# CHALLENGES FACING SOUTH AFRICAN ROAD AUTHORITIES IN THE TRANSITION TO NEW ENERGY VEHICLE TECHNOLOGY

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## ABSTRACT

In the light of the general acceptance that climate change in the form of global warming is an unacceptable phenomenon, the South African government committed to reducing GHG emissions, embracing green mobility and introducing new vehicle technologies such as electric vehicles and hydrogen related technology.

Road authorities are responsible for the upgrading, maintenance and operation of the country's road network and need to take cognisance of the influence these technologies will have on the network. The aim of the paper is to evaluate the green mobility strategy from the perspective of a road authority and to highlight aspects to be addressed, such as the characteristics and operational requirements of new energy vehicles, possible impacts on road and traffic related standards and procedures, requirements of associated infrastructure such as charging and refuelling stations, establishment of a national charging station network, assessment of the impact on cost-benefit analysis methodology (specifically vehicle operating costs), the handling of emergencies involving new energy vehicles, and understanding the impact of a change in technology on funding, especially the fuel levy. The need to plan for the electricity requirements of electric vehicles is also discussed.

## 1. INTRODUCTION

It is worldwide accepted that climate change in the form of global warming is a reality and is caused by the emission of greenhouse gases (GHGs), mainly because of human activity. The most prominent GHG is carbon dioxide ($CO_2$), which is largely being emitted from the burning of fossil fuels, the fuel being used by the internal combustion engine (ICE). Mitigating the impact of climate change is a global priority (DOT, 2018).

The transport sector in South Africa is responsible for 10.8% of the country's total Greenhouse Gas (GHG) emissions (DOT, 2018). Road transport contributes 91.2% to total transport GHG emissions (DOT, 2018).

The South African government as signatory of the Paris Agreement, through the Department of Transport (2018), is committed to reduce GHG emissions from transport, to embrace green mobility and to introduce new vehicle technologies. Several other entities and initiatives in South African are actively working with government in introducing and implementing alternative fuel vehicle (AFV) technology, including:

- Department of Trade, Industry and Competition (DTIC).
- Department of Mineral Resources and Energy (DMRE).
- Department of Science and Technology (DST).
- Just Energy Transition (JET) programme of the Presidential Climate Commission.
- The Automotive Business Council (NAAMSA).
- The Electric Vehicle Industry Association (EVIA).
- Retail Motor Industry Organisation (RMI).
- The South African Motor Body Repairers' Association (SAMBRA).
- Trade & Industrial Policy Strategies (TIPS).
- Technology Innovation Agency (TIA).
- Hydrogen South Africa (HySA), University of the Western Cape.
- The uYilo E-mobility Programme, Nelson Mandela University, Gqeberha/Port Elizabeth.
- The African Climate & Development Initiative (ACDI), University of Cape Town.
- The Energy Systems Research Group, University of Cape Town.
- The Department of Electrical and Electronic Engineering of the University of Stellenbosch.
- Centre for Transport Development, University of Pretoria.
- Technical Innovation Hub (TIH), SANRAL.
- GreenCape, a not-for-profit organisation focussed on growing the green economy in the Western Cape Province.
- Private sector entities such as GridCars (specialising in charging infrastructure) and motor manufacturers.

## 2. PROBLEM STATEMENT

Each of these initiatives and organisations has its specific vision and goals it wishes to achieve. Road authorities, however, carry a specific responsibility regarding new technologies in that they are responsible for the establishment, upgrading, maintenance and operation of the country's road network. Road authorities need to, and are, taking cognisance of the influence these technologies may have on existing infrastructure, new needs to be catered for, new impacts to accommodate, and the influence on the operation of the road network. Road authorities need to prepare themselves for the anticipated change and ensure that in terms of their role, they are ready to accommodate new energy vehicles (NEVs) onto the road network.

## 3. AIM OF THE PAPER

The aim of the paper is to provide an overview of the AFV technologies being implemented worldwide. Although road authorities have to some extent been part of the policy formulation process, the practical implications and time frames related to the policies adopted, and those to be adopted, need to be assessed and addressed. For this reason, a short overview of the South African policy direction is provided.

Several aspects which road authorities need to attend to are discussed, including:

- Their role within the new dispensation.
- The characteristics and operational requirements of AFVs, including possible impacts resulting from a shift to AFV technologies on industry standards.
- Requirements for associated infrastructure, specifically charging and refuelling stations.
- Support to the establishment of a nationwide charging station network.
- The impact on cost-benefit analysis for new road projects and road upgrading projects, specifically vehicle operating costs (VOCs).
- Operational matters such as the handling of emergencies and accidents.
- Understanding the impact of a change in technology on road funding, specifically the fuel levy, and contributing towards finding alternative sources of funding.

In summary, the aim of the paper is to evaluate the green mobility strategy from the perspective of a road authority, and to highlight aspects which need to be addressed.

## 4. THE TRANSPORTATION INDUSTRY METAMORPHOSIS

### 4.1 Key Developments in Alternative Fuel Technology

Alternative fuel vehicles are described as vehicles which are propelled by fuels other than conventional petrol or diesel. However, hybrids (vehicles using a petrol or diesel engine with some level of electrical assistance), as well as vehicles operating on bioethanol and liquid petroleum gas (LPG) are also included in the definition (Harvey, 2022).

The most popular AFV to date is electric vehicles (EVs). Most electric vehicles are charged via a wall box charger from home, or at public charging facilities. These vehicles are also referred to as battery electric vehicles (BEVs) (Lie, Prasad & Ding, 2017).

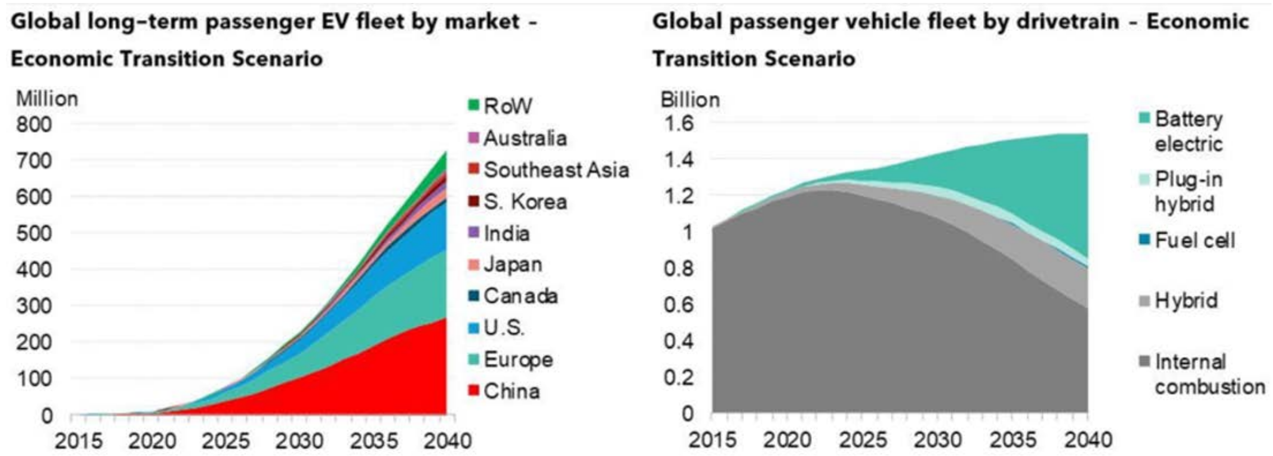
Vehicles which have internal combustion engines, but which are supplemented by electric motors and batteries, are defined as either hybrid electric vehicles (HEVs), or plug-in hybrid electric vehicles (PHEVs). With hybrid vehicles the battery is being charged from the fossil-fuelled engine as well as kinetic energy recovery, while PHEVs are charged from a charge point in the same way as a BEV.

A second technology being used is hydrogen fuel cell vehicles (FCEV). Hydrogen fuel cells generate electricity which drives an electric motor in the same way as BEVs. A battery is not being used in all applications, and where it is incorporated, it is generally much smaller than in the case of BEVs (Harvey, 2022).

A third technology being developed for AFVs is hydrogen combustion in an ICE, with hydrogen replacing the traditional petrol or diesel as energy source in the engine. These engines are referred to as hydrogen combustion engines (HCEs). Vehicle manufacturers experimenting with this technology include Porsche (du Toit, 2022), BMW (Hydrogen Central, 2022) and Toyota (Campbell, 2023).

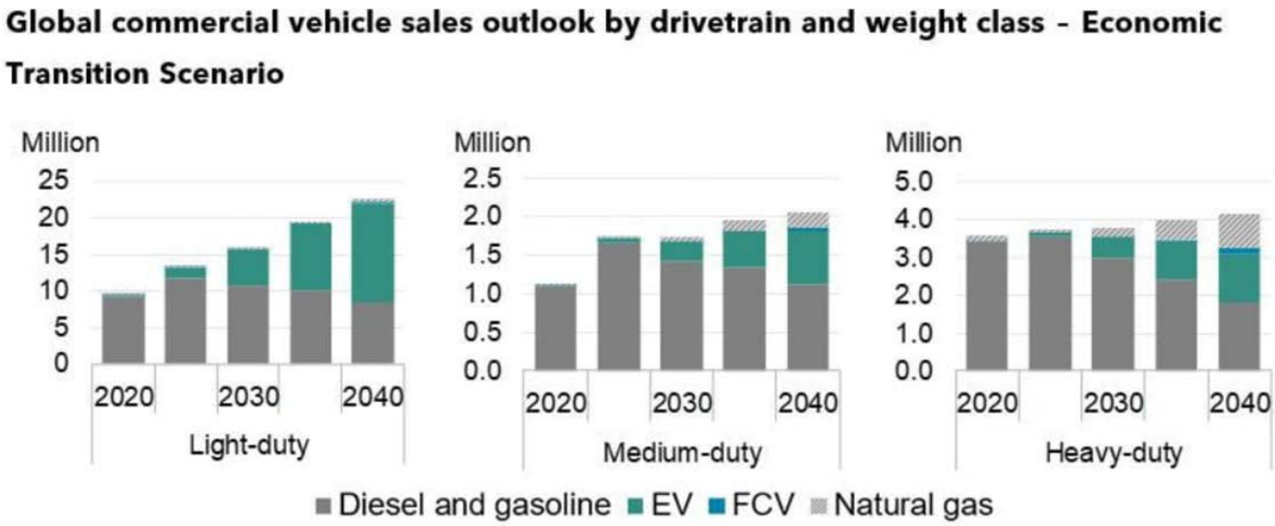
### 4.2 Alternative Fuel Technology: The Future

McKerracher et al. (2022) in the Bloomberg Electric Vehicle Outlook Report, developed an Economic Transition Scenario for passenger vehicles, shown in Figure 1, and for commercial vehicles (Figure 2). The future markets are also shown in Figure 1. In terms of this projection the dominant AFV technology going into the future is the electric vehicle, consisting of BEVs, HEVs and PHEVs.




Source: McKerracher, C et al., 2022, Electric vehicle outlook 2022, Bloomberg

**Figure 1: Global long-term passenger EV fleet by market, and vehicle fleet by drivetrain - economic transition scenario**




Source: McKerracher, C et al., 2022, Electric vehicle outlook 2022, Bloomberg

**Figure 2: Global commercial vehicle sales outlook by drivetrain and weight class – economic transition scenario**

## 4.3 Vehicle Spectrum

In assessing the impact of new technologies cognisance need to be taken of the difference in impact on the various vehicle classes. Perna (2022) indicates that BEVs are more suitable for light-duty vehicles and short-range use, while FCEVs can be used with longer ranges (for example trucks and long-distance buses). Examples illustrating this statement are listed below:

- Hydrogen fuel cell technology (FCEV) seems to be better suited to heavy vehicles:
  - Campbell (2022) reports on fuel cell electric truck performance matching the performance of diesel vehicles.

  - Sasol and Toyota SA Motors announced the formation of a partnership to develop a demonstration project consisting of the use of hydrogen powered heavy-duty long-haul trucks on corridors such as the N3 route between Johannesburg and Durban (Hydrogen Central, 2021).
  - Diversified miner Anglo American launched a zero-emission hydrogen-powered mine haul truck at the Mogalakwena Platinum Mine, capable of carrying a 290-ton payload and generating more power than its diesel predecessor (Engineering News, 2022).

- BEV technology seems to be particularly suited for light motorcycles and delivery vehicles:
  - Martin (2021) reports on the sharp increase in motorcycle electrification over recent years in Nairobi, specifically in the motorcycle taxi market.

- BEV is being used successfully for bus projects worldwide, for example:
  - Topal (2022) reports that the use of electric buses worldwide is increasing. Electric buses offer advantages in terms of operating costs and zero emissions.
  - BYD manufactured electric buses were rencently introduced at Golden Arrow Bus Services in the Western Cape (Venter, 2021).

4.4 Battery Charging

The provision and operation of battery charging infrastructure is a key component of the EV industry. Electric vehicle batteries are either charged from home or at the workplace by means of a normal domestic socket, making use of alternating current (AC), or from a public charging station making use of direct current (DC). DC chargers deliver higher charging rates (EVcharge, 2022).

GridCars (2023) was established in 2009 and operates an extensive network of public charging stations across South Africa. A total number of 300 charging points were available as on 1 Feb 2023. These charging points are distributed along the main national corridors and in the larger centra as is discussed in Paragraph 6.4 and shown in Figure 5.

4.5 Hydrogen Fuel Stations

Hydrogen fuel stations contain highly specialised technology, involving pressurising hydrogen to 700 to 900 bar (70 to 90 MPa) (Perna et al., 2022). Samsun et al. (2022) reported that at the end of 2021 there were 729 hydrogen refuelling stations in operation worldwide, serving a total number of 51 437 fuel cell vehicles. In South Africa hydrogen refuelling initiatives include:

- A hydrogen refuelling station was unveiled at the Impala Refining Services in 2016 as a combined project amongst Impala Platinum Refineries, Hydrogen South Africa Systems, the University of the Western Cape and the Department of Science and Technology (Hypertext, 2016).
- Planning by Sasol, in partnership with Toyota, to build hydrogen refuelling stations along the N3 route between Gauteng and the Durban harbour, aimed at creating hydrogen mobility along this important freight corridor (TechCentral, 2021).

## 5. SA POLICY AND INITIATIVES

### 5.1 Green Transport Strategy

Against the background of the worldwide movement towards the reduction of GHGs, the South African Department of Transport (DOT) committed Government to address the reduction of GHG emissions in the country. A Green Transport Strategy (GTS) has consequently been formulated, aimed at minimising the negative impact of transport on the environment and promoting green mobility - in support of achieving green economic growth targets (DOT, 2018).

### 5.2 Industry Focus

From the side of the vehicle industry there is overwhelming support to promote new-electric vehicles (NEVs) in South Africa, as reflected in a document published on 18 May 2021, "First input towards the development of the Auto Green Paper on the advancement of new energy vehicles in South Africa – Public consultation version" (DTIC, 2021). This green paper focusses on the development of a framework within which a comprehensive and long-term automotive industry transformation policy on NEVs can be developed. South Africa already has a world-class automotive industry in place and is committed to the new technologies. The worldwide shift away from internal combustion engines (ICEs) to New Energy Vehicles (NEVs) is a disruptive trend to the motor industry globally and South Africa will be impacted by it directly.

### 5.3 Just Energy Transition Investment Plan (JET IP)

The Just Energy Transition Investment Plan (JET IP) (The Presidency, 2022) was launched during the World Leaders' Summit at COP 27 in November 2022 (McKenzie, 2023). The South African government is committed to its Just Energy Transition and decarbonisation initiatives. This follows on COP 26 which took place in 2021, and where the governments of France, Germany, the United Kingdom, the United States, and the European Union had pledged financial support of USD 8.5 billion to assist South Africa with energy transition projects. This is part of the Just Energy Transition Partnership (JETP) between the countries. The JET IP outlines the investments required to achieve the country's decarbonisation commitments, to promote sustainable development, and to create opportunities for workers and communities affected. The JET IP addresses electricity generation, new energy vehicles (NEVs) and green hydrogen (McKenzie, 2023).

## 6. CHALLENGES FACING SA ROAD AUTHORITIES

### 6.1 The Role of SA Road Authorities

Road authorities in South Africa have a specific role in that they are responsible for providing, upgrading, maintaining, and operating the infrastructure to be used by the new technology vehicles. These vehicles, whether BEV, FCEV or even HCE, differ considerably from the ICE vehicles road authorities traditionally catered for. In this section, aspects which road authorities need to focus on and adjust to in order to be able to continue to serve the motoring public, are identified.

Regarding the JET IP, it is foreseen that national, provincial, and local government will be jointly responsible for the implementation of JET IP. The implementation responsibility must be incorporated into the existing management structures. Road authorities also have a role to play in this regard. Further, active engagement by the business sector, civil society, and labour organisations in the delivery of the JET IP is foreseen, as is illustrated in Figure 3 (The Presidency, 2022).


Source: The Presidency, 2022, South Africa's Just energy transition investment plan (JET IP) for the initial period 2023-2027

**Figure 3: South Africa's role players in the implementation of JET IP**

## 6.2 Electric Vehicle Characteristics

The characteristics of electric vehicles (EVs) differ from those of ICE vehicles. They tend to be between 10 and 20 percent heavier; and have more torque and therefore higher acceleration (Cooley, 2022). One can, therefor, expect EV behaviour to differ from that of ICE vehicles, especially on unpaved roads. Although indications from the literature are that these vehicles behave just as well, or even better than ICE vehicles, this is a factor to be kept in mind by road authorities. The additional weight is also a factor in collisions, even though heavier vehicles are generally considered to be safer than lighter vehicles (Cooley, 2022).

Feedback from an internet-based road user forum suggests that driving an electric vehicle in conditions of flooding, for example by crossing a flooded low-level bridge, is no different from using an ICE vehicle (March-E Forum, 2020).

Battery electric heavy vehicles are also heavier than their diesel counterparts. In most cases this affects the allowable payload (Lambert, 2021). Lambert (2021) reports that both the Unites States (US) and the European Union (EU) approved higher weight allowances for electric heavy-duty trucks, compared to the diesel truck equivalent (an additional 2 ton per vehicle in in the EU and 0.9 ton per vehicle in the US). This relaxation allows electric heavy vehicles to carry the same payload as traditional vehicles in those countries. This is not necessarily the case in other countries, however, and specifically not in South Africa.

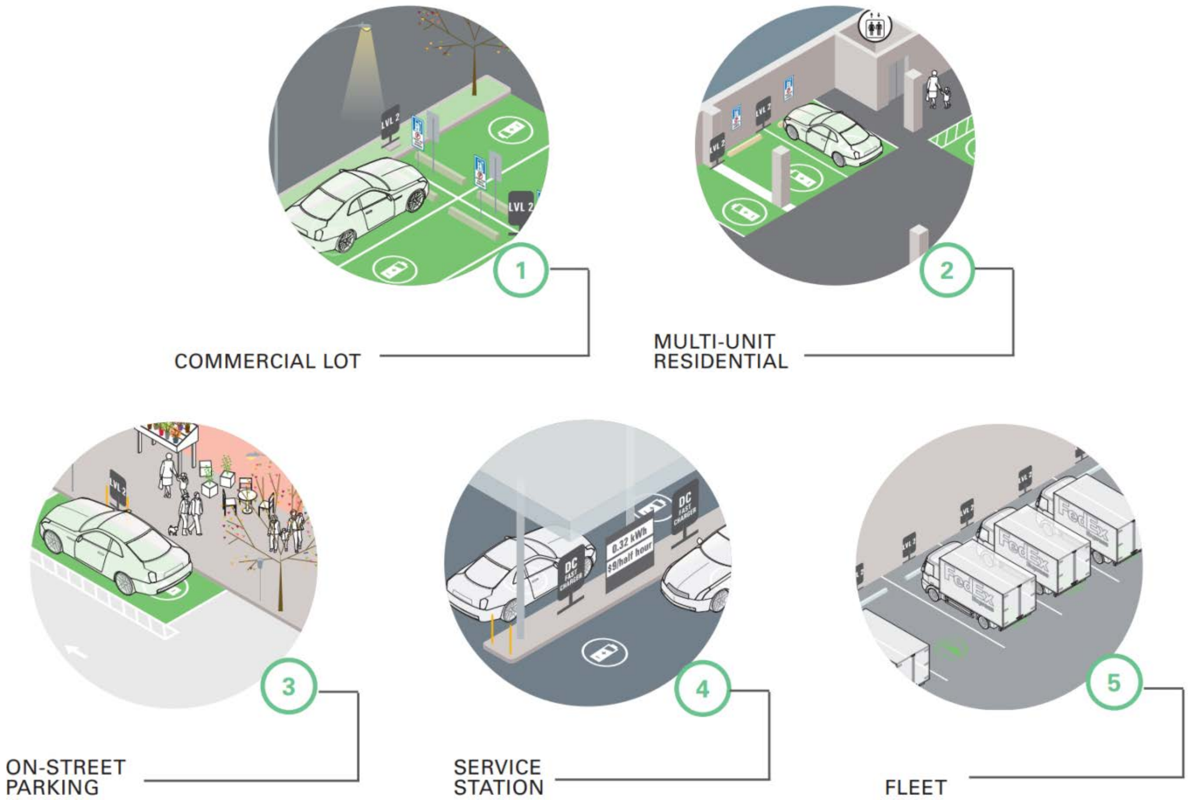
Road authorities in South Africa need to continue to monitor the change in vehicle characteristics as the percentage of new technology vehicles increases; and need to adjust design and operational standards if and where necessary.

## 6.3 Charging Facilities and Hydrogen Refuelling Stations

Standards for the design and operation of hydrogen refuelling and electricity charging stations need to be adopted and adjusted for South African conditions where this hasn't already been done. Standards need to cover both the technical equipment being used, as well as the site layout and circulation planning. As an example, WXY Architecture & Urban Design (2012) prepared siting and design guidelines for electric vehicle supply equipment (EVSE). Factors to be considered for site-level planning, which addresses the EV charging user interface, include accessibility, ease of use, visibility and the safety of installers, users, and the public in general.

The guidelines (WXY, 2012) address communication networks, connectivity to the electricity grid and the user interface. The guidelines indicate that the siting and installation of EVSE depend on considerations such as proximity to the power supply point, parking space size and orientation, pedestrian traffic flow patterns, lighting and visibility.

Figure 4 shows different charging configurations.




Source: WXY Architecture & Urban Design, 2012, Siting and design guidelines for electric vehicle supply equipment, New Your State Energy Research and Development Authority and Transportation and Climate Initiative (Nov 2012).

**Figure 4: Different charging configurations**

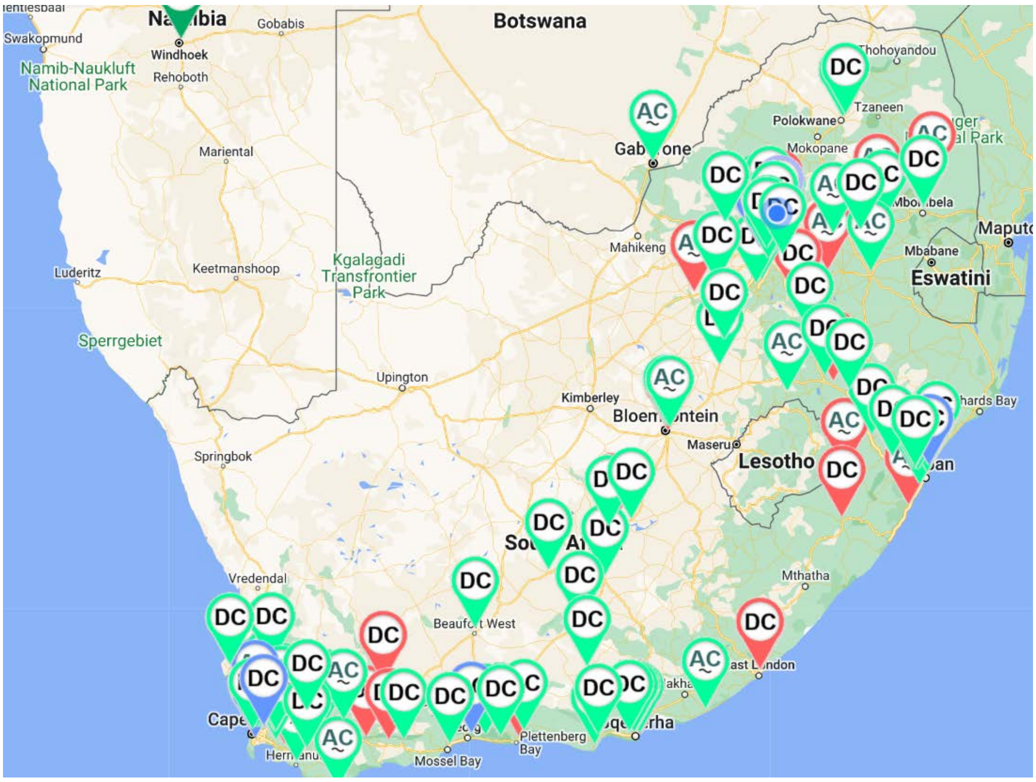
Regarding hydrogen refuelling stations, ISO19880 (2020) defines the minimum design standards, and installation, commissioning, operation, inspection and maintenance requirements for safety purposes. These guidelines apply to public and non-public fuelling stations that dispense gaseous hydrogen to fuel cell electric vehicles.

## 6.4 Charging Station Network

She et al. (2021) discuss the interdependent relationship between electric vehicles (EVs) and charging infrastructure. The nature of the layout of the charging network and the adequate provision of charging services are crucial in promoting the uptake of EVs. Due to the initial low volume of EVs, especially in lower density areas, charging infrastructure may either not be available yet, or if provided, may not meet the business expectation of its investors. This is referred to as the *chicken-and-egg* dilemma.

The road authority may wish to provide input towards the balancing of supply and demand, especially where charging facilities are being provided along national and regional roads. The right to develop economically feasible charging facilities may, for example, be linked to facilities not yet economically viable, with the objective of establishing adequate charging station coverage. South Africa has relatively long travel distances, compared to countries/regions where EVs are already widely used (for example the EU). This situation justifies the involvement of road authorities in contributing towards adequate supply of charging infrastructure.

The company, Gridcars (2023), is considered as the industry leader in direct current (DC) fast charging systems in South Africa. Gridcars has extensive experience with the installation, maintenance, and operation of DC fast chargers, and already has a network of more than 300 charge points in place, shown in Figure 5.




Source: Gridcars website (2023)

**Figure 5: Gridcars national charging network**

## 6.5 Social Cost-Benefit Analysis for New Road and Road Upgrading Projects

Social cost-benefit analysis (SCBA) methodology is well-known within the engineering fraternity. The purpose of the SCBA of infrastructure projects is to inform the decision-maker on the social costs and benefits of road projects. It is a standardised and systematic methodology to indicate whether the initial capital expenditure (the 'cost') is justified when compared to the expected benefits over the life of the project. The 'benefits' consist of savings regarding road maintenance costs, vehicle operating costs, the time cost of vehicle occupants, accident costs, etc. (Pienaar, 2018).

Vehicle operating cost models being used in South Africa have been developed for ICE vehicles and are not necessarily applicable to NEVs. Rout et al. (2022) did a comparative total cost of ownership analysis of heavy duty on-road and off-road vehicles powered by hydrogen, electricity, and diesel, which attempted to develop cost models and compare costs for the different vehicle types. Indications regarding the cost in South Africa of BEVs, compared to ICE vehicles, are:

- The purchase price of a BEV is currently higher than that of the equivalent ICE vehicle.
- The mechanical system of a BEV is simpler, which indicates that vehicle maintenance costs may be lower.
- BEVs are heavier than the equivalent ICE and use a heavier tyre. Tyre costs for BEVs can be expected to be higher.
- While the price of fuel being used in ICEs is fairly standardised in South Africa, the cost of the electricity to charge the battery of a BEV varies considerably. Generally, slower alternating current (AC) charging at home of the workplace is considerable cheaper than the fast DC charging at public charging stations. There may also be significant geographic differences in the price of electricity, or whether charging takes place in the peak or off-peak period. It will, therefore, be quite a challenge to determine the cost of electricity as part of the vehicle operating cost model. Indications are that in most cases electricity consumption cost is less than fossil fuel cost per kilometre.
- It is doubtful whether sufficient information to determine the economic life of a BEV is know at this stage. Because of the simpler driving system of a BEV the economic life may be found to be longer than for a ICE.

Regarding FCEVs the determination of standardised vehicle operating costs becomes even more complex.

The use of SCBA play a significant role in the road authority's project implementation programmes, and it is necessary to address the development of vehicle operating cost models for NEVs.

## 6.6 Handling of Emergencies

In many instances road authorities, in collaboration with fire, police and emergency medical services, also towing companies, are responsible for road incidence management on the road network. An incident is defined as the occurrence of any extra-ordinary condition or event which results in a reduction in road capacity or creates a hazard for road users for a sustained period. The definition of an incident includes a major accident/crash, a minor accident, shoulder/lane blockage, spilled load, a construction area or a special event. Incident management is the co-ordinated and pre-planned use of human, mechanical and electronic resources to manage incidents and to restore traffic to normal operating conditions (SANRAL, 2019).

Incident management includes firefighting and fire prevention measures. Liu et al. (2023) point out that EVs with high-voltage lithium-ion batteries can be particularly dangerous in the case of a fire. EV related fires have a higher temperature and longer duration, and require more water and other resources to control, than ICE vehicle fires. According to the US National Transportation Safety Board (NTSB, 2020) fires in electric vehicles powered by high-voltage lithium-ion batteries pose the risk of an electric shock to emergency responders during exposure to the high-voltage components of the battery. A further risk is that damaged cells in the battery can cause uncontrolled increases in temperature and pressure, referred to as “thermal runaway”. This can lead to hazards such as battery reignition and fire. These risks follow from the “stranded” energy that remains in a damaged battery (NTSB, 2020).

Road authorities and emergency services need to develop appropriate practice guides, or adopt existing guides, which can be used to train and guide emergency staff in the handling of such emergencies (assuming that such documentation is not yet available). EV manufacturers also provide emergency response guides applicable to their vehicles.

### 6.7 The Impact of NEV Technology on the Fuel Levy, and Alternative Sources of Funding

It is in the interest of road users and the economy in general to have well-maintained roads, the reasons being comfort of travel, reduced vehicle operating costs and travel time, and increased safety. Funding of roads in South Africa originates from a general income pool being fed from various forms of direct and indirect taxation of individuals and companies, but also from service delivery (road user) charges. The apportionment of funds to the institutions providing services to the public is in general being determined arbitrarily and subjectively, however. This includes the road provision and maintenance function. The Ministry of Finance phrases this matter as follows: *“Government regards the vertical division of funds between the different spheres of government as a political policy judgement that reflects the relative priority of functions assigned to each sphere of government and not something that can be captured in a formula”* (Ministry of Finance, 1999).

Road user charges in South Africa include fuel tax, consisting of a customs and excise levy on fuel and a contribution to the Road Accident Fund; VAT on vehicles sales, parts and repair/maintenance services; licencing fees; fines and toll fees. In 2000 the fuel levy formed approximately 70% of total road user contributions collected (Stander & Pienaar, 2000). One can, therefor, accept that reduced fossil fuel sales resulting from an increase in the NEV component of the vehicle fleet will affect government’s income negatively. Other sources of road user funding will have to be identified to fill the shortfall being created.

Although road authorities are generally not directly responsible for the creation of income, except for toll fees, it is in the interest of these authorities to be involved in the identification of alternative income sources, as to indirectly protect their income stream.

## 7. OTHER CHALLENGES

Apart from the aspects discussed above, posing a challenge to road authorities, there are also other challenges facing South Africa in the transition towards new vehicle technologies, specifically electric vehicles. These challenges include:

### 7.1 Loadshedding and the General Shortfall in Terms of the Meeting the Electricity Needs of the Country

Loadshedding and the availability of electricity is often mentioned as a threat to the uptake of EVs. Provision should be made for the impact of EVs in the determination of future electricity demand and supply strategies. Government has an electricity infrastructure development plan in place which is based on least-cost electricity supply and demand analysis, referred to as the Integrated Resource Plan (IRP2019) (Department of Energy 2019). Forecasts of electricity demand for this plan has been prepared by the CSIR (2017). As far as could be ascertained, provision has not been made for the additional demand stemming from the introduction of electric vehicles.

The Just Energy Transition Investment Plan (The Presidency, 2022) – referred to in Section 5.2 – addresses initiatives to increase green electricity supply, as well as initiatives to promote EVs. The impact of EVs on electricity demand is, however, not specifically being addressed.

Other strategies to address the shortfall in electricity production include the utilisation of off-peak electricity supply and the use of renewable energy, for example by means of solar technology at charging stations.

Further work needs to be done in order to assess the electricity needs of EVs and how the necessary supply can be secured.

### 7.2 The High Purchasing Price of Electric Vehicles in South Africa

The first electric vehicles that became available on the market were luxury models. The high cost of these vehicles discouraged the update of EVs. Indications are that more affordable models will become available within the foreseeable future, which can be expected to boost the EV market.

### 7.3 Import Duty on Electrical Vehicles Higher than Other Vehicles

Import duty on electrical vehicles amounts to 25% of the vehicle price, compared to 18% for internal combustion engine vehicles. Furthermore, there are currently no tax incentives or subsidies available in South Africa to encourage the uptake of electric vehicles, the opposite from many other countries (Mienie, 2022). A reduction in import duty and the establishment of a subsidy system will benefit the uptake of EVs in South Africa.

### 7.4 Unfamiliar Technology and Range Anxiety

The vehicle owning public in South Africa is generally not yet familiar with electric vehicle technology. Apart from this, range anxiety and perceived long charging times (compared to gasoline refuelling) create uncertainty. These concerns can be addressed and should be overcome over time.

As this paper is focused on the role of road authorities, the above aspects are not addressed in detail in the paper.

## 8. RECOMMENDATIONS AND RESEARCH NEEDS

The following suggestions and recommendations are offered:

(a) Regarding new vehicle technologies, it is suggested that road authorities should increase their participation in the processes of policy formulation, planning, development of strategies and implementation of for example the Green Transport Strategy and the Just Energy Transition Investment Plan.

(b) Road authorities should familiarise themselves with the characteristics and operational requirements of alternative fuel vehicles, including accommodating the possible impact on industry standards.

(c) In assessing the impact of new technologies road authorities need to take cognisance of the different impacts on the various vehicle classes. The suitability of battery electric vehicle technology for motorcycles and light vehicles, compared to the promising role which hydrogen fuel cell technology can play regarding long distance freight transport, are examples of this.

(d) Road authorities need to familiarise themselves with the requirements for associated infrastructure, specifically related to charging and refuelling stations. Specifications and planning guidelines need to be adopted or developed to suite South African circumstances.

(e) As part of their service to the travelling public, road authorities have a role to play in promoting the establishment of a charging station network coving the total road network, also where not commercially feasible.

(f) The new technologies will have a significant impact on the cost-benefit analysis of new road and road upgrading projects. New vehicle operating cost models will have to be developed and incorporated into the project evaluation software that is widely used in South Africa, to continue to provide accurate answers regarding the economic justification of road projects.

(g) Operational aspects regarding the new vehicle technology must be addressed. An example is the updating of best practice guides regarding the handling of emergencies and accidents.

(h) A reduction in the use of fossil fuels will reduce the contribution of the fuel levy to the state coffers. This may indirectly influence fund allocation towards the upkeep of the road network. Road authorities need to continue to be involved in road user charging arrangements and contribute towards finding solutions which will ensure sufficient funding, while also considering the interest of road users. SANRAL Research Project P2.6: “Road funding models and the impact of carbon tax and alternatives fuels on funding”, is aimed at quantifying this issue.

(i) The electricity demand of EVs being deployed in South Africa needs to be quantified for different scenarios and means of addressing these needs have to be identified and described.

## 9. CONCLUSIONS

The threat of global warming due to the emission of greenhouse gases, and the contribution of the internal combustion engine to this situation, has led to the introduction of several new energy vehicles technologies. These technologies include the battery electric vehicle, the hybrid battery electric vehicle and hydrogen as a fuel. Good progress is being made worldwide towards the development and implementation of these technologies, especially the battery electric vehicle.

The South African government through the Department of Transport committed to reduce greenhouse gas emissions, to embrace green mobility and to introduce new vehicle technologies. Several entities and initiatives were formed in South African which are all actively working towards the implementation of green mobility. The paper emphasises the role of road authorities in the process. Road authorities need to prepare themselves for the anticipated change and ensure that in terms of their role, they are ready to embrace the new technologies. Several areas to be addressed are identified and discussed, after which various recommendations are offered.

Reference was also made to aspects largely outside the control of road authorities, the most important being ensuring the sufficient electricity is available to provide in the energy needs of electric vehicles

## 10. ACKNOWLEDGEMENT

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