs are a possibility, however it will be export driven. There will not be a pediment at all to produce EVs in South Africa for the export markets." – **P12**

"It will never work for South Africa to produce old engine technology for South Africa and new engine technology for export markets as a result of the low quality of fuel being produced at South African refineries - it is not sustainable." – **P11**

"Europe has been South Africa's largest export market concerning automotive products for the past 30 years and will continue to be so for the following 130 years and therefore South Africa will need to adapt." – **P11**

"There is no reason that we cannot produce new generation vehicles (electrical vehicles) for the future world markets. The ideal however to first develop a strong local market for the vehicles produced in the country. If more affordable electrical vehicles are offered to customers in South Africa, sales grow and the perceptions of customers regarding

electrical vehicles are changed, then international OEM head office might choose South Africa to develop and build EVs in South Africa." – **P11**

4.3.11 Future need for ICEVs

All of the participants interviewed concerning the gathering of primary data indicated that the demand for ICEVs would continue in South Africa into the long term. South African customers trust ICEVs. Concerns regarding the lack of battery recharging infrastructure and the challenges experienced by the country's electricity utility are forcing customers to continue to utilise ICEVs. Participants also noted that South African cities are far from one another and ICEVs eliminate the range anxiety experienced by customers. One participant indicated that diesel-powered vehicles will continue to be utilised due to the agricultural activities associated with South Africa.

Participants representing the *retail side of* the local automotive industry are of the opinion that ICEVs powered by petrol and diesel engines will continue to dominate the South African vehicle industry in the long term, with some participants indicating diesel engines might be phased out sooner than their petrol counterparts.

"ICEVs will remain in South Africa and in other countries with big farms such as the United States of America (USA) and Australia as these countries utilise tractors." – **P05**

"There will be a high demand for ICEVs in South Africa; the infrastructure is there to support ICEVs. Diesel will perhaps not have a big future due to the emission scandal (Diesel Gate), but Petrol definitely." – **P05**

"Petrol and Diesel will remain in South Africa, diesel will be phased out in more developed countries and this trend will follow suite in South Africa. Petrol and diesel vehicles will remain in South Africa for a very long time. Petrol will always remain in South Africa." – **P02**

Numerous chief executive officers have indicated that their companies are reviewing international markets to determine whether or not to continue operations in a specific country and market. This has been likewise mentioned under the problem statement of this research study where General Motors exited South Africa to focus on markets with potentially higher returns on investment.

“Large OEMs will align their Research and Development to match the biggest target markets including China. Large OEMs are launching key models in China due to market demand.” – **P12**

“The core of Volvo will remain, continental Europe, China and the United States of America” – **Hakan Samuelsson, CEO of Volvo**

“Ford is looking at its Geographical reviews, if Ford is not winning in a specific market, it will consider exiting that specific market” – **Jim Hackett, CEO of Ford Motor Company**

“The Volkswagen business has always been a business with global markets with different markets and tastes and barriers. Volkswagen is investing in major growth markets and electrical vehicles will be introduced over a period of five to ten years.”– **Hiebert Diess, CEO of the Volkswagen Group**

South African OEMs produces specific models for OEM head office for world markets, and for now it is diesel and petrol and it might be electric in the future, the ideal situation would then be to sell EV in South Africa as well. The exporting of these types of vehicles (ICEVs) will never disappear, at least not in the following few decades. However, having said that, it is beneficial to enter the space of manufacturing EVs.” – **P11**

Participant P11 noted above that the OEMs operating and producing vehicles in South Africa do so under the mandate of the parent OEM company as mentioned in Chapter 2 of this study’s Literature Review, whereby OEMs producing vehicles in South African contribute to the international supply chain of vehicles to meet the demand of numerous countries. Therefore, South African OEMs will need to develop vehicles, which will satisfy the requirements of the parent OEM companies as well as meet the demands of local customers.

“Currently EV sales are low in South Africa, but the industry is looking at ways to stimulate EV sales. South African OEMs produces specific models for OEM head office for world markets, and for now it is diesel and petrol and it might be electric in the future, the ideal situation would then be to sell EV in South Africa as well.”– **P11**

Thomas Schafer, the current CEO of Volkswagen South Africa, indicated that a strategy has been developed for Volkswagen South Africa to focus on exporting vehicles into Africa.

"Volkswagen (South Africa) is definitely here to stay, that is the commitment, we have invested heavily in the past two years. A clear strategy has been set for Volkswagen South Africa. From this production facility, they are moving into Africa. That is Volkswagen South Africa's future to export vehicles into Africa. To export to other regions are nice, but South Africa is fighting against locations like China, India and Mexico that are highly competitive." – **Thomas Schafer, CEO Volkswagen Group South Africa**

Participant P11 indicated that Africa is a major priority for the OEMs producing vehicles in South Africa, which supports the view of Thomas Schafer.

"Africa is a priority for the South African Automotive Industry. Governing bodies have been developed to assist with the exporting of vehicles to Africa. Africa does have potential concerning the importation of new vehicles, however the risk remains that Africa will only have potential. Implementation is a concern. Africa has 54 different countries, each with their own legislations and rules. SADC is in place concerning rules of origin and the suggestion is to expand SADC to include additional African countries. Another Risk is to convince African government who generates revenue from the importation of 2nd hand used vehicles. The African markets needs to be developed for the South African automotive industry to ensure China or Brazil does not enter the African markets. Due to the geographical location, South Africa's natural markets needs to be Africa, but the challenge remains to implement the rules and procedures to start with the trading." – **P11**

"Internal combustion vehicles will always be necessary, because the lower income, less-developed, third world countries will not have the resources to develop and to build the infrastructure to support EVs, but the western, developed countries will move to electrical vehicles." – **P01**

Participant P11 is also of the opinion that ICEVs will continue to maintain a large market share in South Africa:

“For a very long period in the Future ICEVs will still maintain a 90%+ market share in South Africa and therefore the lack of quality fuel being produced in South Africa cannot be ignored.” – **P11**

From the above, two imperative opinions need to be noted. Firstly, the opinion of participant P11 that an established local market for EVs is required to try and convince the parent OEM company to produce EVs to be exported to global markets. However, the same participant indicated that EVs are new-age vehicles and therefore they are expensive to produce, which increases the cost prices of these vehicles, which, in turn, increases the import duties on these vehicles. This is combined with unfavourable economic conditions, all of which negatively affect the establishment of a strong the local base of EVs.

Secondly, the statement of Thomas Schafer, the CEO of Volkswagen South Africa that this company’s main priority will be to export vehicles to African markets. This statement raises the question: What type of vehicles are required to successfully meet the demands of African markets?

If the opinion of participant P11 is taken into consideration, the preferred scenario would be to export a type of vehicle to meet the demands of the export markets, which is already satisfying the demand of the local market. Currently, ICEVs have a market share of more than 90% in South Africa, and therefore the assumption can be made that the needs of African markets would likewise be satisfied with ICEVs.

In conclusion, the factors that would contribute to convince the participants interviewed to adopt EVs are discussed.

4.4 Categorising the significant codes identified

The central aim of this research study was to identify the factors that will influence the adoption of electrical vehicles by South African customers.

The succeeding decade will constitute numerous vehicle design changes from how vehicles look to how they are being operated, for example large air intakes with the goal of cooling internal combustion engine vehicles will not be required anymore and the

interior of vehicles will allow customisation and incorporate a multi-functional space (Lewis *et al*., 2019).

The researcher, therefore, displayed the current controls required to operate a vehicle (Figure 19-1) below, as vehicles produced in the future might look very different from the vehicles known to customers in the year 2020.

Figure 19-1: Vehicle controls required to operate a vehicle

Source: AVG Motors (2018)

The researcher thought it would be applicable to this specific research to categorise the prominent identified codes into specific labels associated with the different vehicles controls, which are currently required to operate a vehicle from the year 2020. The vehicle controls used, which will represent the categories of code groupings are: 1) *the accelerator,* 2) *the brake pedal*, 3) *the ignition switch* and 4) *the steering wheel.*

- The accelerator category includes codes that will lead to the increased adoption of EVs.
- The brake pedal category will include codes that will discourage customers to adopt EVs.
- The ignition switch, when turned off, will represent codes, which could lead to the possible long-term non-adoption of EVs.
- The steering wheel will represent codes, which could steer vehicle customers and vehicle manufacturers to align the demand and supply of new-age vehicles.

The table below represents the initial categorising of the profound identified themes into the four choses vehicle controls.

Table 8-1: Categorising profound themes into the four identified vehicle controls

(1.)Accelerator	**(2.)Brake pedal**
Supply of electric vehicles	Battery recharging infrastructure
Battery recharging infrastructure (sharing of battery recharging points)	Cost price of electric vehicles
Taxation incentives	-
Opportunity to produce electric vehicles in South Africa*	-
(3.) The ignition switch (off)	**(4.) The steering wheel**
Customer trust	Time frame
Insufficient electricity being produced	Willingness to adopt electric vehicles
The continued need for internal combustion engine vehicles.	-
Opportunity to produce electric vehicles in South Africa*	-

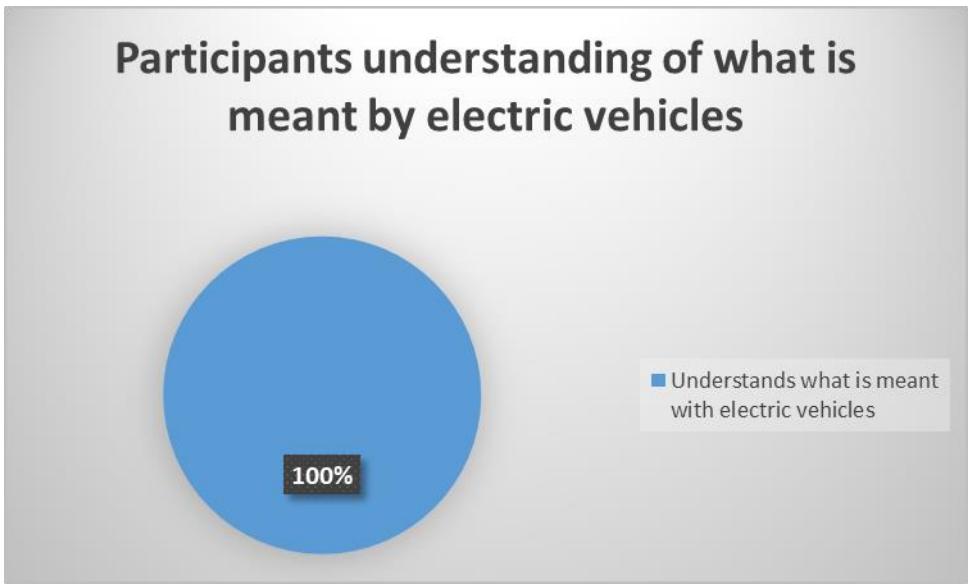
Source: Compiled by the researcher

*The opportunity to produce EVs is categorised under the accelerator category as well as the ignition switch (Off) category. As stated above, certain participants indicated that the future of the South African automotive industry might be to export vehicles into Africa. More research is required to determine the needs of the other African countries and what type of vehicle will satisfy those needs, be it ICEVs or EVs.

The succeding figures will visually indicate the data obtained from the participants representing the *retail side of* the local automotive industry in South Africa pertaining to the questions posed to them during the semi-structured interviews.

The researcher wanted to determine whether the participants are familiar with EVs and whether they understand what is meant by the term electrical vehicles. The objective was to ensure the participants are familiar with EVs to provide meaningfull opinions for succeding questions posed to the participants during the semi-structured interviews. The data obtained is populated on the graph below.

Figure 20-2: The participants understands what is meant by the term, electrical vehicles

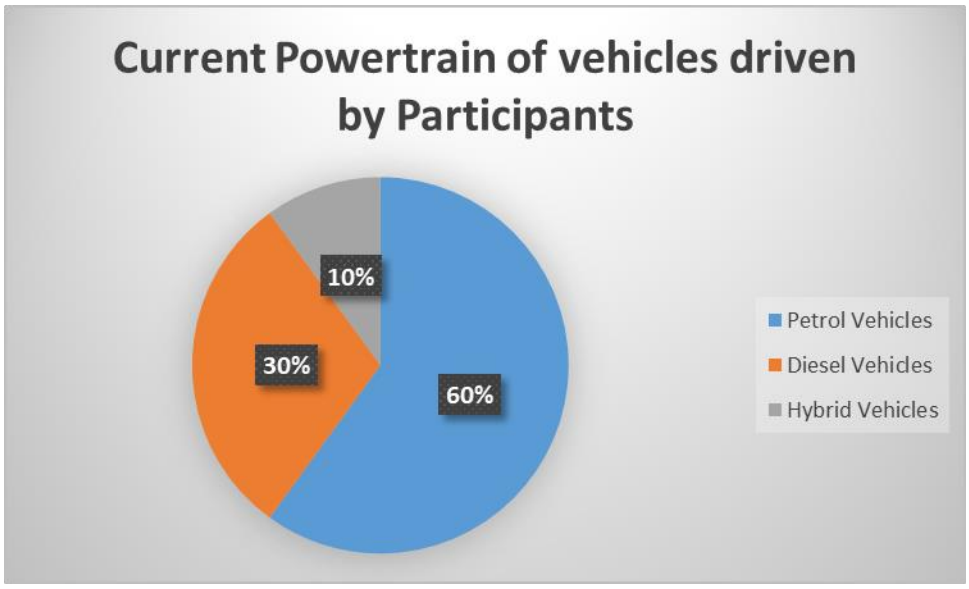


Source: Compiled by the researcher

The graph above indicates that all ten participants interviewed are aware of electrical vehicles and understand fully what is meant by the term electrical vehicles.

The two figures below are an indication of the current vehicles driven by the participants, when the researcher conducted the semi-structured interviews and displays the propulsion powertrain and gearbox transmissions of these vehicles.

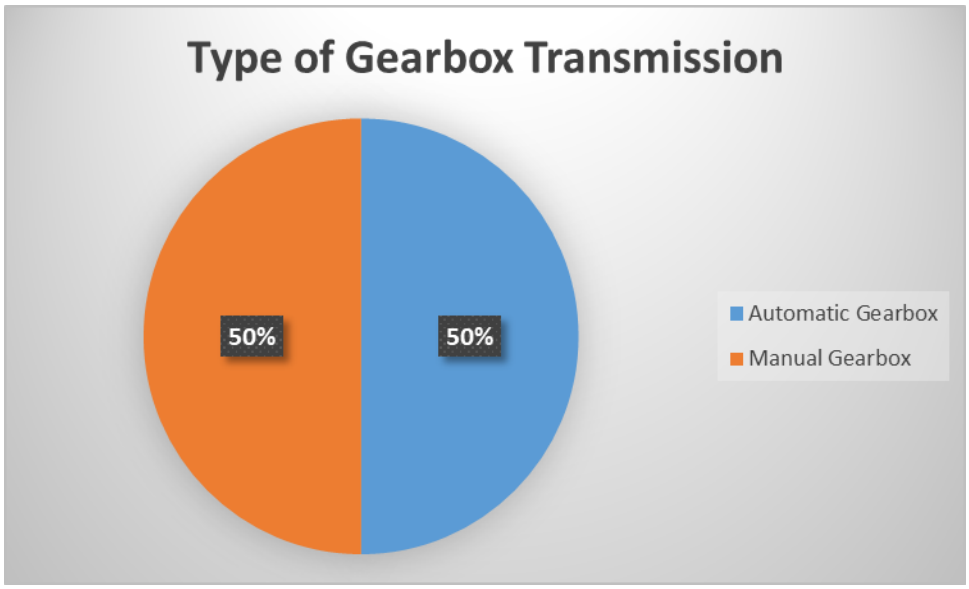
Figure 21-3: Propulsion powertrains of current vehicles driven by participants representing the *retail side of the automotive industry*



Source: Compiled by the researcher

The motive of the researcher to showcase this data was to determine whether partipants only drive ICEVs or whether there are participants who currently drive EVs. The graph indicates that out of ten participants, only one participant drives a hybrid vehicle, while the remaining nine participants all drive ICEVs. This graph corresponds with the automotive export manual published by the automotive industry export council, which indicated that EVs maintain a minor share of the total market for new vehicles sold, with only 202 EVs sold in 2018 compared to an aggregate number of new vehicles sold of 552 226 (AIEC, 2019:16).

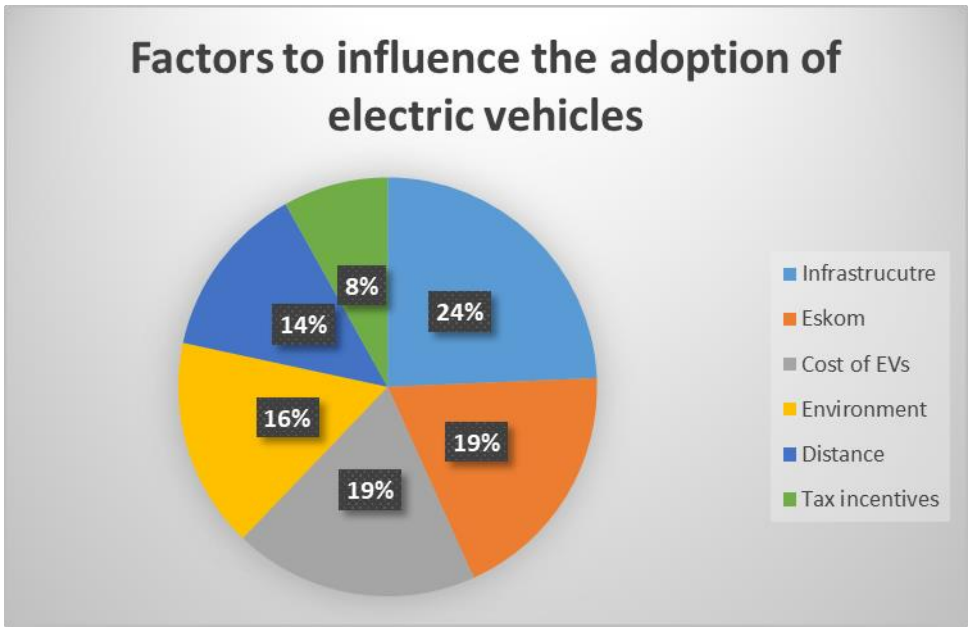
Figure 22-4: Gearbox transmission of current vehicles driven by participants representing the *retail side of the automotive industry*



Source: Compiled by the researcher

The graph above highlites the split between an automatic transmission vehicle and a manual transmission vehicle, which indicates the level of convenience experienced by the participants. As shown above, there is a 50/50 split between these two transmissions. The same vehicle with an automotive gearbox transmission is more expensive than a manual gearbox transmission.

Figure 23-5: Factors identified that will encourage participants to purchase electrical vehicles



Source: Compiled by the researcher

The graph above states the most significant factors identified from the data that will influence the adoption rates of EVs in South Africa. The lack of a battery recharging infrastructure, the unstable electricity supply of Eskom and the high costs of EVs are the top three main concerns of the participants interviewed, which will lead to the non-adoption of EVs in South Africa. The adoption rate of EVs among South African customers will improve should the current environment of these factors be amended, wherby an adequate recharging infrastructure is available to customers, stable electricity supply from Eskom is provided to customers and cheaper EVs are on offer to customers.

The damage caused by ICEVs to the environmnet, as discussed under the literature review of this study, is another factor that will encourage participants to purchase an EV rather than an ICEV.

The long distances travelled in South Africa are a concern for the participants. The table below is a summary of the nine longest roads in South Africa displayed from the lenghiest road to the least-lenghiest road.

Table 9-2: Longest roads located in South Africa

Road located in South Africa	Total length (kilometers)
N2	2 255
N1	1 937
N12	1 170
N14	1 186
N10	998
Route 62	850
N11	660
N4	650
N7	666

Compiled by the researcher, data gathered from KH Plant (2017)

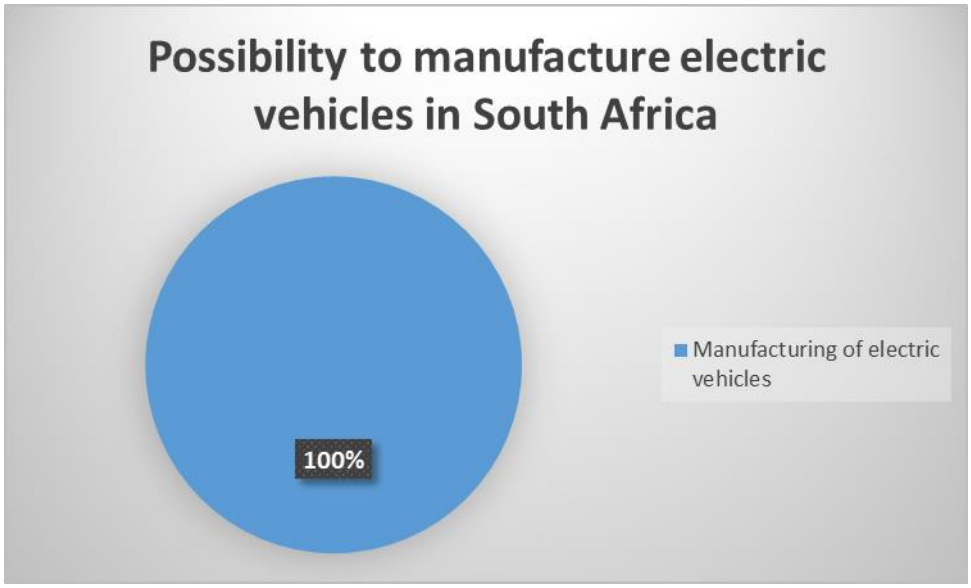
South Africa's road system has an aggregated total of 7 200 kilometers, which is the ninth lengthiest road system in the world. According to Van Der Post (2019), the Nissan Leaf has a driving range of 195 kilometers when fully charged, the BMW I3 has a range of between 130 and 160 kilometers and Jaguar reported that the I-Pace model can drive 470 kilometers when the vehicle is fully charged. The researcher makes the assumption that participants therefore prefer a battery recharging infrastructure throughout the country or hybrid vehicles without having to charge batteries will be more suited for South Africa, as noted by Andrew Kirby.

"Hybrids will be a more practical solution in South Africa for at least the next few years" – **Andrew Kirby, CEO of Toyota South African Motors**

Taxation incentives on offer to customers when purchasing an EV will encourage customers to adopt EVs as the high cost of these vehicles is the third highest factor identified that needs to be reduced prior to customers considering purchasing an EV.

A question was posed to the participants to determine their opinion on whether South Africa has the opportunity to produce EVs or not. The data obtained is populated on the graph below.

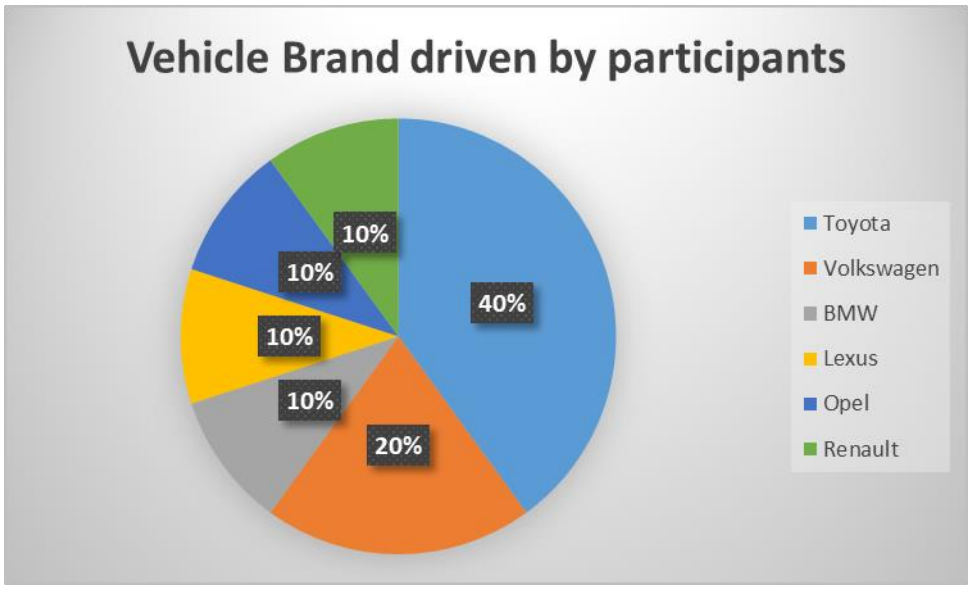
Figure 24-6: Opinion of participants, representing the *retail side of the automotive industry* of whether South Africa has the opportunity to manufacture electrical vehicles



Source: Compiled by the researcher

The graph above indicates that all ten participants interviewed are of the opinion that South Africa has the opportunity to manufacture EVs, mainly because of the existing infrastructure available in South Africa to produce ICEVs.

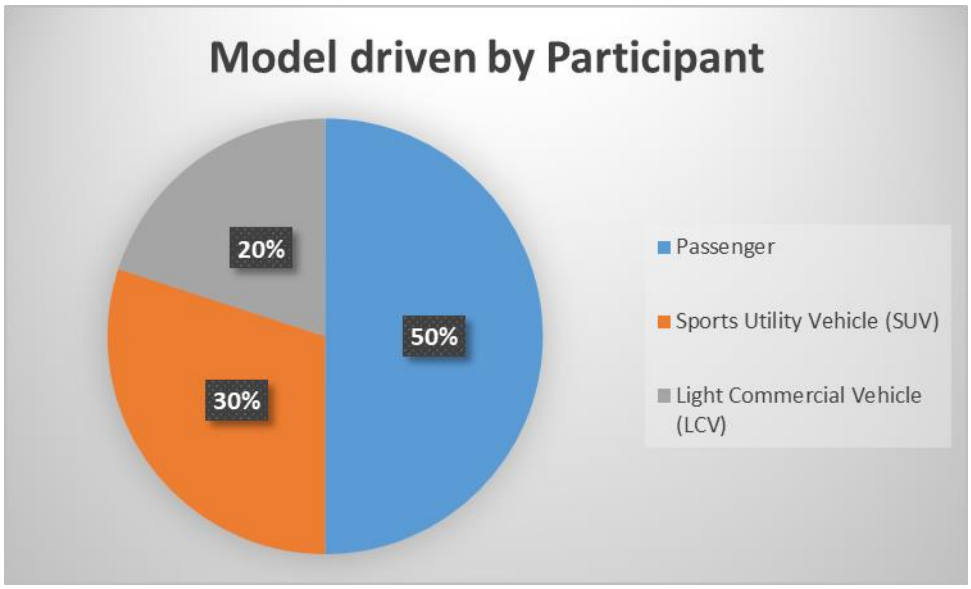
Figure 25-7: Different vehicle brands driven by the participants representing the *retail side of the automotive industry*



Source: Compiled by the researcher

The graph above corresponds with the automotive export manual published by the automotive industry export council, wherby Toyota and Volkswagen are the two front runners pertaining to the new vehicle market share in South Africa (AIEC, 2019:15).

Figure 26-8: Different vehicle models driven by participants representing the *retail side of the automotive industry*



Source: Compiled by the researcher

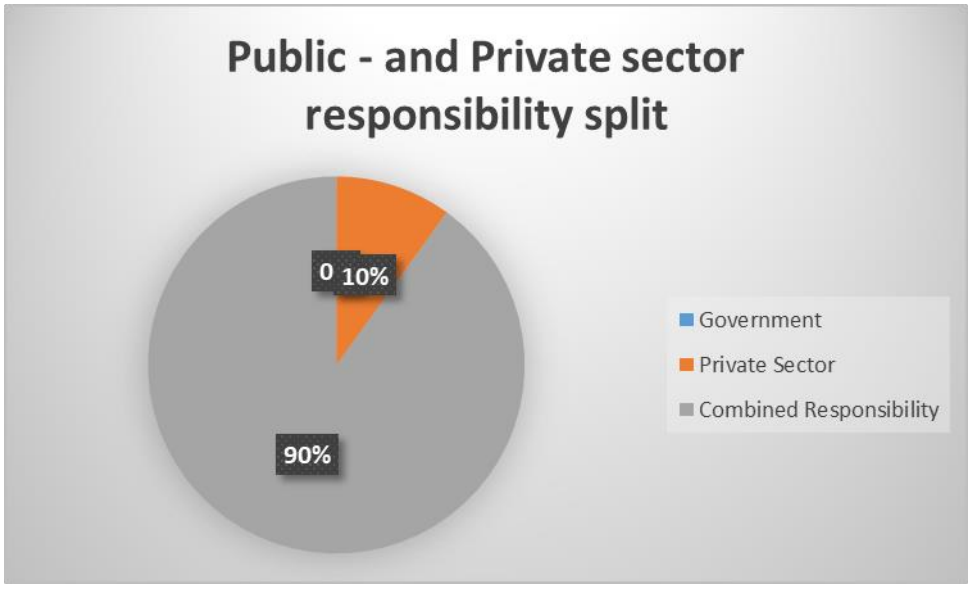
The data displayed on the graph above corresponds with the data published by the automotive industry export council, whereby the total number of passenger vehicles sold in South Africa amounted to 365 242, wherby the total number of LCVs sold amounted to 159 449 (AIEC, 2019:14). The total number of SUVs sold in South Africa in 2018 amounted to 28.8% of the aggregate number of passenger vehicles sold in the same year; the high market share experienced by SUVs is in line with globale vehicle sales trends (AIEC, 2019:14).

From the data above, the researcher makes the assumption that, should Toyota and Volkswagen produce affordable passenger and/or sport utility EVs, combined with an adequate battery recharging infrastructure and stable electricity produced by Eskom, it should remain the market share leaders of new vehicles sold in South Africa.

Contrastingly, Toyota and Volkswagen might lose their top spots pertaining to the South African new vehicle market share, should an environment be developed with an adequate battery recharging infrastructure and the production of stable electricity, without these two vehicle manufacturers developing more affordable EVs.

The figure below highlightes the opinion of the participants interviewed pertaining to the development of these factors, as mentioned above, and who will be responsible to developed these factors: the private sector, the public sector or will it require a combined effort between these two latter mentioned parties?

Figure 27-9: Opinions of participants representing the *retail side of the automotive industry* of what party will be responsible to develop the required infrastructure to entice customers to purchase electrical vehicles

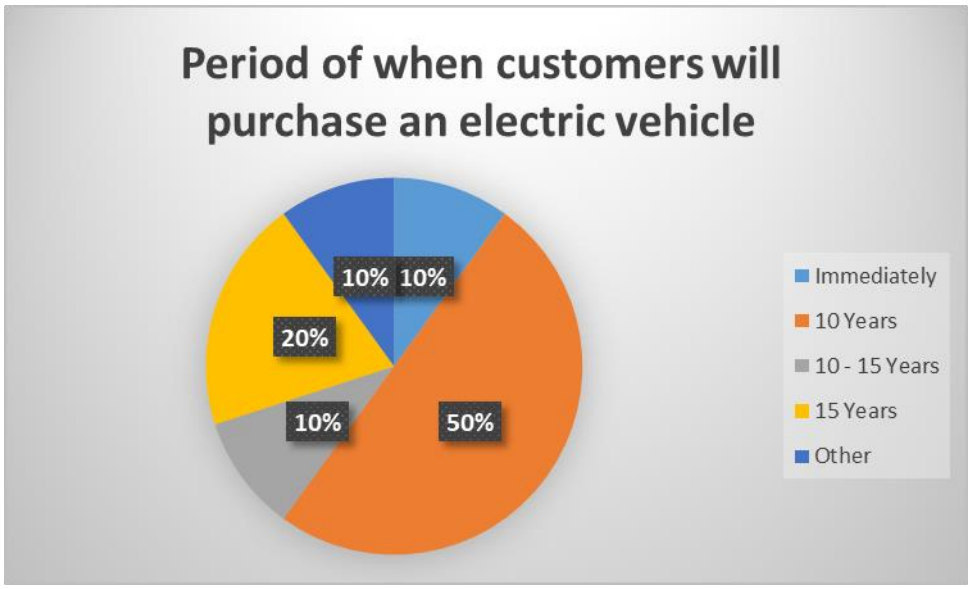


Source: Compiled by the researcher

The figure above provides a clear indication that the majority of partiipants believe that a combined effort will be required between the private- and public sector to develop the factors required to increase the adoption rates of EVs. The majority of participants indicated that the role of the government would be to ensure Eskom provides sufficient electricity to ensure EVs can be recharged and the responsibility of the private sector would be to ensure a sufficient quanity of battery recharging points are available to EV drivers.

"The Private Sector will have to come to the party to ensure there is adequate supporting infrastructure to customers. The government can play their role to ensure that Eskom is upgraded so the utility can produce sufficient electricity" – **P01**

Figure 27-10: Time period of when participants representing the *retail side of the automotive industry* will consider purchasing an electrical vehicle



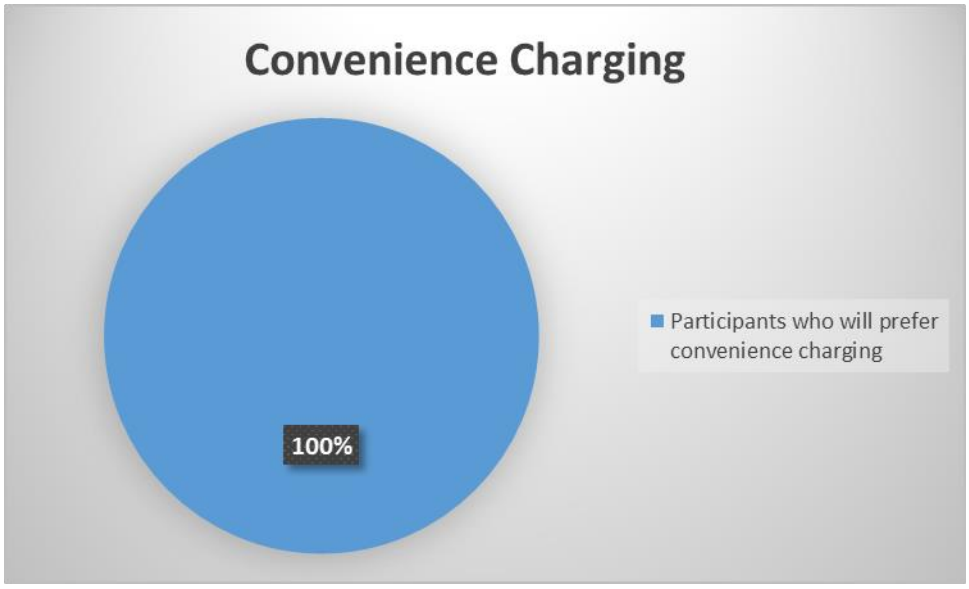
Source: Compiled by the researcher

The participant who will immedialty purchase an EV is the same participant who is already driving a hybrid vehicle and the “other” category as shown on the graph above, is a participant who indicated that a decision to purchase an EV will be made when an EV is available on the market, which will satisfy the vehicle needs of the participant, which is currently being achieved with ICEVs. This strenghtens the argument made by Rogers (1962) with his diffusion of innovation model and Davis’ (1989) technology acceptance model (TAM) as described under the literature review study (Chapter 2), whereby these models highlighted that a customer will adopt an innovative product if the product will provide a relative advantage over existing products and wheter the customer percevied the product as being useful to satisfy the needs of the customer.

The majority of participants are willing to purchase an EV in either the next 10 years, or in the next 15 years. The researcher made the assumption that this data indicates when the participants feel that the factors as mentioned above will be developed and implemented and when EVs will be more affordable.

The graph below highlights the data obtained from the participants pertaining to whether these participants would prefer having a battery recharging station available at their homes and offices/work places.

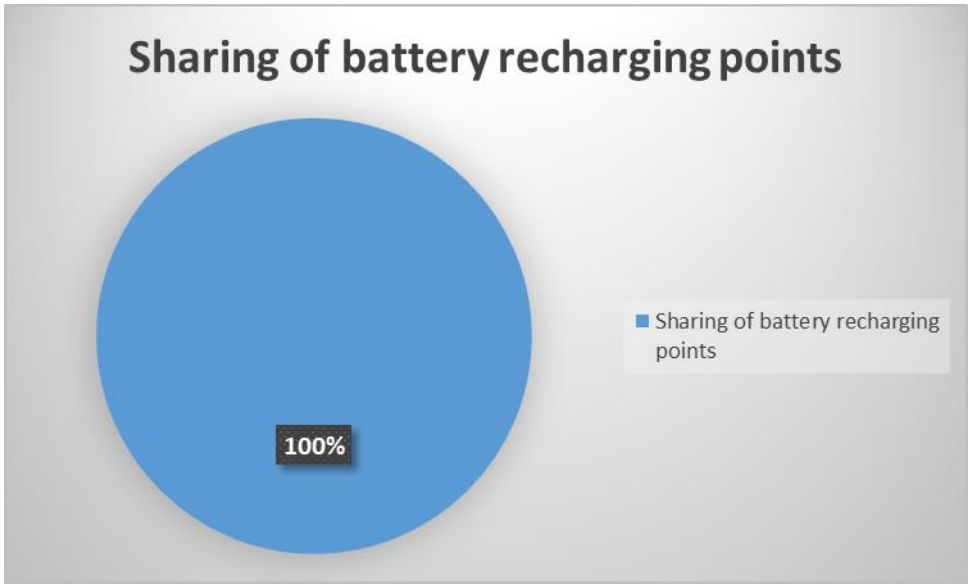
Figure 27-11: The percentage of participants representing the *retail side of the automotive industry*, opting for convenience to recharge electrical vehicles



Source: Compiled by the researcher

All ten participants indicated that they would prefer having a battery recharging point available at their homes and/or offices/workplaces.

Figure 28-12: The percentage of participants representing the *retail side of the automotive industry*, opting to share battery-recharging points to recharge electrical vehicles



Source: Compiled by the researcher

All ten participants indicated that they would not be against sharing a battery recharging point at their homes; some participants indicated that it would assist in reducing the cost of EVs. As highlighted above, the current high cost of EVs is contributing to the non-adoption of EVs, and therefore certain participants would prefer to share a battery recharging point to reduce the cost of EVs. Other participants highlighted that many South African citizens are choosing to live in residential estates and complexes and therefore it will make economic sense to share a battery recharging point within these estates and complexes. This is in line with Figure 27-1, whereby participants would prefer having a battery recharging point located at their homes and/or offices/workplaces.

In conclusion, the main objective of this research study was to determine the factors that will increase the adoption rate of EVs in South Africa. The problem statement of this research study, under Chapter 1, highlights the importance of the vehicle exports for the South African automotive industry to achieve the required economies of scale. The literature review study under Chapter 2 clearly indicated the vast contributions made by the South African automotive industry to the country's economy pertaining to foreign direct investment and GDP. The literature study furthermore indicated that Europe is

South Africa's largest export market concerning vehicles and Europe is the second highest adopter of EVs. Therefore, the need to determine the factors to increase the adoption rate of EVs in South Africa was identified.

The factors identified as mentioned above were the lack of battery recharging infrastructure, the problems facing Eskom, the high cost of EVs, the impact ICEVs have on the environment, the long distances travelled in South Africa and taxation incentives.

All ten respondents representing the *retail side of* the South African automotive industry indicated that South Africa has the opportunity to manufacture EVs in South Africa; however, Thomas Schafer, the current CEO of Volkswagen South Africa and participant P11, indicated that the future of the South African automotive industry might be to export vehicles to other African countries.

Their opinions were that other countries manufacturing vehicles are located closer to Europe than South Africa and the country is competing against other competitive countries such as China, India and Mexico. It was also noted that Africa is an opportunity for the automotive companies manufacturing vehicles in South Africa as the only other African country with a noteworthy automotive manufacturing industry, but Africa remains a challenge to establish the trade relationship with South Africa.

CHAPTER 5 CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

5.1 Introduction

The introduction to this research study under Chapter 1 highlighted that there is a global shift to reduce carbon emissions and that the transport sector requires significant amendments to reduce its carbon emission contributions. The signing of an international climate change agreement with a few countries announcing the ban on ICEV sales in the nearby future supports this global shift to reduce carbon emissions. The introduction concurrently highlighted the future forecasts and predictions of EV sales.

The problem statement of this research study in Chapter 1 highlighted the predicament of the South African automotive industry, whereby the vehicles produced in South Africa do not only satisfy the demand of the local market, but these vehicles are destined for numerous international markets. The local industry requires the economies of scale generated by the exporting of locally produced vehicles, with vehicle exports in return contributing significantly to the South African economy. The predicament, which this research study aimed to address, is to eliminate the risk for local, South African consumers to be subjected to the dumping of old-technology/previous generation technology vehicles, should local vehicle manufacturing companies decide to only produce EV to meet the demand of their international customers. Previous business-specific research could not be identified, which addresses this predicament. Therefore, the findings of this research study are contributing to the knowledge pertaining to the factors, which need to be developed and implemented to ensure the increased adoption of EV by South African customers.

This research study included a literature review, which is presented in Chapter 2. The researcher identified and presented specific information pertaining to EVs, which included the current development plans of vehicle manufacturers to increase the production of EVs, the forecasted sales figures for EVs, and the need to shift from ICEVs to EVs. However, the researcher concurrently aimed to present information that outlined the situation in South Africa that needs to be taken into consideration should EVs be employed in large scale into the local market.

The methods pertaining to data collection and analyses were briefly summarised in Chapter 1 of this research study. However, Chapter 3 included an in-depth explanation of the sampling strategies employed including convenience- and purposive sampling to identify potential participants, and the methods utilised to obtain primary- and secondary data from these participants were discussed. The researcher included participants representing both the local retail- and supply side of the automotive industry and the *international supply side* of the automotive industry. The process of data analysis including transcribing interviews and secondary data and encoding this data by using Atlas.ti was discussed.

The principal focus of Chapter 4 was to obtain answers to the primary and secondary listed research objectives through an empirical study. For ease of reference, the primary stated research objective of this study is: “Exploring the factors that will influence the adoption rate of electrical vehicles by South African customers.”

The profound factors identified, which, in the current operating environment, are discouraging customers to adopt electrical vehicles, and therefore, require addressment are:

1. The lack of battery recharging infrastructure
2. The problems faced by Eskom, which equate to loadshedding and unstable electricity produced
3. The current high cost of electrical vehicles
4. The long distances travelled by South African commuters
5. The lack of taxation incentives, to reduce the cost price of electrical vehicles.

The only factor identified, which will currently entice customers to switch from ICEVs to electrical vehicles, is:

1. The negative impact ICEVs have on the environment concerning carbon dioxide emissions and global warming.

Recommendations to vehicle manufactures operating in South Africa and to the government are made and discussed under section 5.2 in Chapter 5 with the objective to create an appealing environment for the widespread utilisation and adoption of EVs in South Africa.

The secondary stated research objectives are:

- To understand the new vehicle technology being produced by vehicle manufacturers.

The different technologies that are being produced by the foremost vehicle manufacturers are discussed in detail under section 2.4. The main categories are internal combustion vehicle engines (ICEVs) and electrical vehicles (EVs). The researcher included the following vehicles as part of EVs, which include battery electrical vehicles (BEVs), hybrid electrical vehicles (HEVs), plug-in hybrid electrical vehicles (PHEVs), and fuel-cell electrical vehicles (FCEVs). ICEVs are defined in paragraph 1, under section 2.4. BEVs, HEVs, PHEVs and FCEVs are defined in paragraphs 3, 4, 5 and 6, respectively, and the differences between these categories are expounded, all located under section 2.4. *Therefore, the first secondary objective has been achieved.*

- To define the different EVs being produced by vehicle manufacturers.

The location to find the definitions of the different EVs being produced by the foremost vehicle manufacturers is discussed above. *Therefore, the second secondary objective has been achieved.*

- To understand the essence of factors positively influencing the adoption rate of electrical vehicles by customers in the leading countries and to determine whether a correlation exists.

The information pertaining to addressing the secondary objective pointed out above is discussed under section 2.9. The leading countries identified are China, Europe and the United States of America. In essence, the factors identified that increased the adoption and widespread utilisation of electrical vehicles included: *cost price of EVs, an adequate battery recharging infrastructure, taxation incentives to reduce the cost price of these vehicles, future carbon emission standards of vehicles* and *the different EV models available to customers.* The correlations identified between the factors contributing to the increased EV adoption in these three leading countries and the factors identified through the empirical study performed in this research, include: *the cost price of EVs, an adequate battery recharging infrastructure* and *taxation incentives to reduce the cost price of EVs. Therefore, the third secondary objective has been achieved.*

- To determine the factors influencing the adoption or non-adoption of innovation by customers.

Different definitions regarding innovation were discussed in paragraph 1, under section 2.11 and the researcher projected these definitions onto EVs and argued that EVs can be classified as innovation. These arguments are listed in paragraphs 3, 4, 5 and 6 under section 2.11. The characteristics influencing customers to either adopt or to reject innovations are discussed and presented in Table 4-1 under section 2.11, but for ease of reference, these characteristics are: *Relative advantage, compatibility, complexity, trailability* and *observability.* The researcher expanded this section and discussed the different stages whereby an individual decides to either adopt or reject innovations; these stages are presented in Table 5-1 under section 2.11. These stages are: *Knowledge, persuasion, decision, implementation* and *confirmation.* The categories of different adopters in a social system regarding innovations are likewise presented in Figure 13-1, under section 2.11. *Therefore, the fourth secondary objective has been achieved.*

- To determine the future possibility of South African-based vehicle manufactures to produce EVs.

Paragraph 1, under section 2.14 includes a discussion of the globalisation of the automotive industry and South Africa's inclusion as part of the global supply chain of vehicles. Paragraph 2, under section 2.14 includes the number of vehicles exported and the income generated by exporting vehicles to numerous export markets. The different vehicle models produced by several OEMs operating in South Africa are presented in Table 6-1 under section 2.14. The opportunity to manufacture EVs in South Africa was identified as a profound theme as a result of the empirical research performed in this study. The opportunity for the South African-based OEMs is present due to the high investments made in the country and it will depend on what the head offices of these OEMs decide pertaining to the vehicles that need to be produced in South Africa for the local and international markets. *Therefore, the third secondary objective has been achieved.*

- To better understand the current oil refinery- and carbon taxation environment in South Africa.

Paragraphs 1, 2 and 3 under section 2.15 include a relating to dominance of ICEVs in South Africa and the fact that although the South African government committed to the goals of the Paris agreement to reduce carbon emissions, they have not indicated any bans on the sales of ICEVs in the country. The main two categories of the global oil industry are discussed in paragraph 6, under section 2.15; these categories are upstream, and downstream sectors. South Africa is classified as a downstream oil industry as the country is not involved with the extraction of oil, but is limited to only refinery activities. Paragraph 7, under section 2.15 included a discussion of the six oil refineries located in South Africa, which distributed refined oil (fuel) to 4 600 retail petrol outlets throughout the country. Paragraphs 7 and 8 highlighted the fact that modern internal combustion engines require Euro 5 standards of clean fuel and the oil refineries in South Africa are only producing Euro 2 standards, with the costs to upgrade the oil refineries in South Africa to produce fuel of a higher quality estimated at R 40 billion. Paragraph 11, under section 2.15 includes an argument that states that South Africa is producing vehicles for numerous developed export markets and to produce vehicles of a lower standard for the local market is inefficient and impedes the global competitiveness of the local automotive industry.

Carbon taxation is defined in paragraph 3 under section 2.16 and the initial implementation and taxation rate on carbon as well as the incremental increases in this rate are discussed under paragraph 4 under section 2.16. The carbon taxation on liquid fuels is likewise discussed in paragraph 4, under section 2.16. Paragraph 5, under section 2.16 contains information from one party arguing that carbon taxation is a step in the right direction to meet the goals set out by the Paris agreement, to which South Africa pledged its commitment. Paragraph 5 also includes contrasting arguments from OUTA, who is stating that there is no proof to suggest that carbon taxation will change customers' behaviour. Paragraph 6 under section 2.16 includes a discussion regarding the high amounts of taxations imposed on new vehicles, ranging from R200 000 to R900 000, of which carbon taxations form part of the 42% aggregated total. Paragraph 7, under section 2.16 includes a discussion relating to carbon taxations that will either increase the cost of living and job losses will be the result, or carbon emissions will be reduced as a result of the carbon taxation imposed, but it will deter economic behaviour, which will also result in job losses. *Therefore, the fifth secondary objective has been achieved.*

5.2 Recommendations to stakeholders

This research study sough to determine the factors that will increase the adoption rate of electrical vehicles in South Africa. The researcher's recommendations are based on empirical research performed and insights obtained from the *international supply side* of vehicles, the *local supply side* of vehicles and the local *retail side of the automotive industry*. The researcher provided recommendations to both the private sector, which compromises the vehicle manufacturers operating in South Africa and to the South African government.

The most important recommendations to automotive manufacturers operating in South Africa are to increase the efforts in developing and constructing a battery recharging network as customer range anxiety was a main reason identified that is discouraging customers to purchase electrical vehicles.

The literature review highlighted that perceived usefulness of innovation would increase or decrease the adoption; therefore, OEMs can test the market appetite for electrical vehicles, by offering more hybrid vehicles to South African customers. The research study argued that hybrid vehicles are part of the electrical vehicle fleet, but hybrid vehicles are on the opposite scale of a full battery electrical vehicle as these vehicles can operate by utilising diesel or petrol as an alternative fuel source. Providing customers with this usefulness and functionality would arguably result in more hybrid vehicles being adopted. It would be a good indication if customers will switch from ICEVs to electrical vehicles, if hybrid vehicle sales increase over a period of time and sales forecasts are positive for these types of vehicles. This functionality eliminates the range anxiety of customers pertaining to the lack of battery recharging points and this would provide OEMs with more time to develop and to roll out a battery recharging network as the research indicated that consumers would switch to electrical vehicles within the next 10 to 15 years.

It is recommended to all OEMs in South Africa planning to manufacture vehicles to form strategic partnerships to reduce the cost of developing and rolling out a battery-recharging network. A complementary strategy, which can be implemented is to develop electrical vehicles with solar panels, which can charge vehicle batteries while customers are driving, would arguably decrease the number of battery recharging stations required throughout the country. Furthermore, the research indicated that participants would prefer

convenience charging, which includes being able to recharge vehicles at their homes and offices/workplaces. It is therefore further recommended that OEMs provide customers with the option to have a home-based battery recharging station installed at their homes. Strategic partnerships can be made with OEMs and the developers of office- and residential complexes to install a number of battery recharging stations at these complexes. This would arguably reduce the number of battery recharging points required throughout metropolitan areas and investments can be made to increase the number of battery recharging points on the roads between large cities, for example the N1 between Johannesburg and Cape Town and the N3 between Johannesburg and Durban.

The most important recommendations to government would be to ensure that the current challenges faced by the national electricity producer are addressed to ensure that sufficient and stable electricity supplies are generated to eliminate the anxiety experienced by customers. The lack of electricity supply was identified as one of the most profound reasons why customers would not switch from ICEVs to electrical vehicles.

Furthermore, electrical vehicles can be driven by governmental employees to create awareness in South Africa by increasing the number of electrical vehicle sightings on South African roads, if the problems facing the national electricity producer are eradicated and if an adequate battery-recharging infrastructure is developed. This will highlight the confidence levels of government departments in the electricity output that is generated, which will instil confidence in the public. If government departments adopt electrical vehicles, this will likewise indicate an adequate number of battery recharging stations available to the public.

The South African government can pass legislation to enable private suppliers to generate electricity for consumers by investing in renewable/green energy technology such as solar panels and wind turbines, which could eliminate loadshedding and increase the total electricity output of the country.

The government can develop legislation in the form of either taxation incentives given to South African OEMs to reduce the cost prices of electrical vehicles or incentives given directly to customers to reduce the net taxation returns on an annual basis. This could incentivise South African customers to switch from ICEVs to electrical vehicles, as

previous research studies concluded with certainty that these types of incentives increased the adoption of electrical vehicles.

Cooperation is required between the private sector (OEMs) and the South African government to provide direction whether the OEMs operating in South Africa will predominantly focus on the African continent as an export market, which will require new technology-advanced oil refineries. Should Africa be the future focus pertaining to vehicle exports, then the government could assist the private sector to establish more technology advanced oil refineries to produce cleaner fuels, which will eliminate the adaptions required to South African vehicle engines to enable them to operate on inferior fuels. Another export revenue stream can be develop whereby South Africa can export cleaner fuels to African countries alongside new vehicles. Should Europe remain the focus pertaining to vehicle exports, then investments can rather be made into green energy sources to enable the development of a strong local market for electrical vehicles, which will support the export drive of electrical vehicles to Europe and other countries demanding electrical vehicles.

However, in summary, by taking all the information presented above into consideration, it seems like South Africa is not yet ready for a major transition to electrical vehicles. It is clear that a great deal of time, effort, cooperation and investment are required to develop a conducive environment for the increased adoption and widespread utilisation of electrical vehicles, and therefore the researcher provides the final recommendation to all parties involved, including the private- and public sector, which is discussed below.

There are four main South African automotive industry bodies, namely the National Association of Automobile Manufacturers of South Africa (NAAMSA), the National Association of Automotive Component and Allied Manufactures (NAACAM), the Retail Motor Industry organisation (RMI) and the African Association of Automotive Manufacturers (AAAM) (AIEC, 2019:8-9). These industries have contributed significantly to creating an appealing environment for global OEMs and component suppliers to produce automotive vehicles and -products in South Africa (AIEC, 2019:8-9).

The researcher argues that automotive industry bodies are imperative to create an environment for an automotive industry to flourish and therefore recommends to OEMs and the government to create an industry body with the main objective of cooperating

efforts from numerous parties, including the private- and public sectors to create a conducive environment for electrical vehicles in South Africa. For example, a National Association for Electrical Vehicle Development in South Africa (NAEVDSA) can be incorporated to commence with creating an appealing environment for electrical vehicles in the country. The existing industry bodies have their own mandates and objectives, which are presented in the table below.

Table 10-3: Mandate and objectives of the existing automotive industry bodies

Automotive industry body	Mandate and objectives
NAAMSA	This industry body represents the interest of both new vehicle manufacturers in South Africa regarding the manufacturing of passenger- and commercial vehicles, as well as companies involved with the importation and distribution of new vehicles throughout South Africa.
NAACAM	This association represents the interest of automotive component manufacturers in South Africa, which comprises almost 80% of first-tier component manufacturers. With 200 local manufacturing sites, this body is also the administrator of the South African Tyre Manufacturers conference, representing the four international companies manufacturing tyres in South Africa, including, Bridgestone, Continental, Goodyear and Sumitomo.
RMI	The industry bodies discussed above, represented the *local supply side (manufacturing)* of new vehicles and components associated with the manufacturing of new vehicles. The RMI represents the interest of the *local retail side of the automotive industry*, which includes 7 500-member businesses throughout South Africa.
AAAM	The main objective of AAAM is to develop the economic potential of the African continent, by specifically

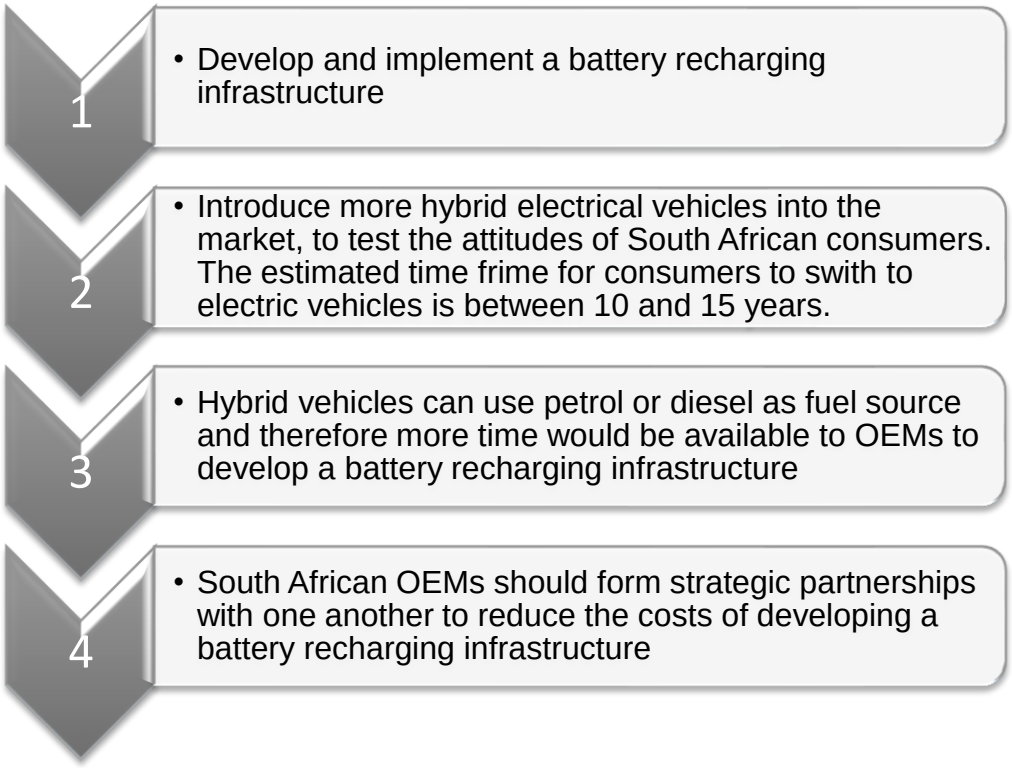
	developing a conducive environment for a pan-African automotive cluster. This includes engaging with government, industry bodies and representatives from the African automotive sector to develop a regulatory framework, which is investor friendly, to establish a viable automotive manufacturing industry on the continent for both vehicle assemblers and automotive component suppliers.

Source: Compiled by the researcher, adapted from AIEC (2019:8-9)

It can be argued that the promotion of electrical vehicles should fall under the mandate of NAAMSA; however, the researcher argues that a specific industry body is required to promote the development of electrical vehicles. The industry body can have the same mandate as AAAM, who is starting from scratch to develop a pan-African automotive manufacturing industry, with the electrical vehicle industry body focusing on developing a viable electrical vehicle market in South Africa. The mandate of this proposed industry body, if successfully implemented in South Africa, can be expanded to include other African countries to become a true pan-African industry body for the promotion of electrical vehicles on the African continent.

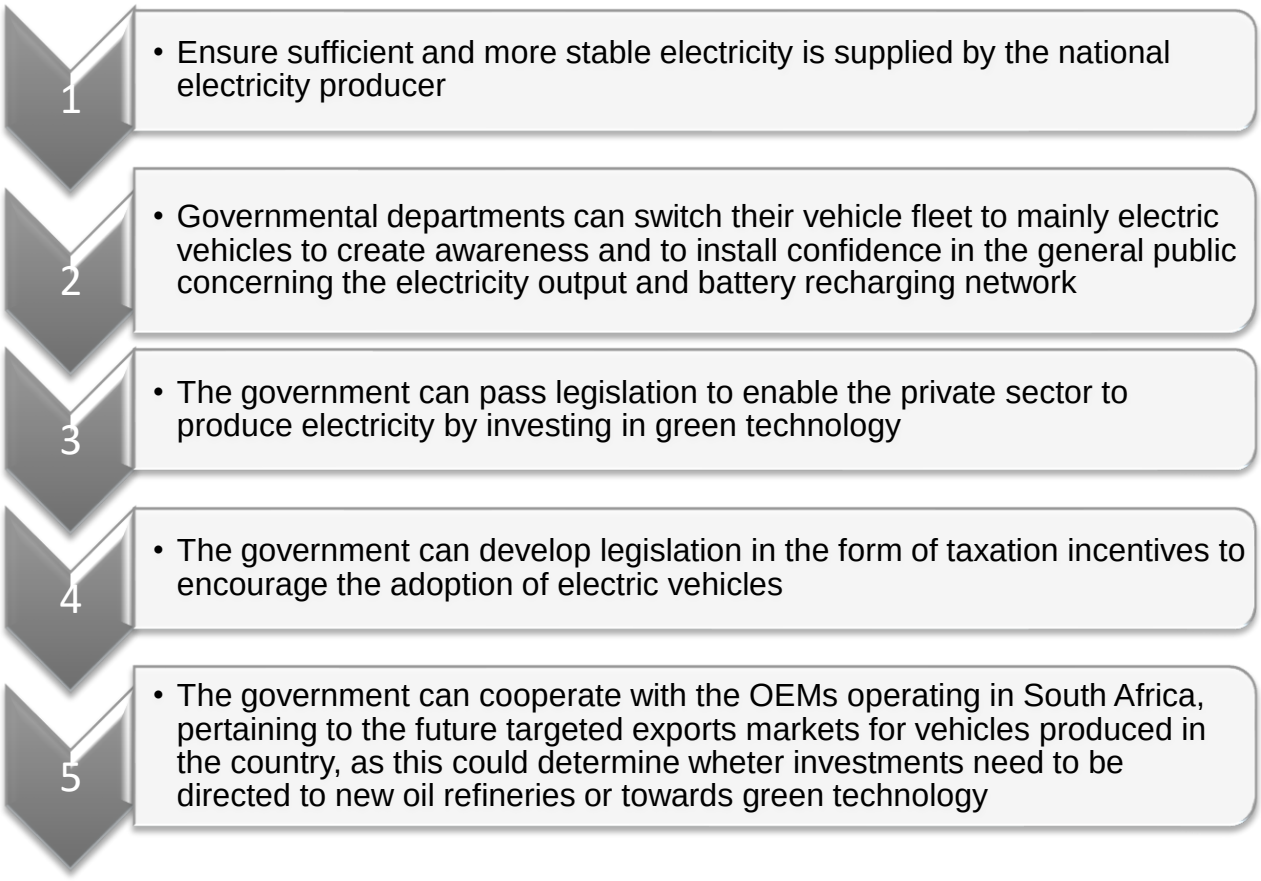
The succeeding two figures highlight the recommendations, as discussed in detail above, to vehicle manufacturers operating in the country and the South African government pertaining to creating an environment, which will be conducive for the widespread adoption and utilisation of electrical vehicles in South Africa.

Figure 29-13: Recommendations to vehicle manufacturers operating in South Africa



Source: Compiled by the researcher

Figure 30-14: Recommendations to the South African government



Source: Compiled by the researcher

5.3 Limitations of the research

A convenience sampling strategy was employed rather than a random sampling strategy to source potential participants representing the local *retail side of* the South African automotive industry.

Convenience sampling was used as result of the national lockdown imposed by the South African government due to the Corona (COVID-19) virus outbreak. The Corona virus is a respiratory illness, which emerged from the Republic of China in December 2019, resulting in a global pandemic (Sauer, 2020). Precautions implemented by the South African government because of the Corona virus included the implementation of a 21-day lockdown from 26 March to 16 April due to an increase of confirmed cases in the country; however the initial 21-day lockdown was increased with two weeks, to the end of April

2020 (Heiberg & Winning, 2020; SA News, 2020). The president of South Africa, Mr Cyril Ramaphosa, announced that the five-week nationwide lockdown would be alleviated with a risk-adjusted strategy to gradually reopen the economy of the country (Cotterill, 2020). The South African government announced that the risk-adjusted strategy to progressively reopen the economy will last between six and eight months (Business Tech, 2020).

The ethical clearance received for this study specifically mentioned that should the study incorporate the process of collecting data from participants and/or be in any other contact with participants, the researcher should ensure compliance with the restrictions imposed by the South African government pertaining to the COVID-19 crisis. A copy of the ethical clearance is added as Annexure 1 in this research study.

Therefore, the researcher decided on a convenience sampling strategy to identify potential participants to partake in this research study as this strategy will eliminate the possible risk of not completing the research study within the scheduled period, a risk that might have realised if a random sampling strategy was followed.

Vehicle manufacturing companies are resolute in their efforts upscale the productions of EVs to ensure the forecasted sales of EVs are met.

5.4 Recommendations for future business research

The information obtained through the literature review study in Chapter 2 and the data obtained through the empirical study in Chapter 4 led to obtaining more insights into the EV market and -environment in South Africa. These insights also led to more questions that require addressing to strengthen the local environment for the widespread adoption and utilisation of EVs. The researcher, therefore, recommends the following future studies, which could be performed to contribute to the future of the South African EV industry.

First and foremost, this research included a convenience sample to recruit respondents, due to the challenges imposed on the researcher as a result of the COVID-19 pandemic. As a result of this, the researcher recommends future studies to utilise this research as a foundation to include a random sampling strategy to determine whether the same conclusions are obtained.

Furthermore, research can be performed pertaining to the raw materials required to manufacture batteries, which are vital components for EVs. It is recommended that researchers with an engineering background should conduct this research. Should deposits of these raw materials be located in South Africa, then the research should be expanded to determine the financial viability to mine for these deposits. This part of the research should include researchers deemed as financial experts to determine the viability of mining projects and should include qualified chartered accountants, chartered financial analyst charter holders (CFAs) and Master's in Business Administration graduates (MBAs).

Should sufficient deposits of the raw materials be located in South Africa to ensure the feasibility of mining companies to invest to mine for these deposits, then the research can be further expanded to determine the feasibility to not only produce vehicles in South Africa, but to also attract foreign direct investment from battery manufactures to produce batteries for EV locally.

The availability of different EV models was one factor identified in one of the leading countries concerning the increased adoption of EVs, and therefore the researcher recommends a study to determine what EV models South African customers would prefer. This research included data pertaining to the current models and current vehicle brands driven by the respondents, but future research should be expanded to effectively determine the type of models, such as passenger vehicles, LCVs or SUVs.

EVs are a possible solution to reduce and eliminate tailpipe emissions and consequently contribute to reduce the negative effects of global warming; however, studies should be performed to assist vehicle manufacturer to reduce carbon emissions as a result of producing vehicles in their factories.

The South African *retail side of the automotive industry* should not be forgotten, as the retail vehicle industry (non-manufacturing of vehicles) likewise contributes to the local economy pertaining to job creation and GDP. The next research study is therefore recommended:

- Determine the impact of EVs on the traditional retail vehicle dealership model and the possible future loss of revenue streams.

- Develop a framework of numerous scenarios to innovate and to transform the traditional business model of retail vehicle dealerships to embrace EVs as the vehicles of the future.
- By adopting the innovation of electrical vehicles, a framework would be required to assist retail vehicle dealership to develop new revenue streams.
- A new possible revenue stream that can be develop is to install battery recharging points at dealerships to recharge passing EVs.

The innovation index per country was presented in Figure 14-1 under chapter 2 and this information indicated that South Africa ranked 64th out of 129 countries assessed in the world pertaining to this index, with Switzerland being ranked as number 1 and Yemen ranked last. This section also indicated that innovation is a key driver of economic growth, and therefore the researcher is recommending research to be conducted to improve South Africa's innovation index ranking, which will arguably constitute increased economic growth for the country.

5.5 Conclusion of the research study

The infrastructure in South Africa pertaining to a battery recharging network is by far not well enough developed to enable the widespread use of electrical vehicles. Similarly, the supply of electricity creates a major constraint. The shortage of skilled artisans to keep these vehicles on the road is another limiting factor.

Presently, no taxation incentives would coax vehicle owners to switch to electrical vehicles. Those who have switched to hybrid vehicles are mostly the affluent people who do this out of environmental concerns.

The potential of South Africa to become a major producer of electrical vehicles for local, continent-wide, and international use is also not a real short-term option. This could, in the longer run, become viable, tough. This long-term viability could be positively influenced if the global forecasts of electrical vehicle sales materialise and the OEM headquarters require South Africa as a manufacturing hub to commence with large-scale production of electrical vehicles to satisfy the high demand for these vehicles, if production facilities to specifically manufacture electrical vehicles are not developed and constructed in time.

The viability for South Africa to produce electrical vehicles can be negatively influenced if the disposable income of consumers in African countries increases as a result of sustainable economic growth and consumers can purchase new vehicles instead of purchasing imported second-hand vehicles. The potential increased demand for new vehicles could be satisfied with vehicles produced in South Africa. However, these vehicles would be ICEVs, as it can be argued that the environment of other African countries, as in the case of South Africa, is not conducive for the widespread use of electrical vehicles (Rao, 2019). This potential demand can be further expedited if additional governments in African countries develop and impose policies and legislation banning the importation of second-hand vehicles, which is currently the case in South Africa, Egypt, Morroca and Sudan (Kuhudzai, 2020; Silekwa, 2019).

The study has revealed that, although many South African vehicle owners are well aware of electrical vehicles and all four derivatives forming part of EVs in this research study, including BEVs, HEVs, PHEVs and FCEVs, they are however, unanimous that the South African environment is not conducive for the widespread adoption of these vehicles and specifically battery electrical vehicles.

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ANNEXURE A – COPY OF THE ETHICAL CLEARANCE FORM

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Economic and Management Sciences Research
Ethics Committee (EMS-REC)

19 June 2020

Dr Johannes Jordaan
Per e-mail
Dear Dr Jordaan,

EMS-REC FEEDBACK: 19062020
Student: Marais, Q (22861939)(NWU-00641-20-A4)
Applicant: Dr J Jordaan - MBA

Your ethics application on, *Factors influencing the adoption of electric vehicles by South African customers,* which served on the EMS-REC meeting of 19 June 2020, refers.

Outcome:

Approved as a minimal risk study. A number NWU-00641-20-A4 is given for one year of ethics clearance.

Due to the Covid-19 lock down ethics clearance for applications that involve data collection or any form of contact with participants are subject to the restrictions imposed by the South African government.

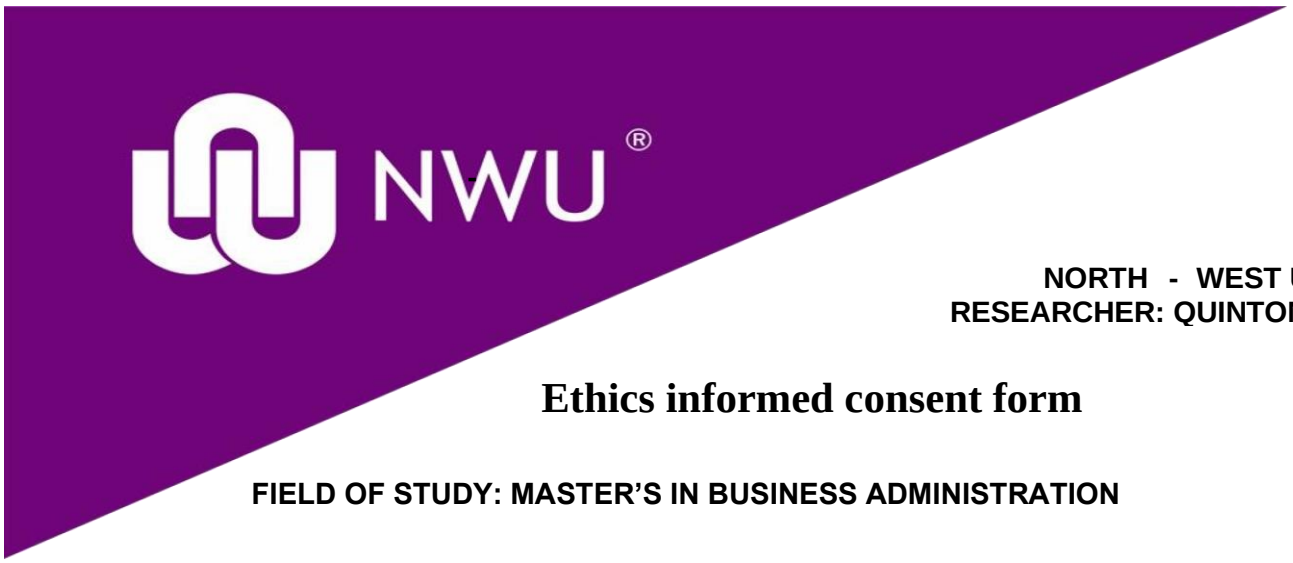
Kind regards,

Mark Rathbone

Digitally signed by Mark Rathbone
DN: cn=Mark Rathbone, o=North-West University, ou=Business management, email=mark.rathbone@nwu.ac.za, c=ZA
Date: 2020.06.26 11:40:01 +02'00'

Prof Mark Rathbone
Chairperson: Economic and Management Sciences Research Ethics Committee (EMS-REC)

ANNEXURE B – COPY OF THE INFORMED CONSENT FORM



NORTH - WEST UNIVERSITY
RESEARCHER: QUINTON MARAIS

Ethics informed consent form

FIELD OF STUDY: MASTER'S IN BUSINESS ADMINISTRATION

Contact Details

CELL: 074 894 2982

Email: q.marais92@gmail.com

Dear Interviewee

This **Informed Consent Statement** serves to confirm the following information as it relates to the MBA mini-dissertation on **Exploring factors that will influence the adoption of electrical vehicles by South African customers**

1. The sole purpose of this study is to obtain information from experts (such as yourself) employed and/or operating in the energy industry in an attempt to determine the nature of your everyday experience related to the research topic.
2. The procedure to be followed is a qualitative research design, which includes semi-structured interviews which will include open-ended questions where you will have the opportunity to communicate your views on the relevant topic during a telephonic interview. Telephonic interviews will be utilised to ensure social distancing as a result of the Corona (COVID-19) virus. Basic background

information related will be asked e.g. your name, academic qualifications and related experience to the topic.

3. The researcher will ensure a private and confidential environment by being alone in a room during the interview process. No person will be allowed in the room during the interview process.
4. The researcher will inform each participant that the interview will now commence, to ensure the potential participant can create a private and confidential environment.
5. The duration of the interview will take no longer than a maximum of 2 hours.
6. If at any point during the interview you should feel uncomfortable, you will be provided with the opportunity to make your discomfort known or immediately have the option to end your participation.
7. This interview takes place on a voluntary basis.
8. The confidentiality of the interview data is guaranteed. Fictitious names will be utilised when quoting statements in the dissertation. The interview will be recorded on the researcher's private computer. Access to the researcher's private computer is protected by a username and password. The data will be stored on the researcher's computer up and till the completion of the research study.
9. Any confidential information that prohibits the researcher to publish it in the final dissertation should be communicated during the interview.
10. A list of questions to be asked in the interview will be made available to the interviewee prior to the interview. This is done to ensure a mutual understanding of what will be asked to avoid confusion during the interview.
11. A summarised copy of the final dissertation will be made available to the interviewee upon request.
12. The data gathered from the interview will only be used for research purposes.

I, _____ (name and surname), hereby declare that I have read and understand the contents of the Informed Consent Statement, and give my full consent to progress with the interview on _____ (date) and use the information communicated by myself to him in his MBA dissertation.

Name and designation	**Signature**	**Date**

Interviewee		

ANNEXURE C – COPY OF THE LANGAUGE EDIT CERTIFICATE

To whom it may concern

Cecile van Zyl
Language editing and translation
Cell: 072 389 3450
Email: Cecile.vanZyl@nwu.ac.za

2 October 2020

Dear Mr / Ms

Re: Language editing of mini-dissertation: Exploring factors that will influence the adoption of electrical vehicles by South African customers

I hereby declare that I language edited the above-mentioned mini-dissertation by Mr Quinton Marais (student number: 22861939).

Please feel free to contact me should you have any enquiries.

Kind regards

Cecile van Zyl

Language practitioner

BA (PU for CHE); BA honours (NWU); MA (NWU)
SATI number: 1002391