UNPACKING THE TECHNICAL AND PERCEPTION BARRIERS TO ELECTRIC VEHICLE UPTAKE IN SOUTH AFRICA

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ABSTRACT

Rapid population growth and urbanization in South Africa exert ever more pressure on energy and transportation demand. As the South African transport sector is very reliant on fossil fuels, this may lead to increased tailpipe pollution, increased imports of fuel and pressure on the fiscus. Simultaneously, the global transition to electromobility is occurring rapidly in Asia, Europe, and the United States. South Africa lags the rest of the world with electric vehicle uptake. This paper unpacks the technical and perceived barriers that may hinder the mass uptake of electric vehicles. It furthermore assesses the opportunities in South Africa for electric vehicles and the global growth thereof. The study uses a quantitative approach to address the research objectives and uses primary and secondary data sourced using snowball sampling techniques and social media platforms to gather opinion data from experts in the automobile industry, public sector and general public.

The results indicate that electric vehicle technology can lower carbon emissions, stimulate innovation, decrease the country's dependence on fossil fuel and foster economic development by lowering transport costs. Nevertheless, electric vehicle technology is associated with social, infrastructure, economic and political challenges that need to be overcome. The results further show that the higher price premium of electric vehicles cannot be offset by only lower running costs. As a result, capital subsidies, lower import tariffs and supportive transport policies are required to promote electric vehicles. The study informs consumers, automobile industries and policymakers of the implications of mass uptake of electric vehicles and the incentives required to stimulate electric vehicle update.

Keywords: Electromobility, electric vehicles, adoption barriers and opportunities, global electric vehicle development.

1. INTRODUCTION

The transport sector is a catalyst for economic development and the improvement of the welfare of nations. It provides accessibility, lower production costs and ultimately leads to larger markets. Transport operations are however associated with many externalities such as greenhouse gas emissions being the sector that consumes the most energy (Ritchie & Roser, 2017). With rapid urbanization and car ownership in developing countries such as South Africa, the rate of carbon emission is increasing at a higher rate than before. Soaring oil prices, fuel shortages and the impact of climate change have led to global disruption in the transport sector, causing countries and automakers to explore alternative options such as biofuel, solar and battery-powered vehicles (World Bank Group, 2015).

This research aims to provide some information on the adoption barriers and the public perception of electric vehicle technology in South Africa. It is also important as it contributes towards the ongoing conversation of electric vehicle adoption on a wider global scale. On the global level, much research has been conducted on the use of electric vehicles, but limited research has been conducted that relates to South Africa or Sub-Saharan Africa. To address this gap, the research provides an in-depth analysis of electric vehicle development, adoption barriers, and opportunities that electric vehicle technology will bring to South Africa. It further evaluates the ownership cost of electric vehicles compared to internal combustion engine vehicles in South Africa. Such cost comparison will yield much insight into the affordability of electric vehicles and the developments that will need to take place to lower the total cost of ownership. The study is important as it informs consumers and policymakers of the important cost drivers that influence the uptake of electric vehicles. This can be useful to automobile industries, fleet purchasers and private owners who are planning to switch to low-emission vehicles.

2. LITERATURE

2.1 South Africa's Electric Vehicle Roadmap

Holley (2017) indicates that as countries develop the impacts on global energy consumption and greenhouse gas emissions become substantial. The transport sector, particularly in developing countries, plays a critical role in global energy consumption and strategies to reduce greenhouse gas emissions. South Africa is committed to cutting emissions by 34% by 2020 and 42% by 2025 (World Bank Group, 2015). To achieve this carbon emission commitment, several technologies such as electric vehicle innovation is considered. According to Ritu Shah (2019) in 2018 about 1.6 million electric vehicles were sold in the United States, Europe and China and the uptake is set to increase in the coming years. The most rapidly growing electric vehicle markets globally include the People's Republic of China, Germany, Netherlands, Norway, Sweden, United Kingdom and the United States. These countries are currently active in electric vehicle production and account for high global electric vehicle sales.

South Africa's electric vehicle market is very small compared to other countries in the Western world. According to the Department of Transport, there are only 867 electric vehicles on South African roads, with the majority of these vehicles in the Gauteng and the Western Cape (DoT, 2018). Nevertheless, many projects and demonstrations such as 'Green Transport Strategy 2018-2050' and Jaguar 'Powerway' will assist the country roll out electric mobility.

2.1.1 Department of Transport (DoT) Green Transport Strategy

The DoT's 'Green Transport Strategy 2018-2050' is the first national policy document promoting electric vehicle adoption in the country. It is committed to providing a world-class transport system that reduces both the cost of transport and the emission of greenhouse gases in South Africa (DoT, 2018). This strategy proposed several electric vehicle policies such as a reduction of import tariffs on electric vehicles and incentivizing the electric vehicle market to make it affordable and attractive to both the local and international market. It is also committed to working with research institutions and battery manufacturing companies to create an enabling environment for mass production (DoT, 2018). Other public and private organizations such as the South African Energy Development Institute (SANEDI), United Nations Industrial Development Organization (UNIDO), National Association of Automobile Manufacturers of South Africa (NAAMSA) and Greencab are some of the organizations promoting electric mobility in South Africa.

2.1.2 *Jaguar Land Rover*

Jaguar Land Rover in conjunction with GridCars, which is an electric vehicle charging service and equipment company, has involved R30 million into an electric vehicle infrastructure project known as Jaguar ‘Powerway’, a network of public charging stations being developed in South Africa. This will include about 80 charging points, some of which will be located at Jaguar Land Rover dealerships and shopping centers around the country. Twenty-two (22) of the charging stations will be along the N3 between Gauteng and Durban and the N1 between Gauteng and Cape Town. Besides, Cape Town will be connected to East London through the Garden Route (N2) with several charging stations (Reuters, 2017).

2.2 The Ownership Cost

The total cost of ownership (TCO) of a vehicle is the purchase price plus the costs of vehicle operation. The lower the total cost of ownership the better value for the consumer (Al-Alawi & Bradley, 2013). Dumortier, (2015) therefore studied the effects of providing information on the total cost of ownership on consumers’ decision to purchase electric vehicles in the US. The study provided information on five-year fuel cost savings, the total cost of ownership and the effects of this information on consumers’ purchase decision. Through an online survey with an embedded experimental design using different labels, the study found that respondents' preference for certain vehicles was not affected by information on five-year fuel cost savings. However, the information on the total cost of ownership increased consumers' preference for car size.

Wu, Inderbitzin and Bening (2015) on the other hand compared the total cost of ownership of electric vehicles to conventional vehicles in Zurich, Switzerland using probabilistic analysis and projection across different market sectors for 2014, 2020, and 2025. The results indicated that the relative cost-efficiency of electric vehicles increases with the consumer's driving distance, especially for smaller vehicles. However, the total cost of ownership is subject to the specifications of the vehicle and operating costs. The study further indicated that the total cost of ownership of electric vehicles may become close to or even lower than that of conventional vehicles by 2025. The total cost of ownership does not affect consumers’ purchase decision making.

The study by Letmathe and Suares (2017) theorized that the total cost of ownership method can be used in two different ways, through a consumer-based method or a society based method. Their study explains that a consumer-based total cost of ownership method includes the purchasing price as well as all costs related to receiving and using the item, which is borne by the consumer. The society-based total cost of ownership considers environmental costs such as carbon dioxide (CO_2) emission costs in addition to the capital and operating cost of the vehicle.

Gilmore and Lave (2013) compared resale prices and total cost of ownership for fossil fuel, hybrid and diesel passenger cars in the US. The study confirmed that higher fuel economy vehicles retain a higher proportion of their initial price than conventional options and that the ratio of the resale value to the initial purchase price increases at higher fuel prices. The study used estimations for resale ratios to compare the difference in resale prices between the electric and conventional vehicles to the discounted expected fuel savings during the periods of 2008 and 2009.

3. METHODOLOGY

Since very little information is available on the electric vehicle in South Africa and Sub-Saharan region, primary data was useful in identifying and assessing the possible barriers and opportunities of the electric vehicle technology. The study used primary data sourced from experts in the automobile industry and the general population. The experts included people working in the automotive industry in either the public or private sector. Various research techniques such as snowball and authoritative methods were used to recruit the participants. Second survey included ordinary South Africans residing in and around Cape Town, Durban, Johannesburg, Pretoria, Nelspruit and Port Elizabeth. Participants from these six cities in South Africa were chosen using a convenient sampling method. Moreover, electric vehicles are known to be popular among city dwellers due to the accessibility of charging infrastructure in the city centers. The second survey used social media such as Facebook to get more general views and perception about electric vehicles. The sample collected was not necessarily representative of the general population; however, it provided helpful marketing information about electric vehicles uptake in South Africa.

3.1 Expert Survey

Snowball sampling, which involved a primary data source nominating another potential primary data source was used. Twenty-nine (29) respondents through five experts initially recruited through LinkedIn participated. The sample of 29 experts had a significantly higher representation of males (93%) compared to females (7%). A greater percentage of the respondents (72%) were between the ages of 36 and 56. From the working sector standpoint, less than half (45%) of the sample worked as consultants, NGOs and as researchers in the automobile industry. The questionnaires covered aspects such as vehicle ownership and vehicle use costs, opportunities and challenges of electric vehicles uptake in South Africa as well as the trend in local electric vehicle development compared to the global trend. The survey was created on the University of Stellenbosch survey platform. An official invitation letter with the link to the survey was sent to the respondents through their LinkedIn accounts or email addresses, and they could log in to take part anonymously after accepting to participate.

3.2 Public Survey

To complement the opinion of the experts, a second data collection effort was undertaken among the public. The targeted population were individuals located within a 50 km radius of selected major cities in South Africa. This was due to the popularity of electric vehicles among city dwellers due to their travel range and the availability of charging infrastructure. These cities included Cape Town, Pretoria, Nelspruit, Johannesburg, Port Elizabeth and Durban. Facebook was used to collect data from the sample population. The sample had a significantly higher representation of males (85%) compared to females (15%). The largest proportion of the respondents (76%) were white, with a greater percentage (81%) aged above 36 years. More than half (81%) of the respondents had some form of tertiary education. The questionnaires dealt with the participants' knowledge of, interest in and motivation for electric vehicle adoption and use. A Facebook page called "Sustainable Transportation Africa" was created for the survey, where an official invitation was posted together with the link to the survey requesting participants participate voluntarily. After accepting the invite, the participants could access the survey and partake anonymously. The link to the survey was shared and advertised on the Facebook page. About 12 000

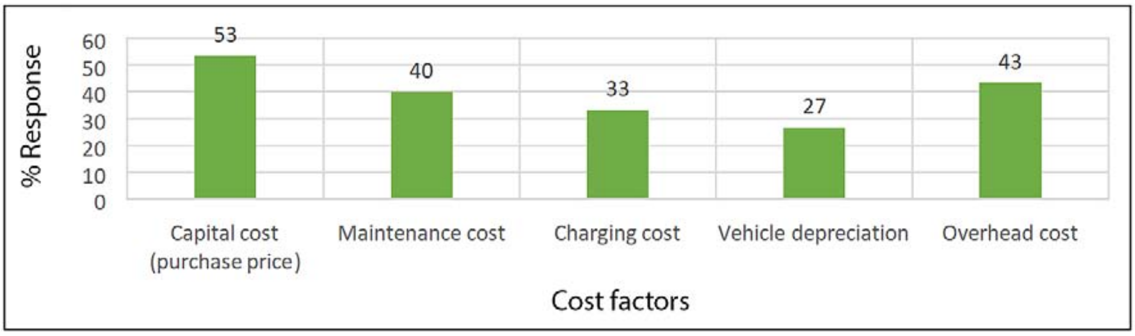
Facebook users within the specified geographical areas were reached, with 1 231 people engagements and 83 responses.

4. RESULTS AND DISCUSSION

4.1 Expert Survey

4.1.1 Electric Vehicle Ownership Cost Factors

The respondents were asked to rate and rank on a 5-point scale from 1 (unimportant) to 5 (very important) some of the related cost factors such as capital cost, maintenance cost, charging cost and overhead cost. The result presented in Figure 1 shows the capital cost (53%) as the most important cost factor, followed by the overhead cost (43%). Maintenance cost (40%) as well as charging cost (33%) featured third and fourth respectively, while vehicle depreciation (27%) represents the least important cost factor in electric vehicle ownership in South Africa. Other costs that are seen to be of concern to some of the experts included the insurance cost, batteries replacement cost and high import tariffs on electric vehicles.

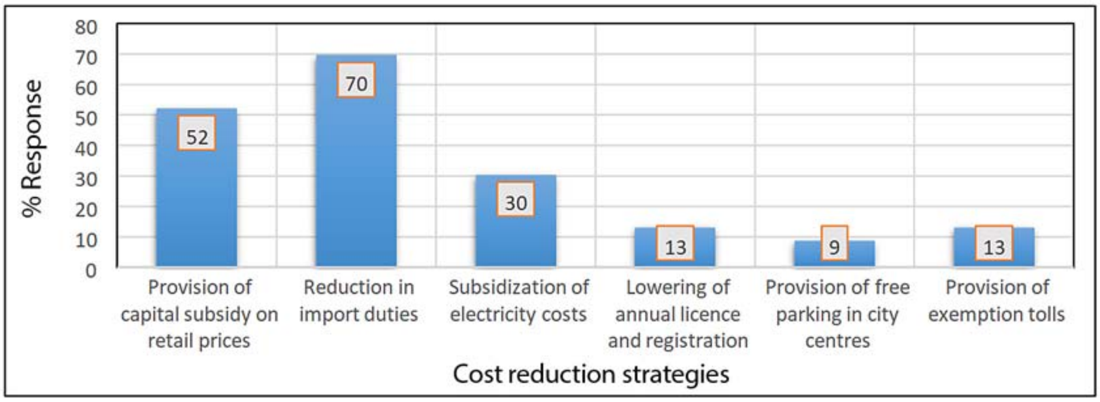


Source: Author, based on the expert survey, 2019

Figure 1: Main cost factors of EV ownership

4.1.2 Possible Cost Reduction Strategies

Many developed countries, for instance, Norway and the US have different strategies such as subsidies and tax exemptions to lower electric vehicle ownership cost and to stimulate their uptake. In the case of South Africa, Figure 2 indicates some possible cost reduction strategies that the experts deemed applicable. A greater percentage (70%) of the respondents suggested a reduction in import duties as the best strategy government can implement to lower electric vehicle ownership cost, followed by the provision of a capital subsidy on retail prices (52%) and subsidization of electricity cost (30%).



Source: Author, based on the expert survey, 2019

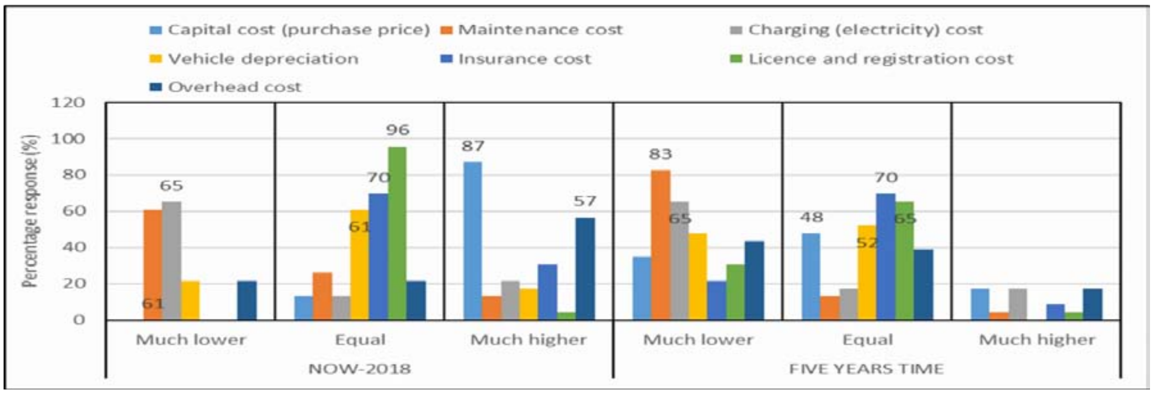
Figure 2: EV cost reduction strategies

Other strategies indicated included lowering annual license and registration cost and providing free parking in city centers for electric vehicle owners. Implementing such strategies could help lower the fixed cost of electric vehicles and induce uptake. When asked for further comments, the respondents alluded that increases in the fossil fuel tax to subsidize electric vehicle cost could be a way to stimulate the uptake. Also, the government can support the growth of local lithium-ion battery manufacturers and subsidize renewable energy systems at home to charge vehicles and power homes. This can incentivize the electric vehicle market and promote national adoption.

To find out more about the future of electric vehicles in South Africa, respondents were further asked to compare some cost factors between electric vehicles and conventional vehicles now (2018) and what they expected to happen in the next five years. Figure 3 shows that more than half (87%) of the respondents were of the view that the current purchase price and overhead cost (57%) of electric vehicles are much higher than those of conventional vehicles due to the low market share of electric vehicles in South Africa.

However, these costs may be equal to or much lower than conventional vehicles in five years. The maintenance cost (61%) and charging cost (65%) of electric vehicles is much lower now and will still be lower than conventional vehicles in the next five years, all things being equal.

Responses to the same question further showed that the depreciation, insurance, license, and vehicle registration costs of both electric and conventional vehicles are currently equal and will remain equal in the next five years' time. This response confirms the modal cost calculation in section 4.3 but only differs concerning the depreciation cost. It also confirms the literature that electric vehicles depreciate quicker than conventional vehicles because of their high initial cost premium. Concerning the overhead cost, more than half (57%) of the respondents were of the view that the overhead cost of electric vehicles is much higher now but stands to be much lower than or equal to that of conventional vehicles in the next five years. This may be due to a lack of infrastructure and special professional services related to electric vehicle technology.

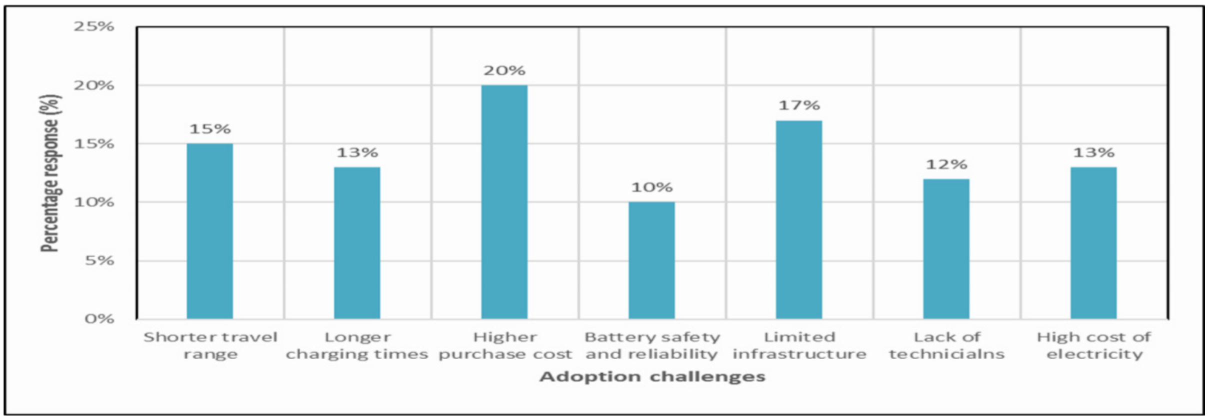


Source: Author, based on the expert survey, 2019

Figure 3: Comparing EV cost now with 5 years to come

4.1.3 Challenges and Opportunities for Electric Vehicle Adoption in South Africa

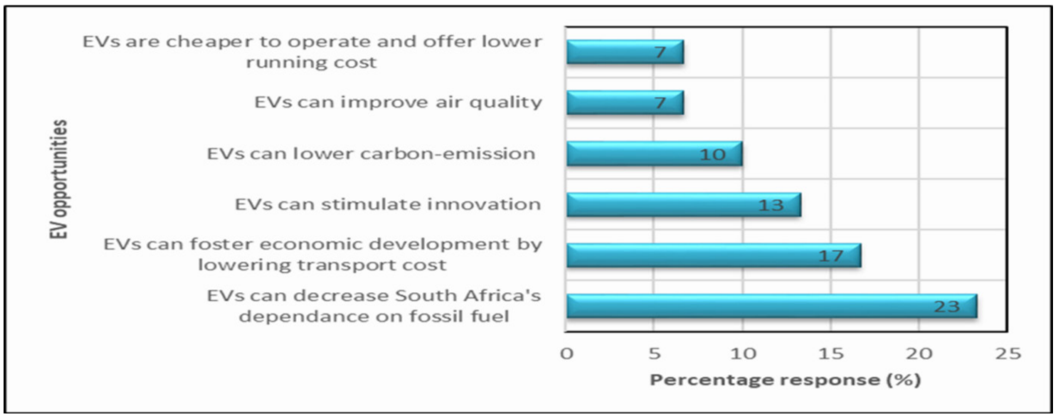
The respondents were asked to rank in order of importance five challenges that potential electric vehicle owners could face in South Africa. More than half (57%) of the respondents both experts and public surveys ranked high purchase cost as the most important challenge, followed by the uncertain value (23%) of electric vehicles as the second most important challenge. Others included the lack of charging infrastructure (20%) and maintenance technicians (20%).



Source: Author, based on expert and a public survey, 2019

Figure 4: Some challenges of EV technology

To assess the opportunities for electric vehicle adoption and innovation, the respondents were further asked to rank in order of importance some benefits of electric vehicle. Figure 5 indicates that a greater proportion of the respondents (23%) believed that the adoption of electric vehicles can decrease the country's dependence on fossil fuel. Secondly, 17% of the respondents indicated that electric vehicle adoption can foster economic development by lowering transport costs in South Africa. In response to the same question, (13%) suggested that electric vehicle adoption can stimulate innovation while 10% indicated that it can lower the rate of carbon emissions in the country. Cheaper operating cost and an improvement in air quality were ranked below all the others. This might be because electric vehicles are charged from a source that many of the respondents think is a pollutant on its own. Secondly, electric vehicle technology is new in South Africa and the country has not experienced its real benefits yet.



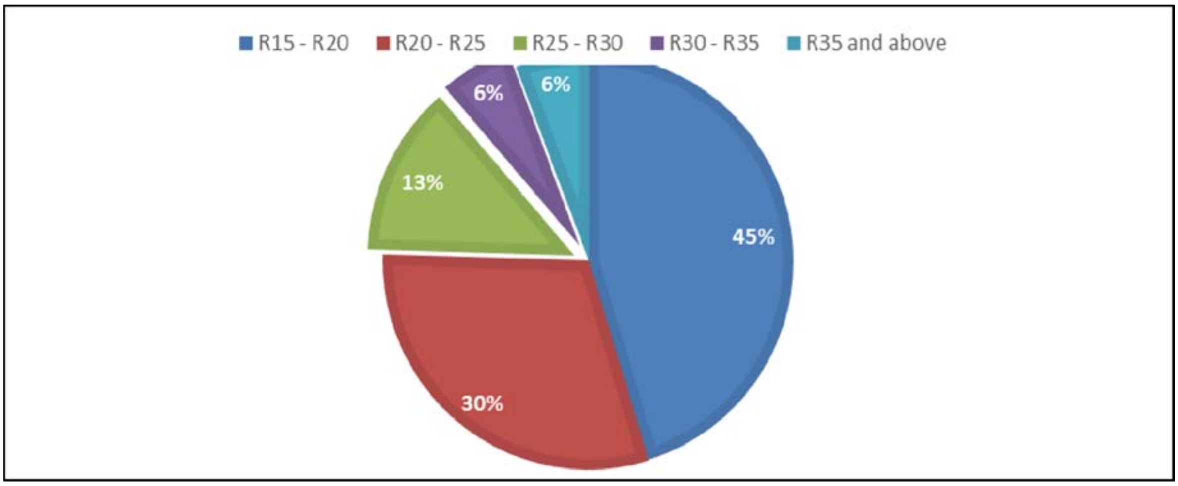
Source: Author, based on the expert survey, 2019

Figure 5: Some major EV opportunities

4.2 Public Survey

4.2.1 Cost of Fossil Fuel and Electric Vehicle Adoption

The cost of fuel influence electric vehicle uptake, as the high price may stimulate consumers to look around for an alternative way of travel. Respondents were asked what petrol or diesel would have to cost to persuade them to buy an electric vehicle. Figure 6 shows that more than half of the respondents (75%) indicated that they would only be persuaded when a liter of fossil fuel reaches a maximum of R25, while only a quarter (25%) of the respondents indicated that a liter of fuel would have to cost above R25 before they would look around for an alternative way of travel such as an electric vehicle.

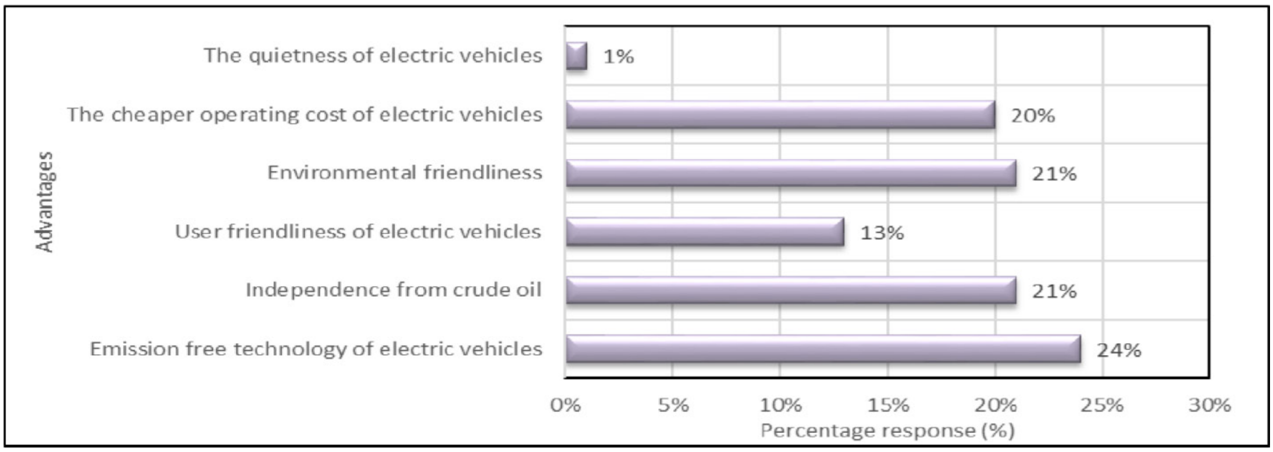


Source: Author, based on the public survey, 2019

Figure 6: Cost of fossil fuel and EV adoption

4.2.2 Advantages of Electric Vehicle Technology

Despite the number of challenges identified with electric vehicle innovation, Figure 7 shows that electric vehicles are emission-free and the most environmentally friendly technology with cheaper operating costs.



Source: Author, based on the public survey, 2019

Figure 7: Advantages of electric vehicles

4.3 Vehicle Ownership Cost

Due to the low level of electric vehicles uptake in South Africa, its technology remains a topic of debate for many while much still needs to be learnt for mass adoption. For this reason, many cost elements such as insurance cost, depreciation and cost of capital related to electric vehicles are not yet known and are therefore assumed to be the same as those of a conventional vehicle until electric vehicles become popular in the country.

4.3.1 Cost of Charging Versus the Cost of Fuelling

While few countries have technology such as battery-swapping stations and wireless charging available to increase efficiency and reduce cost, many developing countries such as South Africa still rely on the traditional electric source plug-in charging methods. This has generated an interest in the author of this study to compare the cost of charging an electric vehicle with the fuelling of a conventional vehicle in South Africa. Based on November 2018 fuel and electricity costs, an energy consumption cost comparison between conventional, hybrid and pure electric vehicles has been done to ascertain which vehicle type has a lower energy cost. To be able to compare the exact amount of energy consumed by either conventional or electric vehicle, the fuel cost per liter is assumed to be R17.08 and R1.50 for a unit of electricity (Eskom, 2018).

The vehicles used in the cost comparison included a 2017 Toyota Corolla (Vehicle D conventional), Toyota Prius (Vehicle C - hybrid), BMW i3 and Nissan leaf (Vehicle B and A battery electric vehicles). Hypothetically, an average South African living in Stellenbosch, who owns and uses a 2017 Toyota Corolla 1.6, works five days in a week and drives a hundred kilometers per return trip, it will cost R109.31 (R17.08 x 6.4L) in fuel per day and R546.55 (109.31 x 5 days) weekly. This is approximately R1.09 per kilometer. The same distance would have cost R63.37 a day and R316.85 a week using Vehicle C (hybrid). Moreover, pure electric vehicles would have lowered the cost to only R46.089 per return trip and R230.45 a week, which is R0.46 per kilometer. This means using an electric vehicle would have been 58% cheaper than using the conventional vehicle, and 27% cheaper than a hybrid electric vehicle.

4.3.2 Total Cost of Ownership

The cost model developed by the transport unit of Stellenbosch University's department of logistics was used in the study to calculate and compare the ownership cost of conventional, hybrid and pure electric vehicles. The ownership cost includes both fixed and variable cost components such as purchasing cost, fuel cost, insurance, maintenance and depreciation. Detailed cost analyses are obtained using the annual vehicle cost elements in the model calculations. The cost model identifies a single value on the complete ownership of each vehicle type for daily, weekly, monthly and annual commuting.

Table 1 shows that the vehicles with the highest purchase price, in this case, vehicles A and C, have the highest fixed cost and ownership costs followed by vehicle B and vehicle D respectively. While the conventional vehicle has the lowest cost of ownership compared to all the electric vehicles, the variable cost exceeds that of the electric vehicles. The main contributing factor to vehicle ownership cost is the vehicle's purchase price.

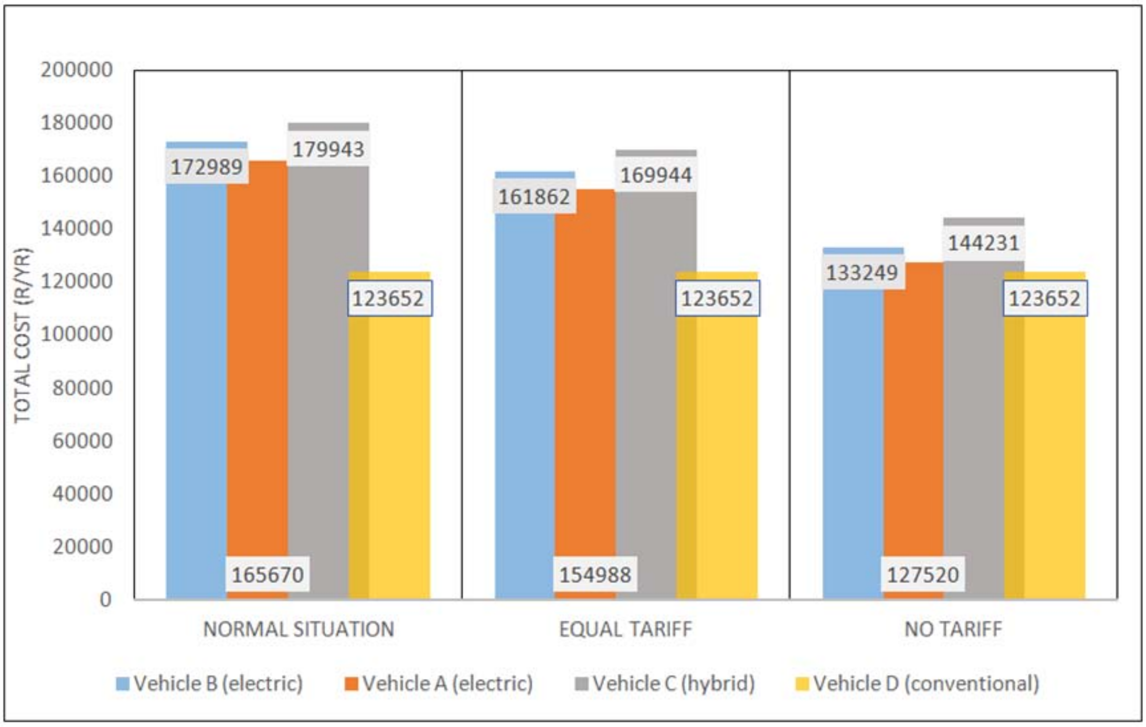
Table 1: Modal Cost Calculation Summary

TYPE OF CAR (2017 MODELS)	PURCHASE PRICE (R)	FIXED COST		VARIABLE COST		TOTAL COSTS (R)			
		R/YEAR	**C/KM**	**R/YEAR**	**C/KM**	**Year**	**Month**	**Week**	**Day**
Vehicle A (electric)	527000	174422	1163	10889	72	**185291**	14214	3554	502
Vehicle B (electric)	457000	151277	1009	10823	72	**162099**	12435	3109	444
Vehicle C (hybrid 1.8)	471 800	171861	1148	12995	87	**184855**	14181	3545	506
Vehicle D (conventional 1.8)	328000	99487	663	19637	131	**119125**	9138	2286	326

Source: Author, based on modal cost calculation

4.3.3 *Sensitivity Analysis*

Figure 8 shows that a reduction in import tariffs has a significant effect on the ownership cost of an electric vehicle. In a normal situation where electric vehicles have 25% and internal combustion engine vehicles 18% tariffs respectively, the electric vehicles have a much higher ownership cost compared to conventional vehicles. When the electric vehicle tariffs are reduced to (18%), the conventional vehicle remains cheaper, but the electric vehicles become competitive. In the third scenario where there is no tariff on electric vehicles, the electric version becomes more competitive, especially the pure battery electric vehicle (BEV).



Source: South Africa's Department of Trade and Industry, 2018

Figure 8: Effect of import tariffs changes on ownership cost

5. CONCLUSION

South Africa has many features such as renewable energy sources and road networks that make it suitable for electric vehicle market uptake. However, the innovation has experienced steady growth due to the lack of solid government support in the form of policies, incentive programs and other barriers. The main ownership cost components identified included the purchase cost, vehicle depreciation cost, insurance cost and cost of capital. Electric vehicles are known to have high purchase costs, resulting in a high ownership cost compared to conventional vehicles. The study further established that the running cost of electric vehicles is much lower than that of conventional vehicles but the high initial cost factor offsets that advantage. Several barriers hindering the uptake of electric vehicle technology in South Africa were identified and can be categorized as being social, infrastructural and economic barriers, technological and political barriers. Electric vehicles offer many environmental, health and economic benefits due to their low carbon emission and low pollution levels compared to conventional vehicles; however, their fleet share in the South African automobile market is too small to make any significant difference. Some other opportunities identified included a decrease in the country's dependence on fossil fuel, fostering economic development by lowering transport costs, stimulation of innovation and entrepreneurial skills.

In general, consumer perception of electric vehicle adoption was neither completely positive nor negative. However, the minimal negativity towards the technology that was detected cannot be ignored. Such negativities included load shedding and the fact that South Africa still relies on coal for power. These allow some consumers to question the sustainability and environmental friendliness of electric vehicles compared to conventional vehicles. Those with this uncertainty may not consider the technology to be as beneficial to the environment as it is supposed to be. The sample population used in this study was limited and may not be fully representative of the entire population; however, the results can be used to understand the electric vehicle market and also provide helpful insights into potential barriers and opportunities of electric vehicle technology in South Africa.

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