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NATIONAL ASSOCIATION OF AUTOMOBILE MANUFACTURERS OF SOUTH AFRICA

HARNESSING ELECTRIC VEHICLES FOR INDUSTRIAL DEVELOPMENT IN SOUTH AFRICA

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TIPS is a research organisation that facilitates policy development and dialogue across three focus areas: Trade and Industrial Policy, Inequality and Economic Inclusion, and Sustainable Growth

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EXECUTIVE SUMMARY

The world of mobility is rapidly evolving worldwide. Technological developments are notably enabling the diversification of drivetrains, away from traditional internal combustion engines (ICE) towards electric and other alternative motors. While EVs still account for a marginal share of global vehicle sales, the shift is evident in leading markets. All forecasts point to an exponential growth of EVs in the coming decades.

Heightened environmental regulations, linked to climate change mitigation and air quality improvement, have initiated the transition to cleaner forms of transportation. Policy impetus, such as support programmes and tight environmental targets, are now driving the market globally. In addition, favourable economics, which see EVs being increasingly cheaper to own than petroleum-based cars over their lifetime, and consumer experience, linked to the connectivity, reactivity and usage experience of the vehicles, are supporting the transformation.

South Africa lags behind this global trend. EVs remain extremely marginal, be it from an offer, demand or manufacturing perspective. As heralded by government and industry alike, it is, however, the ambition of the country to rapidly enter this space. While a coherent policy environment is lacking, the country's Green Transport Strategy sets out government's vision to radically grow the uptake of EVs in South Africa.

As with every transition, the emergence of EVs brings disruptions, calling for the need to adequately manage the transition. In the short term, this requires supporting the development of the sector, both from a market development and manufacturing perspective, through a coherent policy framework consistent with South Africa's domestic context. This report aims to inform this transition in the South African context.

How can the passenger EV offering be supported in South Africa?

When considering the development of the EV market in South Africa, the first question relates to improving the nature (both quantity and quality) of the passenger EV offering in the country. This requires addressing two intertwined questions around a) the availability of EVs on the local market; and b) the competitiveness of the offer.

As of April 2020, the number of EVs available in South Africa remains limited, with only two battery electric vehicles (BEVs), 23 hybrid electric vehicles (HEVs) and 10 plug-in hybrids vehicles (PHEVs). No fuel cell electric vehicles (FCEVs) are currently on offer. This contrasts with the existing 162 models available worldwide in 2019 (and set to rise to 263 in 2020). The lack of local supply is particularly striking in the entry- and mid-level market segments, with most available models competing in the high-end to niche segments. Correspondingly, the sales of EVs in South Africa have remained extremely marginal with 6 043 EVs sold over the 2010-2019 period, corresponding to less than 0.1% of new car sales.

Despite lower running costs, the high upfront purchasing cost of EVs (linked to higher production costs, mainly related to battery production) has been the main inhibitor to increased EV uptake in South Africa. This is exacerbated by the effects of the value-added tax (VAT); the ad valorem excise duty and the import tariff; limited product availability; and awareness issues emanating from range anxiety, security of electricity supply and a limited understanding of the technology. Due to their high upfront cost, EVs are furthermore penalised by the high interest rate associated with vehicle finance in South Africa.

Impacting all these factors is the lack of a coherent and coordinated policy environment aimed at driving increased EV penetration. Experience from other countries shows that active policies and measures are needed to improve the EV offering and stimulate demand. Virtually no incentive exists in the South African market to support the demand for EVs.

Supporting the passenger EV offering in South Africa would hinge on implementing one or more of three key strategies aimed at reducing the upfront price differential of EVs compared to ICE equivalent:

- Reducing the VAT and/or ad valorem excise duties on EVs (through a lower rate or by discounting the battery / fuel cell);
- Changing the customs duties to deliver a "level playing field" for EVs originating from the European Union (EU); and
- Facilitating access to a preferential interest rate for EV finance.

These avenues are not mutually exclusive and should be implemented in conjunction with a package of secondary options. Such complementary interventions can aim to reduce the capital cost of vehicles, further widen the running cost differential between EVs and ICE vehicles, provide non-financial benefits in favour of EVs or enhance customers' experience. These options are all feasible (sometimes very cost effective) and would deliver the intended benefits but would, on their own, not contribute significantly to the cost competitiveness of EVs.

On the capital expenditure front, options range from tax incentives for company fleets or fringe benefits to innovative financing models, to fostering local manufacturing of EVs. Implementing a rebate system is not considered socio-politically viable, unless it is financially self-sufficient (through a feebate system for instance). Measures aimed at altering the operational costs involve modifying the "fuel" costs (by increasing petrol/diesel costs and/or reducing the cost of charging/refuelling), and reducing administrative (e.g. licensing) and associated costs (insurance, parking, toll fees). Non-financial incentives can be beneficial for EVs (e.g. dedicated lanes, parking and/or zones, bundle solar system and EV) or restrictive for ICE vehicles (restricted access, manufacturing or fleet targets). Measures aimed at raising customer awareness are varied. They include improving visibility through the rollout of EVs in public and private fleets as well as public transport, public campaigns and pro-active promotion of EVs by dealerships, and raising the visibility of charging/refuelling infrastructure.

Overall, a package of measures would have to manage the need to reduce the high upfront cost of EVs with the cost and socio-political acceptability of interventions. Reducing the VAT and/or ad valorem excise duties would have a meaningful impact but would be difficult to justify socially (and therefore politically). Levelling the playing field for imports would redress an anomaly for BEVs coming from the EU, but it is not possible to guarantee that this would trigger reduced prices for customers (since local manufacturers can offset duties). Providing preferential finance for EVs would have a material impact but would require a partnership with the financial sector and could be socially regressive. All these measures run the risk of being seen as subsidising a product which, initially at least, would be purchased only by high-income earners. In addition, interventions would need to balance market development and industrial development, as some measures, such as fleet-level targets, would help grow the market but may not be aligned with manufacturing objectives. The variety of technologies available adds another level of complexity. As such, a technology neutral approach is recommended in the short term.

How can the shift to EVs in public transport be supported?

The second question relating to market development deals with introducing EVs into the public transport system. Public transport, i.e. primarily minibus taxis (MBTs) and buses, is responsible for transporting the majority of the population and is particularly important for low- to middle-income households which cannot afford private vehicles. The electrification of public transport would contribute to an inclusive rollout of e-mobility in the country, improving the cost, safety, customer experience and impact of public transport. Led by the aggressive e-bus growth rate in China, e-buses are surpassing the growth of every other EV segment globally. In South Africa, the electrification of public transport remains in its infancy. South African cities are, however, looking to develop electric public transportation (one project in Cape Town to date).

In addition to the lack of a coherent policy environment for public transportation in South Africa, key barriers relate to high upfront costs; concerns around scalability; lower flexibility and limited operational experience; delayed procurement decisions (due to expected technology cost declines); changing electricity tariffs and grid stability concerns; the lack of a hydrogen refuelling network; and the lack of charging/refuelling infrastructure standardisation. There is furthermore no e-MBT currently available in South Africa.

International experience has shown that promoting the deployment of EVs requires policy interventions guided by a vision statement and a set of targets. Supporting the shift to EVs in public transport in South Africa would hinge on implementing one or more of four key strategies:

- Changing the VAT and/or ad valorem excise duty (as for passenger cars);
- Promoting the deployment of e-MBTs through the Taxi Recapitalisation Programme (TRP);
- Facilitating access to a preferential interest rate for e-bus and e-MBT finance; and
- Public procurement, notably from municipal bus and Bus Rapid Transport (BRT) systems.

As with passenger cars, an array of secondary options exists to complement these four primary interventions. A first important complementary measure would be a tariff structure incentivising fleet owners to charge during off-peak periods. Preferential rates could be considered, particularly given the safer and cleaner transport services that public transport EVs could deliver. A second measure would be to leverage operating licenses for selected routes awarded to private bus companies and to MBTs by including conditions that vehicles be powered by electricity or hydrogen (more likely to be viable in the medium term).

Other options, such as capital costs, rebates, feebates and increasing the carbon tax on ICE public transport vehicles, could be justified socio-politically for public transport, but funding challenges make such measures improbable. Reducing company tax is feasible but unlikely to deliver adequate benefit and would be limited to a relatively small number of roleplayers in the industry. Another avenue would be to facilitate access to finance in the form of access to affordable capital, purchase incentives and incentives aimed at getting more vehicle options available in the market (e.g. testing incentives). New business models are also emerging, involving battery leasing, joint procurement, and bus sharing.

Unlike private passenger vehicles, there is no import tariff anomaly that creates an unfair playing field with the import of public transport EVs versus ICE equivalents. Given the strong role of local manufacturing in this segment, reducing the import tariff to benefit EVs is not considered a viable option. Accordingly, stimulating local manufacturing would result in lower-cost vehicles but the price benefit would, on its own, unlikely tip the scales and is not a short-term option. As discussed below, a demand-led strategy would, however, be adequate to support the local manufacturing of e-buses and e-MBTs in the country.

The operational cost differential of e-buses and e-MBTs compared to ICE equivalents could be widened by altering the "fuel" costs (i.e. petroleum products vs. electricity/hydrogen), and reducing administrative and associated costs (such as licensing, insurance, tolls). Other non-financial interventions are also possible. They would range from access bans and/or benefits, investment in vehicle rightsizing, mandatory regulatory targets for operators and/or original equipment manufacturers (OEMs), to communication and awareness raising.

Similar to passenger cars, a mix of measures aimed at promoting EVs in public transport would have to manage a balancing act between various costs and benefits. Reducing the VAT and/or ad valorem excise duty would have a meaningful impact on the upfront cost of vehicles but would come with an opportunity cost, particularly in the current constrained fiscal space. Using the TRP to promote e-MBTs would leverage an existing instrument but would require a partnership with the private sector and come with a much higher price tag than the current programme. Brokering preferential EV finance for e-buses and e-MBT would also have a material impact on the cost of vehicles. This would, however, require a partnership with the financial sector. Public procurement of EVs (by municipalities essentially) would dramatically springboard the rollout of EVs in public transport and could be linked to local manufacturing. This would, however, be limited to pro-active and well-resourced municipalities. More broadly, the rollout of EVs in public transport needs to be done in tandem with an investment in adequate infrastructure (electricity grid and/or hydrogen network). This could be alleviated by providing the lowest possible electricity costs to fleet owners that can charge during off-peak periods, and other measures to shift charging behaviour. Operating licences for selected routes awarded to private bus companies and to MBTs could also be leveraged by including conditions that vehicles be powered by electricity or hydrogen.

How can the local manufacturing of EVs be supported in South Africa?

On the manufacturing side, the issues revolve around developing the local EV value chain. This ranges from the mining and beneficiation of minerals to the manufacturing of parts and components, to the manufacturing of vehicles.

South Africa hosts a vibrant automotive manufacturing industry thanks to long-standing support from government. Support is structured around the Automotive Production and Development Programme (APDP). The APDP framework consists of four key pillars aimed at supporting local manufacturing:

1) customs duty on imported vehicles and components;
2) a rebate mechanism for OEMs, the Vehicle Assembly Allowance (VAA), to be replaced with a Vehicle Assembly Localisation Allowance (VALA) from 2021;
3) a rebate mechanism linked to the supply chain, the Production Incentive (PI); and
4) a cash grant for investment, the Automotive Investment Scheme (AIS).

In 2019, South Africa was ranked 22nd in global vehicle production with a market share of 0.7%. South Africa's automotive value chain is highly connected to global dynamics and dependent on worldwide trends from an import and export perspective. Seven South African-based OEMs dominate the country's automotive industry. The leading four brands for light vehicles in the country all have domestic manufacturing operations. Minibus manufacturing is a duopoly with Toyota and Beijing

Automobile Works (BAW) servicing the local market. In addition, eight bus companies supply the local market. They rely on a number of local body manufacturers and mainly imported parts.

However, existing EV manufacturing is currently limited to one hybrid mass-market passenger vehicle as well as an array of local entrepreneurs targeting niche markets. Indeed, besides local sales, current local manufacturing has traditionally focused on servicing the EU and United States markets with ICE vehicles, two markets that are rapidly shifting to EVs.

The development of local EV manufacturing in South Africa hinges, in the short term, on implementing one or more of three key strategies:

- Enhancing the APDP (through the VALA, PI and AIS) to set a favourable environment for EV manufacturing investment by OEMs;
- Implementing fleet-level targets to trigger market changes; and
- Stimulating demand for EVs, most notably public transport vehicles in the short term.

Importantly, these three avenues are not mutually exclusive, but would rather reinforce each other. Realistically, in the short term, such measures are, however, more targeted at OEMs already producing ICE vehicles in South Africa.

Overall, the manufacturing of EVs is strongly correlated with demand and is unlikely to materialise domestically until demand takes off. As raised, in the short term, some measures aimed at fostering demand may furthermore not be aligned with manufacturing goals, and vice versa. As such, a demand-led approach for passenger EV manufacturing would be viable only in the longer term.

Other options, namely manufacturing-level targets, increased duty protection and a bottom-up approach through the value chain (aimed at leveraging the country's endowment in minerals), do not appear viable in the foreseeable future. Additional support, in the form of development finance, infrastructure provision and small business development assistance, could also be further provided, particularly to attract investment by new OEMs and entrepreneurs.

Given that the APDP already substantially supports the local manufacturing industry, a mix of measures aimed at fostering the local production of EVs would need to weight the costs and benefits of providing additional support. Using the APDP has the advantage of leveraging an existing, tried-and-tested mechanism, but requires government to carry the costs of incentivising OEMs' investment. Fleet-level targets are virtually costless to government and put the onus on OEMs to introduce EVs into the market. Such a new regulatory measure is moreover not guaranteed to trigger local EV manufacturing, as targets could be met through imports. Adopting a demand-led approach would be impactful for public transport vehicles only, where the link between local supply and demand is strong. It does require local stakeholders (essentially, the state as well as the MBT industry) to carry some of the risks associated with the rollout of new vehicles. In the case of passenger cars, such a strategy would only be viable in the long term once demand reaches critical levels.

How can the manufacturing of EV components be supported in South Africa?

Complementing vehicle manufacturing, the local components industry plays a crucial role in South Africa's automotive value chain, even though local content levels are relatively low. There are about 120 Tier 1 suppliers and more than 200 Tier 2 and Tier 3 suppliers in South Africa. The South African components industry is supported by the APDP policy framework, notably the AIS and the VAA/VALA.

Overall, significant changes are expected in component manufacturers' portfolios with existing powertrain-related suppliers scheduled to lose market share, while new opportunities would emerge in EV parts. Despite a noteworthy degree of overlap between the ICE and electric drivetrain value chains, EVs indeed have several unique components (primarily batteries, fuel cells and electric powertrains). In turn, some components, such as engine parts, radiators and catalytic converters are replaced in BEVs and FCEVs.

South Africa's top component exports are ICE-specific and largely exported to European markets, with the exception of engines, which go mostly to India. With major European OEMs and large Tier 1 suppliers looking to expand their output of EVs and components, the adoption of EVs across Europe is set to greatly affect South Africa's component exports.

While Lithium-Ion Batteries (LIBs) are currently imported, South Africa has committed to manufacturing LIBs. Efforts are being made by the public and private sector to further promote the manufacturing of LIBs in South Africa. Similarly, the South African government's efforts along with mining companies to develop a viable fuel cell manufacturing industry has seen a few local projects emerging in the fuel cell value chain.

South Africa is furthermore well-endowed in an array of key EV-related minerals. South Africa is the leading supplier of platinum group metals (PGMs), which are instrumental to fuel cells. South Africa is also the world's largest producer of manganese, a core element of LIBs. The country also has nickel, rare earth elements (REE) and fluorspar, among others that play a role in the EV value chain. In addition, neighbours in the Southern African region also have vast resources, including lithium, cobalt, graphite and REE. South Africa's position in terms of beneficiated minerals is, however, much weaker than at the mining level, largely due to fast-rising electricity prices.

Two main options are available to advance the manufacturing of EV components in South Africa:

1. Using a top-down approach through the APDP pillars, i.e. modifying VALA to include the support of local sourcing for EV components, adjusting the AIS targets to include EV powertrains, LIBs, fuel cells and telematics, and increasing the PI for EV-specific components; and,

2. Using a bottom-up approach to promote value-addition and beneficiation through a mineral beneficiation policy (such as an export tax and/or developmental pricing).

An array of complementary interventions could also reinforce the implementation of a top-down and/or bottom-up approach. They range from increased research and development (R&D) and investment support to stimulating a broader local market (i.e. beyond EVs) for components.

Importantly though, the availability of minerals in South Africa and the region is not a sufficient condition to underpin the local production of EV-related components. As such, policy support would be effective only if mineral beneficiation and component manufacturing are competitive in the first place. The long-term objective of increasing local content and value-add for EV components cannot be instantly brought to reality without addressing wider and deeper structural challenges faced by the local industry.

Breaking into the LIB and fuel cell markets would be challenging for South Africa. However, with demand rapidly growing, the availability of raw materials locally and in the region provides a valuable platform to explore the transition of the local industry towards EVs. The success of policy interventions in supporting the South African automotive industry will ultimately depend on the extent to which these policies can influence competitiveness and facilitate the integration of the local industry into the global value chain.

Conclusion

The development of e-mobility is a multi-faceted endeavour. Crafting a policy framework aimed at increasing the deployment of EVs and fostering the sector requires the consideration of multiple angles. Overall, strong signals are required to kickstart the development of EVs in South Africa. Strong partnerships between national government, cities, fleet owners, operators and manufacturers would be critical. In light of the nascent nature of the sector, a trial-and-error approach, leveraging pilots as well as phased mechanisms, would be most sensible in the short term. It is also recommended that public policy does not actively discriminate between technologies. BEVs, hybrids and FCEVs all have a role to play in the transition to e-mobility.

Beyond this report, many other areas remain to be explored in greater detail, both for enhancing co-benefits and minimising disruptions and drawbacks. These range from considering other market segments (two- and three-wheelers, light commercial vehicles and trucks), to looking at the interplay of EVs with their broader environment (energy sector, spatial development), to gaining a deeper understanding of short-term impacts (both positive and negative) on the economy and society in order to ensure a just transition.

Importantly though, further work should not hinder progress. EVs represent the only platform to a modern, sustainable transport system in the country and globally. Coupled with the transition to renewable energy technologies (from solar and wind energy to green hydrogen), increased connectivity and changes to spatial development, they also are the road to smart cities, inclusive development, and a sustainable economy. The time to act is now.

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ACRONYMS AND ABBREVIATIONS

AC	Alternating Current
AFC	Alkaline Fuel Cell
AfCFTA	African Continental Free Trade Area
AIS	Automotive Investment Scheme
AIEC	Automotive Industry Export Council
APDP	Automotive Production Development Programme
BAW	Beijing Automobile Works
BEV	Battery Electric Vehicle
BNEF	Bloomberg New Energy Finance
BRT	Bus Rapid Transit
CEM	Clean Energy Ministerial
CBU	Completely Built Up
CIT	Corporate Income Tax
CKD	Completely Knocked Down
CSIR	Council for Scientific and Industrial Research
DC	Direct Current
DFI	Development Finance Institution
DMR	Department of Mineral Resources
DMRE	Department of Mineral Resources and Energy
DoT	Department of Transport
DRC	Democratic Republic of Congo
DSI	Department of Science and Innovation
dti (the)	Department of Trade and Industry
dtic (the)	Department of Trade, Industry and Competition
EFTA	European Free Trade Association
EMEA	Europe and Middle East and Africa
eNaTIS	National Traffic Information System
EPA	Environmental Protection Agency (United States)
EU	European Union
EV	Electric vehicle
EVI	Electric Vehicles Initiative
FCEV	Fuel Cell Electric Vehicle
eWASA	e-Waste Association of South Africa
GATT	General Agreement on Tariffs and Trade
GDL	Gas Diffusion Layer
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GTS	Green Transport Strategy
GVC	Global Value Chain
GWh	Gigawatt hours
HEV	Hybrid Electric Vehicle
HySA	Hydrogen South Africa

ICE	Internal Combustion Engine
IEA	International Energy Agency
IOT	Internet of Things
IPAP	Industrial Policy Action Plan
IPM	Isondo Precious Metals
ITAC	International Trade Administration Commission
kWh	Kilowatt-Hour
LCOT	Levelised Cost of Transport
LFP	Lithium Iron Phosphate
LMO	Lithium Manganese Dioxide
LIB	Lithium-ion Battery
MaaS	Mobility-as-a-Service
MBT	Minibus Taxi
MCFC	Molten Carbonate Fuel Cell
MEA	Membrane Electrode Assembly
MIDP	Motor Industry Development Programme
MPGe	Miles Per Gallon Gasoline-Equivalent
MRPDA	Mineral and Petroleum Resources Development Act No 28 of 2002
NAACAM	National Association of Automotive Component and Allied Manufacturers
NAAMSA	National Association of Automobile Manufacturers of South Africa
NCA	Nickel Cobalt Aluminium Oxide
NEV	New Energy Vehicles
NMC	Nickel Manganese Cobalt
NMU	Nelson Mandela University
NPS	New Policies Scenario
NWU	North West University
OEM	Original Equipment Manufacturer
OICA	International Organisation of Motor Vehicle Manufacturers
PAFC	Phosphoric Acid Fuel Cell
PAYS	Pay-As-You Save
PEMFC	Proton Exchange Membrane Fuel Cell
PGM	Platinum Group Metals
PHEV	Plug-in Hybrid Electric Vehicle
PI	Production Incentive
PIC	Public Investment Corporation
R&D	Research and Development
RAW	Real African Works
REE	Rare Earth Elements
RDI	Research, Development and Innovation
SAAM	South African Automotive Masterplan
SABS	South African Bureau of Standards
SADC	Southern African Development Community
SADC-EU EPA	Southern African Development Community-European Union Economic Partnership Agreement

SARS	South African Revenue Service
SDGs	Sustainable Development Goals
SEA	Sustainable Energy Africa
SEZ	Special Economic Zone
SKD	Semi Knocked Down
SOFC	Solid Oxide Fuel Cell
SMMEs	Small, Medium and Micro Enterprises
SSEG	Small-Scale Embedded Generation
TCO	Total Cost of Ownership
ToU	Time-of-Use
TRP	Taxi Recapitalisation Programme
UK	United Kingdom
US	United States
USGS	United States Geological Survey
UWC	University of Western Cape
V2G	Vehicle to Grid
VAA	Vehicle Assembly Allowance
VALA	Volume Assembly Localisation Allowance
VAT	Value-Added Tax
VRFB	Vanadium Redox Flow Battery
WTO	World Trade Organisation
ZEV	Zero-Emission Vehicle

1. INTRODUCTION

The world of mobility is rapidly evolving worldwide. The state of disruption is such that no consensus emerges on how the industry will look in 10 to 15 years (McKinsey, 2016). Four underlying, intertwined technological trends are shaping the future of the global transportation industry: diverse mobility; connectivity; electrification; and autonomous driving. These trends will revolutionise the automotive value chains and shape how vehicle manufacturers and transport service providers respond to changing consumer behaviour, develop partnerships and drive transformative change within the industry.

Technological developments in line with the Fourth Industrial Revolution are enabling the diversification of drivetrains, away from traditional internal combustion engines (ICE), towards electric and other alternative motors. Most notably, battery technologies have dramatically evolved in the last few years, increasing in power and efficiency, reducing in size, and decreasing in cost, while fuel cell technologies are now also starting to see their cost come down. The technological frontier remains far from reached, in this space. Complementarily, renewable energy technologies, which are ideal to power batteries and generate green hydrogen from a climate change and resource management perspective, have also experienced fast progress over the last decade. In addition, the acceleration of internet connectivity (Internet of Things, IOT) has enabled the technological enhancement of vehicles, improving efficiency and consumer experience. This paves the way for the rollout of fully autonomous vehicles in the future. Consumer preferences, discovering the benefits of Mobility-as-a-Service (MaaS), are moreover diversifying the demand for transportation, away from goods to services.

Heightened environmental regulations, to mitigate greenhouse gas (GHG) emissions from transportation as well as improve air quality in urban areas, have initiated the transition to cleaner forms of transportation. Globally, as illustrated in Figure 1, transportation accounted for 18% of GHG emissions in 2016, with the lion's share resulting from passenger cars. In cities, air pollution, triggered notably by motor vehicles, is responsible for dramatic health problems and contributed to more than 6 million deaths globally in 2016 (Health Effects Institute 2019).

Policy impetus, such as support programmes and tight environmental targets, are now driving the market globally. Many programmes aim at encouraging and supporting the adoption of electric vehicles (EVs), from mild hybrids and plug-in hybrids to battery electric vehicles (BEVs) and fuel cell electric vehicles (FCEVs). A selection is included in Box 1.

In addition, favourable economics, which see EVs being increasingly cheaper to own than petroleum-based cars over their lifetime, and consumer experience, linked to the connectivity, reactivity and usage experience of the vehicles, are supporting the transformation of the industry. For instance, BEVs are forecast to be competitive by 2024 on an unsubsidised basis (i.e. without policy support/incentives) and reach parity due to lower battery prices by 2029 (Dane, Wright, and Montmasson-Clair 2019). Similarly, fuel cell electric buses are expected to have a lower total cost of ownership than their fossil fuel-based equivalent from 2024 (Deloitte and Ballard 2020).

Figure 1: Global greenhouse gas emissions per sector (in $MtCO_2e$)

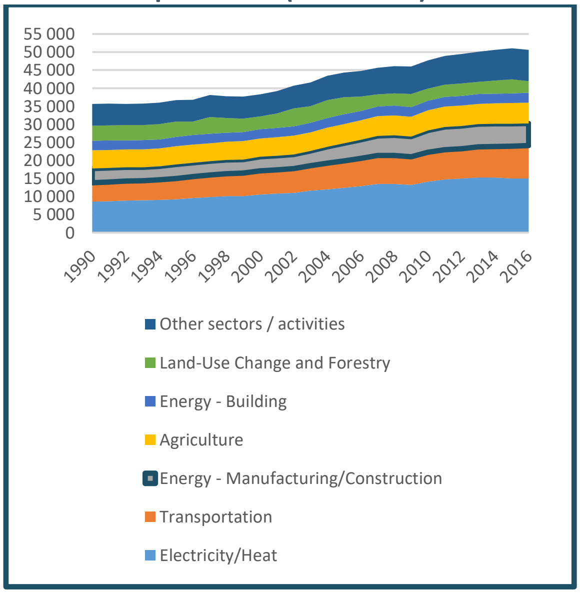
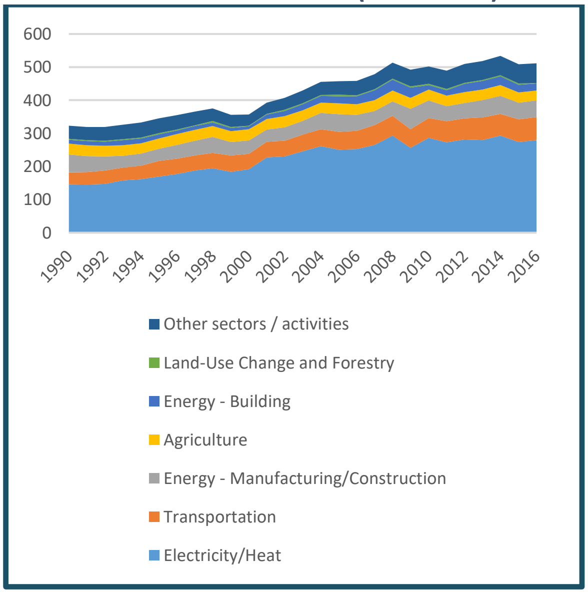


Figure 2: Greenhouse gas emissions per sector in South Africa (in $MtCO_2e$)



Source: Authors, based on CAIT data obtained from https://www.climatewatchdata.org in January 2020. Note: Transportation includes bunker fuels; Other sectors / activities includes industrial processes; waste; fugitive emissions; and other fuel combustion.

While EVs still account for a marginal share of global vehicle sales (2.2% in 2018), according to (Hertzk et al. 2019), the shift is evident in leading markets (see Figure 3). In China, around 1.8 million BEVs were already on the country's roads in 2018, with an additional 0.5 million plug-in hybrid electric vehicles (PHEVs). This is more than half the BEV in circulation worldwide. In Norway, EVs accounted for almost half of new vehicles sales in 2018 (IEA, 2019). In the European Union (EU) as well as other jurisdictions, ambitious mandatory targets have been set by governments, leading automakers to push EVs to the market. For instance, all new cars are to be emission free by 2030 in the Netherlands, Ireland and Slovenia. Similar, but slightly longer term, goals and ambitions have been expressed by Scotland, California, France, Portugal, Spain, Sri Lanka and the United Kingdom (SLOCat, 2019).

Though varying in ambition, all forecasts point to an exponential growth of EVs in the coming decades. Furthermore, every new forecast released raises the projections to new heights. Figure 4, which depicts the International Energy Agency (IEA) 2018 and 2019 forecasts for the rollout of EVs to 2030, illustrates this point.

Figure 3: Global EV stock and market share in selected countries

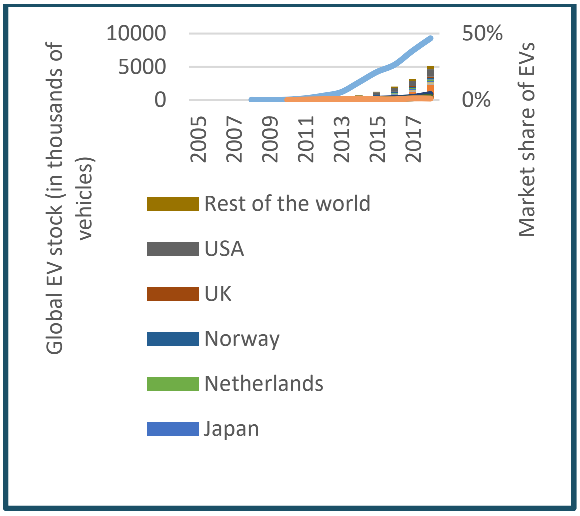
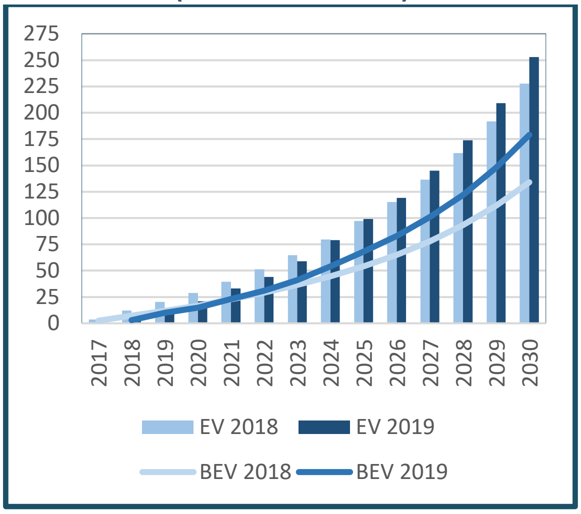


Figure 4: EV stock forecast up to 2030 according to the IEA's EV30@30 Scenario (in million vehicles)



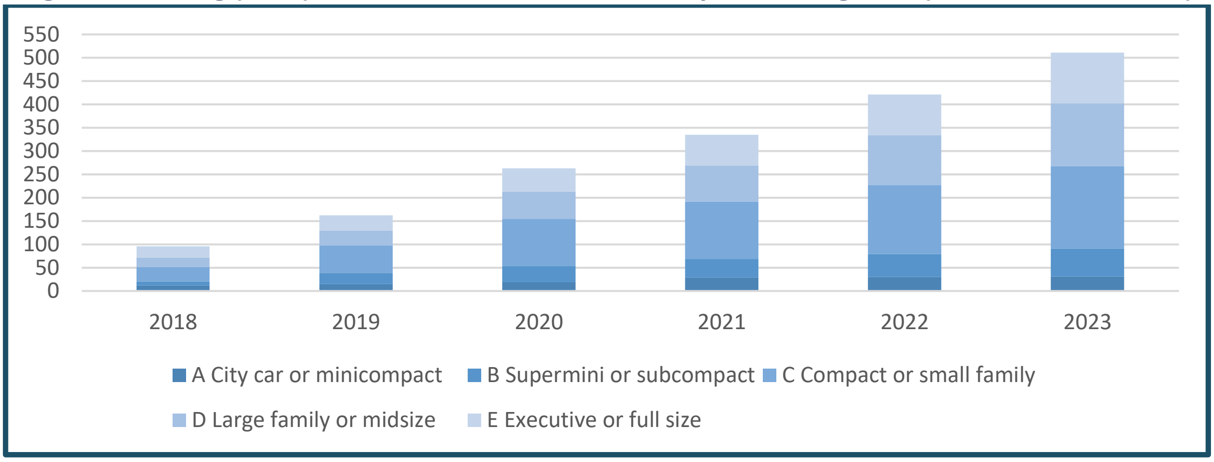
Source: Authors, based on data from the IEA's Global EV Outlook 2018 and 2019.

The industry is responding to this trend. Traditional original equipment manufacturers (OEMs) are increasingly introducing EVs into their model ranges. Major OEMs have already announced the launch of a staggering 400 new EVs over the 2019-2023 period (see Figure 5). Some, such as Volvo, have made ambitious commitments to phase out ICE-based vehicles. New, diverse players are also entering the market in one form or the other. They range from pioneer automotive and energy firm Tesla, information and communications technology companies, such as Google, to mining companies, such as Anglo American, battery manufacturers, and OEMs from emerging economies (primarily China and India) aiming to leverage this shift to take their business to a new dimension, to a multitude of entrepreneurs operating in niche markets.

South Africa lags behind this global trend. EVs remain extremely marginal, be it from an offer (only four BEVs were available on the local market by end of 2019), demand (EVs accounted for 0.04% of sales in 2018) or manufacturing perspective (only one PHEV model was manufactured in South Africa). As heralded by government and industry alike (see Malinga, 2019), it is, however, the ambition of the country to rapidly enter this space. While the country lacks a coherent policy environment and specific commitments or plans in relation to EVs, the Department of Transport's Green Transport Strategy (GTS) (DoT, 2019) sets out government's vision to radically grow the uptake of EVs in South Africa (DoT, 2018). The GTS indicates that government will:

- Offer incentives to EVs manufacturers to both produce and sell affordable EVs in South Africa, for both the local and export markets;
- Work with local research institutions to conduct research on EV batteries;
- Work with national, provincial and local government departments and authorities, and the automobile industry to set annual targets for the uptake of EVs and hybrid electric vehicles (HEVs) in the government vehicle fleet, as well as monitoring the local content of the manufacturing of cars locally, in line with the Industrial Policy Action Plan (IPAP);
- Introduce the conversion of old technology vehicles with higher emission factors to be retrofitted with EV technology;
- Consider providing incentives related to the beneficiation of local resources for the manufacturing of key machineries and/or components (e.g. fuel cell); and
- Assist in establishing and developing local EV OEMs.

Figure 5: Existing (2018) and new launched EV models by vehicle segment (in number of models)



Source: Authors, based on data from Hertzke et al, 2019.

This is critical on multiple fronts as EVs are set to bring multiple benefits to the country (see Dane, Wright, and Montmasson-Clair 2019). For example, consumers would benefit from lower transport costs over time. Provided clean sources of electricity and hydrogen were used, citizens in general would enjoy a healthier environment through reduced air pollution and GHG emissions (see Figure 2 for an illustration of South Africa's GHG emissions from transport). The fiscus would reap the benefits of lower liquid fuel imports. In the long run, the higher energy efficiency of EVs, combined with the use of renewable energy technologies, would also enhance resource preservation.[1]

From a manufacturing side, the transition is also about the future of the automotive industry, a key pillar of the domestic economy. Considered a success of the country's industrial policy, the automotive manufacturing industry accounted for 6% of South Africa's gross domestic product (GDP) and 28% of manufacturing output in 2019 (Lamprecht, 2020). About 112 000 people are directly employed in the manufacturing of vehicles and components while downstream activities (wholesale, retail trade and maintenance) employ more than 350 000 people (Barnes et al, 2018). But the industry is largely export-orientated and highly dependent on the global trends already highlighted. The domestic industry is also facing increasing competition, including on the continent, with automotive manufacturing in countries such as Ethiopia, Kenya and Ghana building up.

As with every transition, the emergence of EVs brings disruptions, calling for the need to manage the transition of the sector to minimise any negative impacts and reap the benefits. In the short term, this requires supporting the development of the sector, from a market development and manufacturing perspective, through a coherent policy framework consistent with South Africa's domestic context.

This report aims to inform this transition in the South African context. It looks at four distinct, although intertwined, angles, considering how to support: a) the offering of passenger EVs (Section 2); b) the rollout of e-mobility in public transport (Section 3); c) the local manufacturing of EVs (Section 4); and d) the domestic production of EV-specific components (Section 5). For each question, the universe of possible interventions is considered and reviewed, to identify primary as well as complementary measures which could be implemented in the South African context. Based on this assessment, the costs and benefits of the primary options identified are discussed. Policy implications are then drawn for each separate issue. Section 6 concludes.

[1] At the global level, transport accounted for 32% of total final energy consumption in 2016. Of this 32%, only 3.3% originated from renewable energy, spilt between 3% from biofuels and 0.3% from renewable energy-based electricity (REN21 2019).

Box 1: A selection of programmes encouraging and supporting EV adoption

- **EV100 Initiative:**[1] EV100 is a global initiative bringing together forward-looking companies committed to accelerating the transition to EVs and making electric transport the new normal by 2030. For example, Unilever has committed to transition its fleet of over 11 000 vehicles to EVs as well as offering workplace charging for staff and work with service providers to prioritise EVs.
- **Electric Vehicles Initiative (EVI):**[2] The EVI is a multi-government policy forum, supported by the IEA, dedicated to accelerating the introduction and adoption of EVs. EVI was launched under the Clean Energy Ministerial (CEM), a high-level dialogue among Energy Ministers from the world's major economies. As of March 2020, South Africa is not a member.
- **EV30@30 Campaign**:[3] The EV30@30 Campaign was launched at the eighth CEM meeting in 2017 with the goal of accelerating the deployment of EVs. It sets a collective aspirational goal for all EVI members of a 30% market share for EVs in the total of all vehicles (except two-wheelers) by 2030. As of March 2020, South Africa is not a participating country.
- **Global EV Pilot City Programme**: Launched at the ninth CEM in May 2018, the EVI Global EV Pilot City Programme aims to create a global platform to facilitate communications and cooperation among leading global cities interested in stimulating and increasing the uptake of electric mobility within their jurisdictions. No South African cities are members, as of March 2020.
- **Government Fleet Declaration**:[4] Recognising the importance of reducing GHG emissions in the transportation sector, eight major nations – Canada, China, France, Japan, Norway, Sweden, the United Kingdom (UK) and the United States (US) – signed a Government Fleet Declaration in November 2016, pledging to increase the share of EVs in their government fleets and calling for other governments to join them.
- **Paris Declaration on Electro-Mobility and Climate Change**: The declaration calls for the deployment of EVs compatible with a 20% share of all road transport vehicles in 2030, including more than 100 million cars.
- **C40 Cities**:[5] C40 is a network of the world's megacities committed to addressing climate change. This includes commitments aimed at promoting EVs. C40 supports cities to collaborate effectively, share knowledge, and drive meaningful, measurable and sustainable action on climate change. This includes the C40 Fossil Fuel Free Streets Declaration. Cape Town, eThekwini, Johannesburg and Tshwane have signed up.
- **Climate Mayors Electric Vehicle Purchasing Collaborative**: A cooperation among Climate Mayors cities across the US to leverage their collective buying power and accelerate the conversion of public fleets to EVs.[6]
- **European Association for Electromobility**:[7] This European association promotes electromobility and sustainable transport across Europe.
- **Zero-Emission Vehicle Alliance:**[8] Members seek to collaborate with other governments to expand the global zero-emission vehicle (ZEV) market and enhance government cooperation on ZEV policies, in order to strengthen and coordinate efforts to combat air pollution, limit climate change, and reduce oil dependence. ZEVAlliance.org is managed by the ZEV Alliance Secretariat, the International Council on Clean Transportation.
- **International Energy Agency - Technology Collaboration Programme -** uYilo is the country liaison member of the Hybrid and Electric Vehicle Technologies and Programmes (IA-HEV).

[1]See https://www.theclimategroup.org/project/ev100 for more details on the EV100 initiative.
[2]See https://www.iea.org for more information on the EVI.
[3]See http://www.cleanenergyministerial.org for more information on the EV30@30 initiative.
[4]See https://www.iea.org for more information on the declaration.
[5]See https://www.c40.org/cities for more details on C40.
[6]See https://driveevfleets.org for more details on the collaborative.
[7]See https://www.avere.org for more details on the association.
[8]See http://www.zevalliance.org for more information on the alliance.

Box 2: The potential impact of the COVID-19 pandemic on policies to develop the EV market and support EV value chain development in South Africa

It is not clear how the COVID-19 pandemic, characterised by uncertainty, will affect the global and local transition to EVs. The IEA suggests that it will create a potentially transformative environment, further accelerating EV adoption during the 2020s (IEA, 2020). Further, at the global level, signs indicate that EV sales will be more resilient in 2020 than the overall car market due to some countries ramping up EV-related support measures.

There is limited commentary available on the potential effect of the pandemic on the policy options for South Africa presented in this paper. The extent and pace of any EV-related developments driven by these policy options will depend on the duration and impact of COVID-19, the global economy and South Africa's recovery and post-COVID-19 influences. Some of the initial findings and key questions are presented here.

Impact on car sales and manufacturing

The IEA (2020) estimates, based on car sales data during January to April 2020, that the passenger car market will contract by 15% over the year relative to 2019, while EV sales for passenger and commercial light-duty vehicles will remain broadly at 2019 levels. This will equate to about 3% of global sales in 2020. However, there is significant uncertainty. While Bloomberg New Energy Finance shares similar findings in its optimistic scenario, it includes more conservative scenarios assuming slower recoveries and prolonged outbreaks. Globally, the automotive industry has been severely affected during the COVID-19 crisis. Practically all major car manufacturers halted production lines for some period (IEA, 2020). Initial signs in countries where the lockdown is gradually easing suggest the potential for a quick recovery.

In South Africa, the automotive industry was already at a tipping point before COVID-19. A survey of the automotive value chain by Deloitte found that 24% of respondents' EBITDA (earnings before interest, taxes, depreciation and amortisation) had declined by 8%-10% prior to COVID-19. With the onset of the virus, the South African industry lost three working days in March and the whole of April, significantly affecting production, domestic new vehicle sales, and exports (NAAMSA, 2020). Deloitte found that 51% of respondents across the automotive value chain in Africa estimated budgeted earnings to be halved or more due to COVID-19 (Deloitte, 2020). Going forward, the National Treasury expects the economy to shrink by 7.2% in 2020 (NT, 2020). There is a close correlation between GDP growth and new vehicle sales.

Government responses to Covid-19 will influence the pace of the transition to EVs

The nature of countries' recoveries and the role this will have on transport systems is uncertain and highly dependent on government responses. Some are calling for fast recovery with an explicit or implicit focus on supporting the actors in the existing economic structures. Others are calling for "green recoveries" and structural changes.

Some countries are explicitly focusing on and ramping up their support measures for EVs. For example, in China, policymakers were quick to identify the automotive market as a primary target for economic stimulus. Among other measures, the central government encouraged cities to relax car permit quotas, at least temporarily, complemented by strengthening targeted new energy vehicle (NEV) measures. In the EU, existing policies and regulations were maintained and countries such as France and Germany announced increased support measures for EVs for the remainder of 2020 (IEA, 2020). In the largest European car markets combined (France, Germany, Italy and the United Kingdom), sales of EVs in the first four months of 2020 reached more than 145 000 vehicles, about 90% higher than in the same period last year, due to EV-related support measures (IEA, 2020).

Other countries are putting the brakes on EVs. In the US, Bloomberg expects EV sales to slow drastically in the coming months as policy support weakens and cash-strapped automakers refocus on their most profitable products, namely ICE-based trucks and SUVs (Bloomberg, 2020).

The crisis presents both threats and opportunities for EVs. In countries where fossil fuel subsidies prevail, the low oil price environment is an important opportunity to phase out price supports, which are detrimental for pursuing energy efficiency efforts in general and for creating a context that supports road vehicle electrification in particular. However, there are also concerns that the economic crisis could lead governments to relax fuel efficiency standards to lower the pressure on struggling automakers, or reduce support measures for EVs to free up funds for use elsewhere (IEA, 2020). When considering the deployment of EVs and the development of the EV value chain in South Africa, the impacts will depend on the nature of South Africa's recovery and the recovery of key markets internationally. Several questions emerge:

- Will there be structural shifts in the economy, influenced by policies and actions (e.g. green stimulus packages) that target certain sectors or activities over others?
- Will South Africa's and key export market's recoveries focus on EVs or strengthening the EV argument, in any way?
- Will some of the behavioural changes experienced, such as reduced business travel, be sustained?
- What will be the pace and extent of the recovery, given uncertainty regarding the virus's trajectory?

A summary of some of the potential impacts on the benefits associated with increased EV penetration and EV market development in South Africa is included in Table 1.

Table 1: Potential COVID-19 impacts on the EV market and EV value chain in South Africa

	AMPLIFIES EV BENEFITS	DAMPENS EV BENEFITS
Short term (within the next two years)	• EV industry and market development could form part of a green recovery package, although this is unlikely.	• Reduced ability of organisations and individuals to afford the EV capital price premium. • Reduced travel due to more remote working and travel restrictions. • Greater focus on protecting existing economic activity (e.g. relaxing fuel efficiency standards). • Reduced financial liquidity in the auto industry • Delay of subsidies and other EV support as resources directed to other priorities. • Cheap liquid fuels erode the economic case for EVs (less in South Africa given relatively high fuel taxes). • Reduced demand for public transport increases demand for private cars in key export markets (overshadowed by reduced vehicle demand generally) – strengthening the status quo.
Long term (beyond five years)	• Ramping up EV support measures in key export markets (particularly Europe). • Low oil price as an opportunity to phase out fossil fuel subsidies. • Demand for more resilient transport services based on decentralised electricity sources.	• Sustained reduction in vehicle demand (e.g. due to remote working and lower travel demand affecting the demand for local industry outputs).

The pandemic has reduced potential EV benefits in the short term but will likely amplified potential benefits in the long term. This suggests a stronger motivation for pursing the policy options presented in this report, albeit with greater care in balancing the short-term challenges with the need to start making the transition to EVs and EV-related manufacturing.

2. HOW CAN THE PASSENGER EV OFFERING BE SUPPORTED IN SOUTH AFRICA?

When considering the market development of EVs in South Africa, the first question relates to improving the nature (of both quantity and quality) of the passenger EV offering in the country. This requires addressing two intertwined questions around a) the availability of EVs on the local market; and b) the competitiveness of the offer. This corresponds to a threefold approach aimed at a) getting EVs available in South Africa; b) improving their financial attractiveness; and c) strengthening the overall ecosystem for EVs.

2.1. Problem statement

As with any new product offering, EVs face a chicken-and-egg situation between demand and supply. Arguably, a successful take-off would see demand for EVs and their availability on the market grow simultaneously in a symbiotic fashion. In reality, 'technology push' measures have spurred the growth of EVs in every leading market.

The main inhibitors to increased EV uptake in South Africa have been:

- The high upfront capital cost of EVs, exacerbated by the effects of the value-added tax (VAT), the ad valorem excise duty and the import tariff, all penalising EVs as they are applied to the capital cost;
- Limited product availability; and
- Awareness issues emanating from range anxiety, security of electricity supply and a limited understanding of the technology.[2]

This section considers these three hindering factors, as they are intertwined and highly co-dependent from the perspective of market demand. In other words, all are required to effectively provide a diversified and competitive offer to customers.

Impacting all these factors is the lack of a coherent and coordinated policy environment aimed at driving increased EV penetration. A key lesson from countries around the world is that active policies and measures are needed to improve the EV offering and stimulate demand (IEA, 2019).

A wide range of policy measures have been introduced around the world to support and incentivise the rapid increase in the roll out and uptake of EVs. Typically, a policy package consisting of a suite of integrated measures have been introduced. These include regulations, such as EV mandates and targets, stringent fuel economy standards and phase-out dates for ICE vehicles (IEA, 2019). Fiscal incentives for vehicles, such as cutting import taxes on EVs, subsidies and direct rebates to customers, have been used to drive down the price of EVs (SLOCAT, 2020; Black, 2019). Industrial policies offering subsidies and other measures to stimulate domestic production of EVs and their components, which can enable a reduced local EV prices, have also been used (see Sections 4 and 5 for a discussion of manufacturing-related dynamics).

Charging infrastructure for EVs has also received policy support in the form of building regulations for new and retrofitted buildings that mandate the inclusion of charging stations. In addition, fiscal

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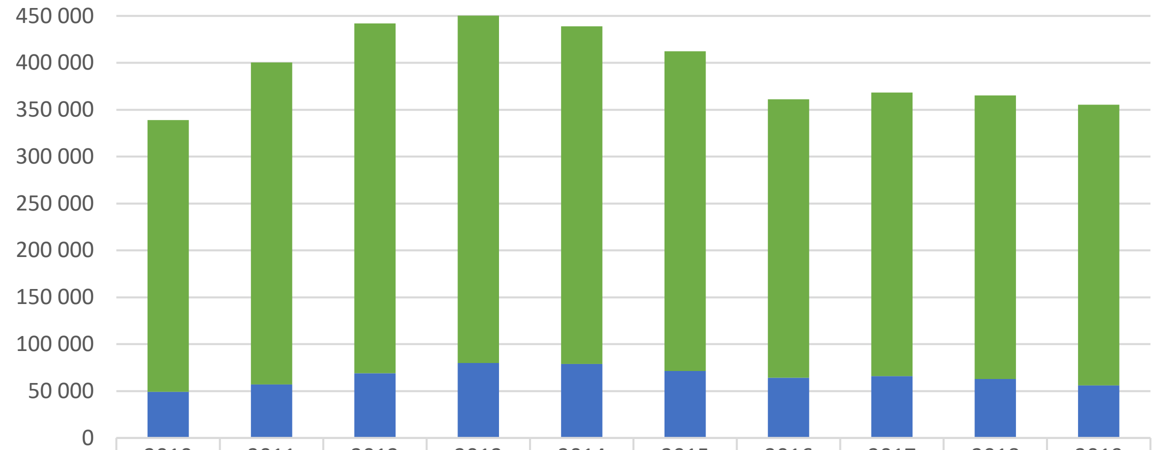
[2] At this stage, charging infrastructure is not a significant limiting factor.

incentives and targets have been introduced to support the rapid rollout of the necessary charging infrastructure and to make it available to the public and to private households (IEA, 2019).

Cities globally have been particularly proactive by developing plans for zero-carbon public transport systems, signing up to initiatives, such as C40 Fossil Free Streets Declaration, procuring electric buses, taxis and other forms of electric public transport options. Cities have also committed to ambitious EV targets along with establishing zero-emission zones in cities and offering priority parking spaces for EVs. Even more broadly, EV strategies are being included as enabling components of ambitious renewable energy and storage strategies in a number of countries (SLOCAT, 2020). Private companies are also driving progress by introducing EV production targets, logistics companies and ride-sharing services converting fleets to EVs.

In the current South African context, virtually no incentive exists in the market to support the demand for EVs. Some locations offer free charging, but this benefit is limited and slowly disappearing. No explicit financial or non-financial benefits in favour of EVs are currently in place in South Africa. As detailed in Figure 6 and Figure 7, the sales of EVs in South Africa have remained extremely marginal with 6 043 EVs sold over the 2010-2019 period, corresponding to less than 0.1% of new car sales in the country.

Figure 6: Passenger car sales in South Africa from 2010 to 2019



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Petrol	289 911	343 489	373 022	370 392	360 122	340 982	297 019	302 227	302 440	299 408
Diesel	48 598	56 317	68 260	79 357	78 155	70 908	63 765	65 516	62 605	55 563
PHEV	-	-	-	-	-	124	168	121	89	72
BEV	-	-	-	34	14	117	100	68	58	154
HEV	430	627	766	513	646	266	213	182	55	181

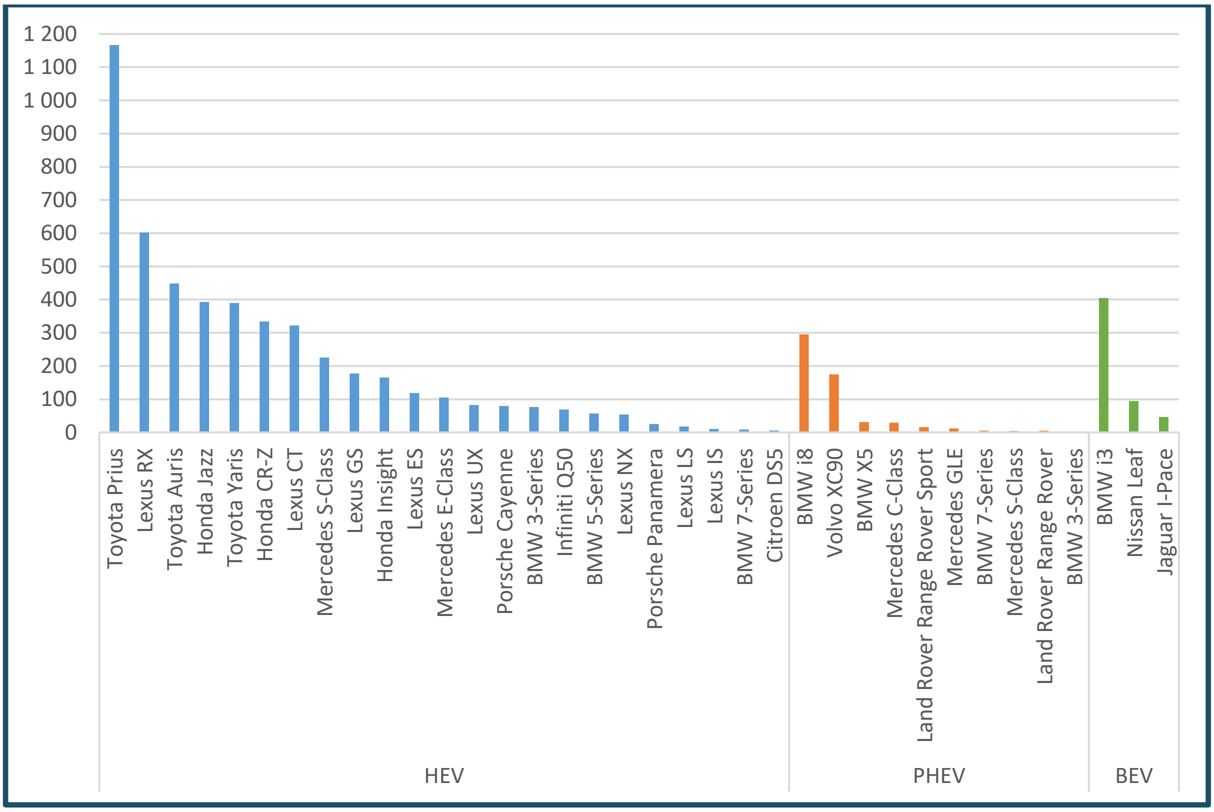
HEV BEV PHEV Diesel Petrol

Source: Authors, based on data from Lightstone Auto and obtained from NAAMSA.

2.2. Context

In the current setting, as of April 2020, the number of EVs available in South Africa remains limited. Only two new BEVs, namely the BMW i3 and the Jaguar i-PACE, were available as of March 2020. More BEVs are expected in South Africa in 2020/2021, including the Audi e-tron, the Mercedes EQC, the New 40kWh Nissan Leaf and the 62kWh Nissan Leaf e+, the Opel Corsa-e, the new MINI-E (Kuhudzai, 2020) and the Porsche Taycan (BusinessTech, 2020). The first-generation Nissan Leaf has been discontinued but does contribute to BEVs on the road in the country. The availability of hybrid vehicles is slightly higher, with 23 HEVs and 10 PHEVs having registered at least one sale by the end of 2019 (Parmar, 2020). No FCEV is currently on offer. This contrasts with the existing 162 models available worldwide in 2019 (and set to rise to 263 in 2020), as shown in Figure 5 in the Introduction section. The lack of local supply is particularly striking in the entry- and mid-level market segments, with most available models competing in the high-end to niche segments. As shown in Figure 7, as of the end of 2019, EV sales had reached 6 043, including 4 924 HEVs, 574 PHEVs and 545 BEVs.

Figure 7: Passenger EV sales in South Africa as of end 2019



Source: Authors, based on data from Lightstone Auto.

On the price competitiveness front, available EVs in the South African market fetch a much-higher price tag than comparable ICE-based competitors. Despite lower running costs (linked to low maintenance requirements, higher efficiency and low charging costs), the high upfront purchasing cost of EVs has discouraged potential buyers. Besides the effective (i.e. the actual financing cost)[3] and psychological barriers triggered by the high selling price, it also lengthens the payback period required for EVs to generate savings compared to their ICE equivalent. Indeed, the selling price plays a much more prominent role in the Total Cost of Ownership (TCO) or Levelised Cost of Transport (LCOT) of EVs relative ICE-based vehicles (see Box 3).

[3] The impact on the financing cost of EVs is furthermore compounded by the nature of South Africa's financial market, which charges high interest rates on vehicle finance. Lower interest rates as well as innovative financing models could assist in reducing this hurdle. They are considered in Section 2.3.

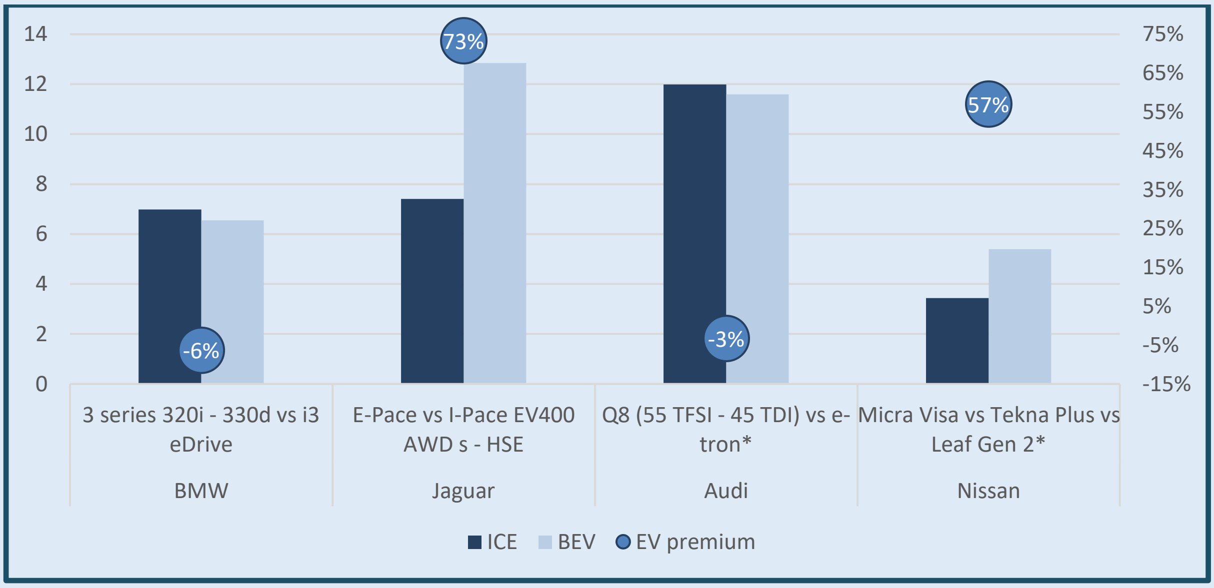
Box 3: Comparing the relative costs of EVs and ICE vehicles

Many studies assess the relative Total Cost of Ownership of vehicles. The TCO allows analysts and buyers to compare the total costs of products by including the purchasing price as well as other costs that are associated with the ownership of a product during its useful life. These studies and tools use different implicit assumptions and the outcomes are influenced significantly by use patterns, fuel prices and any incentives included in the calculations. Therefore, TCO outcomes are specific to local contexts and local numbers. For example, Californian utility PG&E Corporation has made a TCO calculator publicly accessible.[1] The calculator lets customers compare 52 EVs on the market in California.

The IEA suggests that EVs are currently cost competitive, on a TCO basis, in only a narrow range of cases (IEA, 2019). The TCO for all-electric vehicles is strongly correlated with the price of batteries. As battery prices continue to decrease and energy densities increase, EVs are set to become increasingly attractive from the perspective of cost and performance (IEA, 2019). In general, various studies point to the TCO of EVs being equivalent or marginally higher in the small vehicle segment, lower in the medium vehicle segment and higher in the large vehicle segment. Overall, in many instances, the TCO of EVs is lower than their ICE counterparts (Gorrie, 2019). Incentives have led to much lower relative TCO values for EVs in Norway, for example. This is similarly the case for many vehicles in California. Other sources suggest the differences are marginal, even with falling battery prices projected, and call for policy to increase the TCO differential and stimulate the sales of EVs (Van Velzen et al, 2019).

An alternative method of comparison is the Levelised Cost of Transport. A LCOT model establishes the cost of supplying the transport service over the life of the vehicle and is expressed in units of Rands per passenge.km (R/p.km).[2] The details of the methodology and assumptions used in this assessment are provided in Annex A.

Figure 8: Base case cost comparison of private passenger ICE to EV in South Africa



Source: Authors, based on Sustainable Energy Africa's (SEA's) LCOT model. More details in Annex A.
**Models not yet available but expected to be available in the course of 2020.*

In considering the results of these assessments, it is important to note the following:

- It is difficult to pair appropriate EV and ICE comparison and, once more EVs are on the roads in South Africa, it should be possible to conduct a more accurate comparison using class averages;

- Maintenance costs, which are impacted by use patterns, weather conditions and other factors, are not well known due to the latency of the EV market, especially in South Africa; and
- Liquid fuel prices vary across the country (inland versus coastal petrol prices and variable diesel mark-up above the wholesale price) and, at the time of this study, were relatively low due to a price war resulting in the flooding of the oil market, coupled with a fall in demand due to the COVID-19 pandemic, in early 2020.

[1] See https://ev.pge.com for the TCO calculator.
[2] A LCOT approach has been used is this assessment as it allows a comparison of options across different transport services based on the net present value of the costs per passenger kilometre. This allows for a comparison of private versus public transport and could be used to assess the role of ride sharing and MaaS options that impact vehicle occupancy rates and thus influence the LCOT. This study has not considered alternative ownership models, such as MaaS, or the role of other mechanisms to deliver developmental objectives in the transport sector. However, these results could be considered in any future assessment of such options, given the use of LCOT as an assessment indicator.

While the higher (production) cost of EVs is at the root of the higher price tag of EVs compared to equivalent ICE-based models, a variety of factors further widens the gap between the upfront selling prices of vehicles. By nature of their higher upfront cost, EVs are more heavily impacted by existing taxes and levies, such as the VAT and the ad valorem excise duty. The VAT is set at a standard rate of 15% in South Africa. Set at a maximum of 30%, the ad valorem excise duty is calculated on the basis of a sliding scale, with the rate of the duty increasing with the value of the taxed item. Again, the higher upfront cost of EVs, either locally made or imported, would fetch a higher excise duty. Table 2 illustrates the sliding scale applicable to locally manufactured vehicles.[4]

Table 2: Rate of ad valorem excise duty for locally manufactured motor vehicles in South Africa

VALUE FOR DUTY PURPOSES	RATE OF DUTY	VALUE FOR DUTY PURPOSES	RATE OF DUTY
R100 000	1.65%	R800 000	18.45%
R200 000	4.05%	R900 000	20.85%
R300 000	6.45%	R1 000 000	23.25%
R400 000	8.85%	R1 100 000	25.65%
R500 000	11.25%	R1 200 000	28.05%
R600 000	13.65%	R1 300 000	30.00%
R700 000	16.05%	R1 400 000	30.00%

Source: Authors, based on South African Revenue Service (SARS) documents.

In line with a strong automotive manufacturing sector, the import of passenger cars into South Africa is subject to high custom duties. Table 3 summarises the tariff regime for the import of passenger cars into the country. Overall, vehicles coming from the EU benefit from a preferential treatment compared to other jurisdictions, with a duty of 18% instead of 25%. One exception is notable, i.e. BEVs, which fetch a 25% duty irrespective of their origin. This *de facto* penalises BEVs originating from the EU compared to their counterparts. Under the general tariff, all major passenger car types, i.e. petrol,

[4] The ad valorem excise duty is calculated differently whether vehicles are locally manufactured or imported. For locally manufactured vehicles, the rate of duty is calculated based on the recommended retail price, excluding VAT and discounted by 20%. For imported vehicles, it is calculated based on the transaction value, as well as the applicable VAT and tariff duties. As the transaction value is an internal confidential value used by firms to import vehicles, it is therefore virtually impossible to compare the ad valorem excise duties between imported and locally manufactured vehicles.

diesel, HEV, PHEV and BEV, are taxed at 25%. Again, due to the higher selling price of EVs compared to ICE equivalent, these are indirectly penalised.

Table 3: Tariff regime for the import of passenger cars into South Africa

Vehicle type	Heading	General	EU	EFTA	SADC	MERCOSUR
HEV - petrol	8703.40.90	25%	18%	25%	free	25%
HEV - petrol - under 1000cc	8703.40.31	25%	free	free	free	25%
HEV - petrol - between 250 and 800 kg	8703.40.75	free	free	free	free	free
HEV - diesel	8703.50.90	25%	18%	25%	free	25%
HEV - diesel - between 600 and 800 kg	8703.50.85	free	free	free	free	free
PHEV - petrol	8703.60.90	25%	18%	25%	free	25%
PHEV - diesel	8703.70.90	25%	18%	25%	free	25%
BEVs - above 800 kg	8703.80.90	25%	**25%**	25%	free	25%
BEVs - under 800 kg	8703.80.31	free	free	free	free	free
Petrol - under 1000cc	8703.21.90	25%	free	free	free	25%
Petrol - under 1000cc - between 250 and 800 kg	8703.21.75	free	free	free	free	free
Petrol - between 1000cc and 1500cc	8703.22.90	25%	18%	25%	free	25%
Petrol - between 1500cc and 3000cc	8703.23.90	25%	18%	25%	free	25%
Petrol - above 3000c	8703.24.90	25%	18%	25%	free	25%
Diesel - under 1500cc	8703.31.90	25%	18%	25%	free	25%
Diesel - under 1500cc - between 600 and 800 kg	8703.31.85	free	free	free	free	free
Diesel - between 1500cc and 2500cc	8703.32.90	25%	18%	25%	free	25%
Diesel - above 2500c	8703.33.90	25%	18%	25%	free	25%

Source: Authors, based on Schedules to the Customs and Excise Act, 1964, downloaded in November 2019 from SARS at www.sars.gov.za.

The automotive industry in South Africa has called for the tariffs applied to EVs to be reduced, particularly the 25% duty on BEVs originating from the EU. In 2019, the International Trade Administration Commission of South Africa (ITAC) considered and rejected an application for a reduction in the general rate of customs duty applicable to BEVs. The decision was essentially based on the aim of supporting the development of domestic manufacturing of BEVs.

In contrast, ICE-based vehicles are penalised by the application of a carbon tax on motor vehicles. The impact on the selling price remains, however, marginal to having an impact on demand dynamics. Motor vehicles sold in South Africa (either imported or manufactured locally) are subject to an "environmental levy on carbon dioxide emissions of motor vehicles". The levy is set at R120 per g/km CO_2 emissions exceeding 95g/km (R160 per g/km CO_2 emissions exceeding 175g/km for commercial vehicles). The average CO_2 emissions of new passenger cars in South Africa was 148 gCO_2/km in 2015 (Posada, 2018). This corresponds to a levy of R6 360 for the average passenger car sold in the country, a marginal amount on the retail price of vehicles. EVs would normally fall below the 95g/km threshold and be exempted from the levy.

Due to their high upfront cost, EVs are furthermore penalised by the high interest rate associated with vehicle finance in South Africa. In 2019, the average interest rate on vehicle finance was 11.38%. Europe and the US showed rates roughly half of this (South African Market Insights, 2019, Euro Area Statistics, n.d.; Nova, 2019). This barrier is exacerbated by the narrow range of EVs in South Africa, with the few choices predominantly on the higher end of the market with price tags ranging from R480 000 to R1.6 million (Kemraj, 2019; GreenCape, 2019). An additional factor is the credit score of customers, with much of the growth in vehicle sales coming from historically lower-income communities with lower credit scores. The prohibitive cost of capital for much of the market effectively limits new buyers to ICE vehicles with lower price tags (Kwame, 2019; GreenCape, 2019).

Box 4: Tariff regime for the import of vehicle-related batteries into South Africa

Car batteries face a favourable tariff framework as most are exempt from any customs duty. Importantly, all batteries originating from the EU – as well as the European Free Trade Association (EFTA) and the Southern African Development Community (SADC) – can be imported free of duties. Under the general tariff heading, fuel cells (20%) and lead acid batteries (5%-15%) are subject to some duties. Lithium-ion accumulators are, however, exempted across the board.

Table 4: Customs duties for the import of vehicle-related batteries into South Africa

BATTERIES	HEADING	GENERAL	EU	EFTA	SADC	MERCOSUR
Air-zinc	8506.60	free	free	free	free	free
Fuel cells	8506.80.40	20%	free	free	free	20%
Lead-acid, not exceeding 185x125x195 mm	8507.10.1	5%	free	free	free	5%
Lead-acid, others	8507.10.99	15%	free	free	free	15%
Nickel-cadmium	8507.30.	free	free	free	free	free
Nickel-iron	8507.40.	free	free	free	free	free
Nickel-metal hydride	8507.50.	free	free	free	free	free
Lithium-ion	8507.60.	free	free	free	free	free

Source: Authors, based on Schedules to the Customs and Excise Act, 1964, downloaded in November 2019 from SARS at www.sars.gov.za.

The upfront capital cost of EVs is projected to decrease steeply over time, largely due to decreasing battery costs (BNEF, 2019) (IEA, 2019). Bloomberg predicts that battery cost will decrease from US$176/kWh in 2019 to US$87/kWh in 2025 and US$62/kWh in 2030 (BNEF, 2019). Other developments to induce continued cost cuts include options to redesign vehicle manufacturing platforms to use simpler and innovative design architecture, taking advantage of the compact dimensions of electric motors and capitalising on the presence of much fewer moving parts in EVs than in ICE vehicles (IEA, 2019). For example, Volkswagen's ID.3 is its first mass-market BEV underpinned by the development of a dedicated vehicle architecture. It is due in Germany in mid-2020 and is reported as being less expensive than comparable ICE models on a TCO basis (Volkswagen, 2020). Further cost reductions are achieved through investments in charging technologies and battery "right-sizing"[5] (IEA, 2019).

On the operating cost front, EVs have been shown to be more efficient at converting energy into mobility. Most ICEs operate at less than 40% thermal efficiency while electric motors can be over 90% efficient. The energy required per km travelled depends on the vehicle considered. For example, in the US, the Jaguar I-Pace's 90kWh battery pack translates into 76 miles per gallon equivalent (MPGe)[6] (32 km/l). This compares to 136 MPGe (58 km/l) for the Hyundai Ioniq's 28kWh pack

[5] Optimising the battery size to meet customer driving needs, often enabling smaller batteries in certain applications.
[6] The official metric that the US EPA uses to measure the efficiency of alternative-fuel (including electric) vehicles

(Erwin, 2019). Comparing a BMW i3 (BEV) to the 3 series (ICE) and the Jaguar I-Pace (BEV) to the E-Pace (ICE), using the US Environmental Protection Agency's (EPA's) fuel economy comparison tool, finds BEVs between 317% and 377% more efficient on a MPGe basis. The detailed results are available in Annex B. More generally, data suggests that EVs are up to four times more energy efficient than diesel vehicles and five times more efficient than petrol vehicles (Change Pathways, 2018). How this translates into costs depends on the local context. In the US, it costs less than half as much to travel the same distance in an EV than a conventional vehicle (US Office of Energy Efficiency and Renewable Energy, 2020).

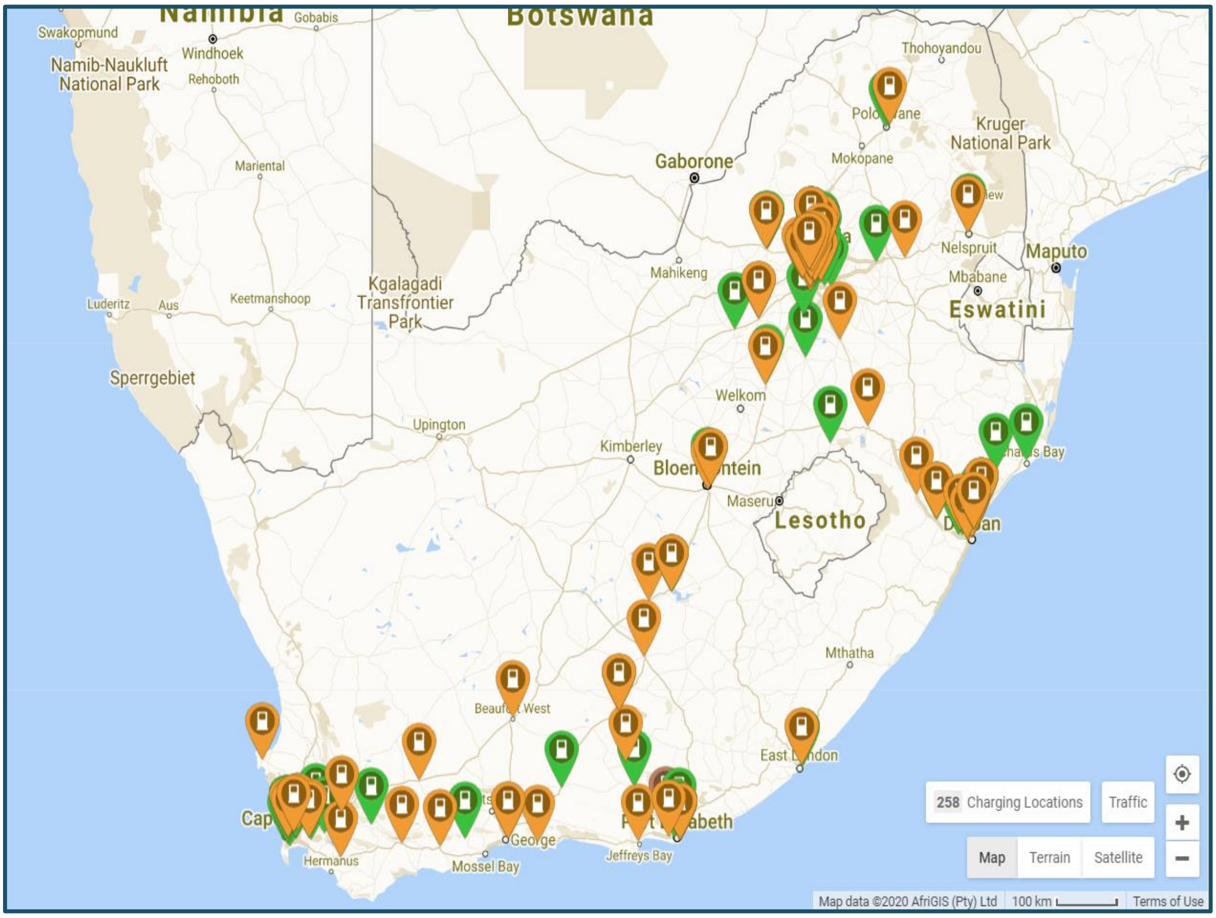
BEVs and FCEVs also have fewer moving parts and less wear and tear than conventional ICE vehicles. Data on maintenance costs is less well understood but sources suggest between a third and two-thirds of ICE maintenance costs (Logtenberg, Pawley, & Saxifrage, 2018). Overall though, EVs tend to have longer warranties than ICE vehicles.

Market adoption of EVs is not only a function of costs but also institutional and behavioural barriers. Range anxiety is often identified as a significant barrier to EV uptake. However, this is often due to a lack of awareness, as demonstrated by studies that have shown range anxiety to only be a concern for non-EV drivers. EVs typically meet driver needs. For example, market research company Ipsos reports that "the average American drives around 170 miles (284 km) during their normal workweek. With many current BEVs offering 200 miles per full charge, an owner would only need to charge once a week to meet their driving needs, much like filling up [petrol] once a week" (Markusic, 2020). Linked to range anxiety is concern about adequate charging infrastructure and the time it takes to charge vehicles. However, experience has shown that most people charge their vehicles at home. For example, in Europe, around 80% of EV owners charge their vehicles overnight at home using AC power. If they have home-charging and workplace charging, 96%-97% of charging is done at home or work (Fishbone, 2017).

Awareness and familiarity are important to overcome many of these barriers. Ipsos found that familiarity with EVs is important to overcome some of the misconceptions. The Ipsos global survey of 20 000 consumers found that just 10% indicated that they know EVs "very well," while less than 10% indicated that they had never driven or ridden in an EV or even looked at one (Markusic, 2020).

In this respect, the availability of charging stations is not considered to be a main barrier at present in South Africa. The country has 258 public charging stations, as illustrated in Figure 9. This translates into 5 plug-in EVs per public charging points, on South Africa's roads.

Figure 9: Public EV charging locations in South Africa

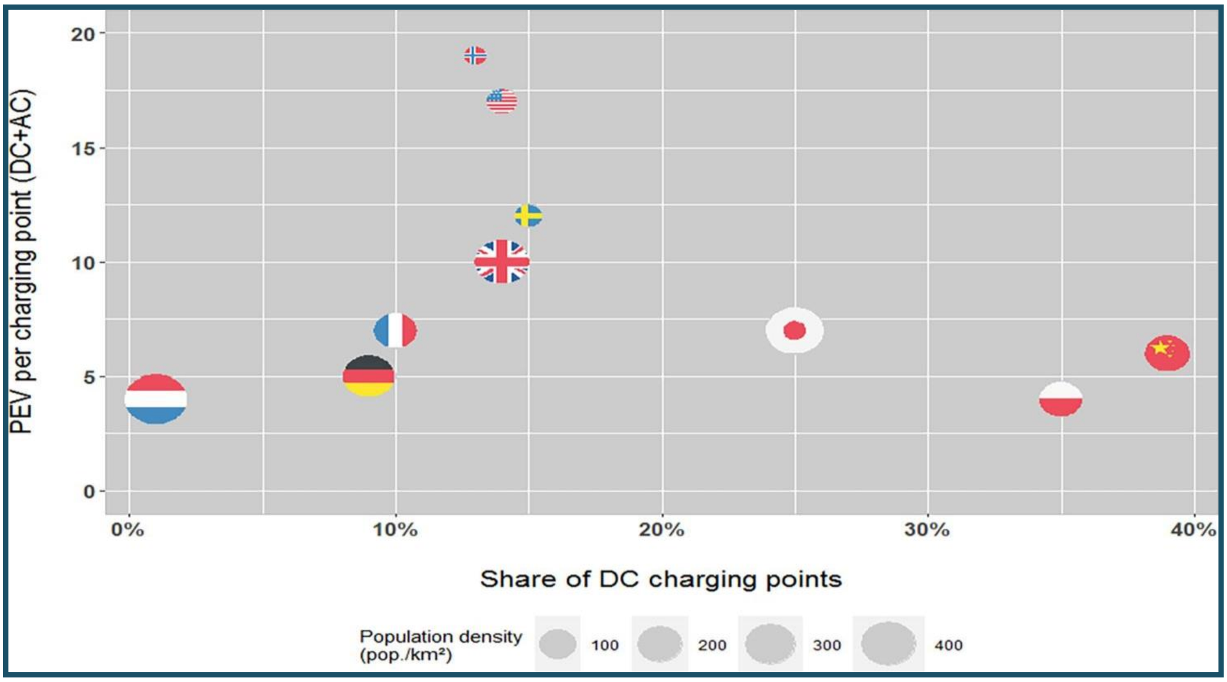


Source: Plugshar (see www.plugshare.com).
Legend: Public ("All stations are public"); High Power ("Has one or more high powered stations").

Importantly, experience internationally suggests that less than 5% of EV charging typically happens at public charging points. As raised, most private passenger EV owners charge their cars at home over night. This limits the need for public chargers. However, studies have found a statistically significant link between EV uptake and charging infrastructure (Slowik and Lutsey, 2017. Some analysts suggest that public chargers, in the early stages of market development, are more important as mechanisms to curb range anxiety rather than to deliver actual charging services.

South Africa compares favourably to other countries in terms of the ratio of plug-in EVs to public charging points, and is on a par with Germany, as shown in Figure 10. Of course, South Africa is a very small market in terms of plug-in EVs on the road (1 119 as of December 2019) and therefore, while the ratio is better or in line with many developed countries, the visibility and coverage of pubic chargers is less advanced. Nonetheless, in spite of a limited market size, this ratio, coupled with the extent of the existing charging network in South Africa, suggests that the private sector is likely to make adequate investments in public charging infrastructure. Adequate public charging infrastructure is not currently a barrier to the growth of the EV market in South Africa.

Figure 10: Comparison of various countries' charging point share and average Plug-in EV per charging point



Source: Funke et al, 2019.
Note: Bubble size indicates population density.
South Africa's share of DC (direct current) charging points is an estimate and remains to be accurately calculated.

South Africa has been proactive and adopted the following foreword for South African Bureau of Standards (SABS) standards for EV charging plugs:

- SANS 62196-2: "In South Africa, the allowed configuration for all AC conductive charging on domestic, industrial, commercial and public access charging stations shall be of Type 2 socket only";
- SANS 62196-3: "In South Africa the allowed configuration for DC conductive charging for domestic, industrial, commercial and public access charging station shall be configuration type AA (CHAdeMO) and configuration type FF (COMBO 2)".

Finally, successful market penetration of EVs may not rely only on the characteristics of the technology but also on the business models available in the market. There is a lack of understanding in South Africa of the preferences for ownership versus battery leasing, vehicle leasing or mobility performance guarantees.

2.3. The universe of possible solutions

To support a competitive and diversified offer of private passenger EVs on the South African market, multiple, complementary avenues are possible. They include establishing an environment that drives or requires the intended EV outcomes by:

- Reducing the upfront price tag of EVs;
- Further improving the comparative advantage of EVs in terms of operational (i.e. running) costs;
- Providing non-financial incentives (which could be positive or negative) in favour of the use of EVs; and

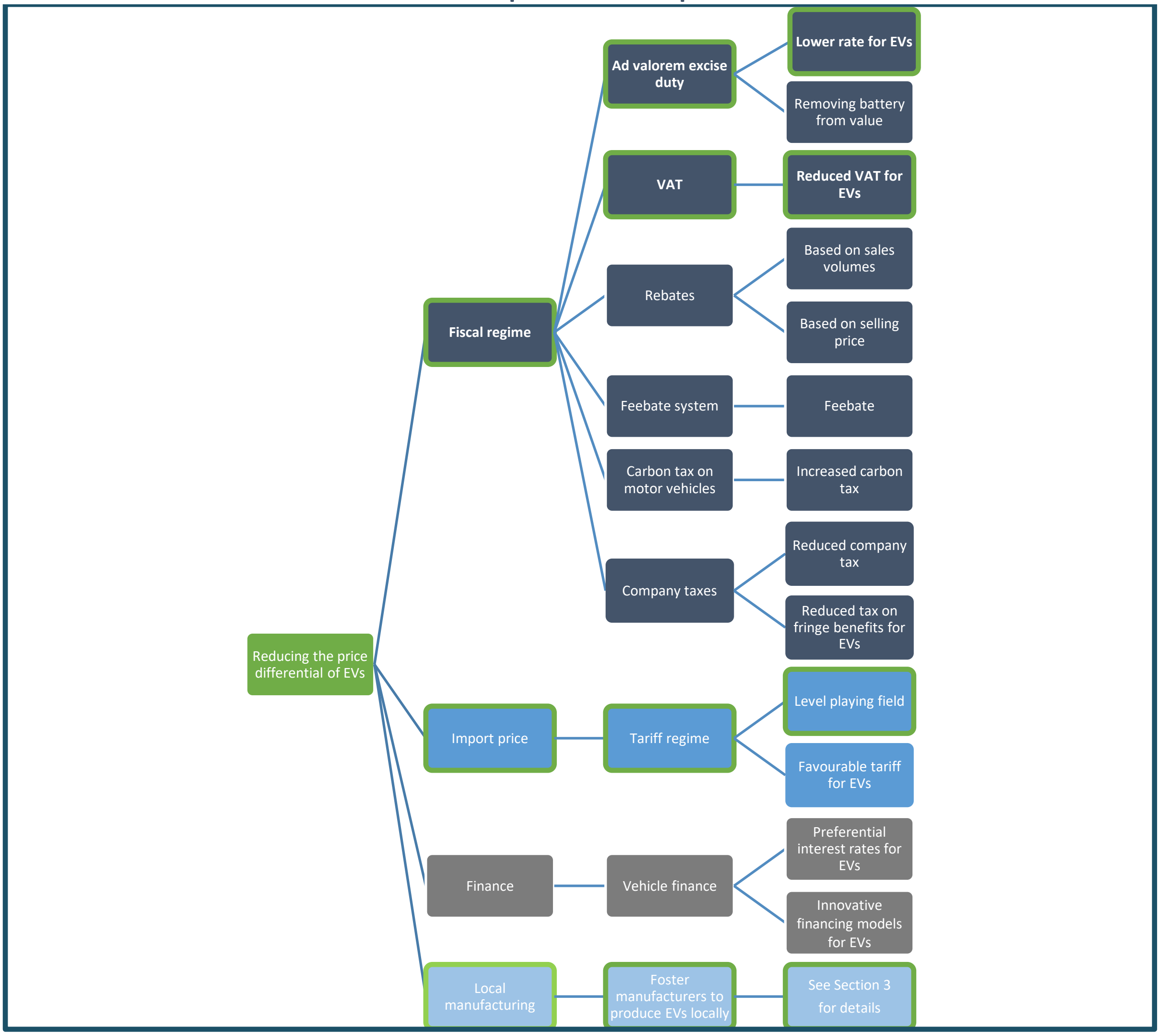
- Enhancing customers' experience.

A key lesson from international experience is that government commitment, in the form of various targets, policies and measures, is required to stimulate investment in EVs and the broader EV ecosystem. A coherent and coordinated policy environment is necessary and relevant to achieving and maximising the outcomes for all the options described below.

2.3.1. Reducing the upfront price differential of EVs compared to ICE equivalent

To reduce the upfront capital expenditure (i.e. the selling price) of EVs, several levers are available. Such levers also complement each other as they target different entry points. Main interventions focus on the fiscal regime linked to vehicle sales, vehicle imports, and vehicle finance. Interventions at the manufacturing level would also complement the mix of measures. Figure 11 summarises the universe of options to reduce the upfront price differential of EVs and how they link to other sections.

Figure 11: Possible options to reduce the upfront price differential of EVs compared to ICE equivalent



Source: Authors

Note: primary interventions are circled in green and highlighted in bold text.

The first avenue would be to adjust the fiscal regime pertaining to the sale of EVs. This could take different forms, which could be applied separately and complementarily.

The ad valorem excise duty, while non-discriminatory, penalises EVs and could be adjusted. This could be implemented through a special dispensation introducing a reduced rate for EVs. Alternatively, the ad valorem excise duty for EVs could be reduced by excluding (partially or in full) the value of the battery packs from the calculation formula. For instance, India exempted customs duty on battery packs for EVs but has recently withdrawn the exemption in favour of a 5% tax to promote local manufacturing (IANS, 2020). Canada applies zero duties based on the end use whereas the US and Mexico apply different tariffs based on technology rather than end use (ICTSD, 2017).

A similar arrangement could be implemented through the VAT, in the same fashion that some basic goods are exempted. EVs imported in Norway are not subject to the 25% VAT on motor vehicles. Austria has in place a VAT deduction and exemption from tax for zero-emission cars (e.g. BEVs and FCEVs) (ACEA, 2020). The Ukrainian Parliament has adopted a provisional exemption on VAT and excise tax for all EVs (SLOCAT 2020).

As a complementary intervention, a tax incentive for companies could drive demand for EVs in company fleets (through the company tax) or vehicles provided to employees as fringe benefits (through the company fringe benefit tax). In both cases, implementing such intervention would fall directly within the control of government entities and could be implemented relatively quickly (in line with government budget cycles). Various countries in Europe have explored this option: companies in Belgium can deduct 120%, under corporate tax, of expenses for zero-emission cars until end of 2019 and 100% from 2020 (ACEA, 2020). In Sweden, a 40% reduction is applied on company car taxation for electric cars and plug-in hybrids (Volkswagen, 2019).

A rebate system could also be implemented to discount the selling price of EVs. The rebate could be a fixed amount (per type of EV) or calculated on a percentage/sliding scale basis. Such a rebate could be limited in time as well as in scope, for instance based on sale volume or selling prices. Buyers of EVs in the US are, for instance, entitled to a federal tax credit of up to US$7 500. However, as soon as a manufacturer's total sales of electric cars have reached 200 000 units, the subsidy for models from this manufacturer expires. So far, only two companies have reached this limit (Volkswagen, 2019). Such a rebate system would require appropriate dedicated funding. In addition to being difficult to justify socially (and therefore politically) in South Africa, such a system appears complicated to finance in the current fiscal environment.

A variant is to channel a rebate through the utility companies. In the US, various utilities have teamed up with vehicle manufacturers to provide rebates of up to US$10 000. Such strategic investments by utilities operating in competitive electricity markets are unlikely in the South Africa context, given the lack of a competitive market (i.e. choices when purchasing electricity); the poor financial position of the national utility company, Eskom; and the potential or high levels of complexity and adverse effects.

Alternatively, or complementarily, the selling price of ICE-based vehicles could be made more expensive by raising the existing carbon tax on motor vehicles. A rebate system and the carbon tax could also be integrated into a (potentially self-funding) feebate system. In Sweden, a climate bonus (*klimatbonus*) is available to purchase new vehicles with CO_2 emissions of maximum 60g/km. It ranges from SEK 60 000 for BEV with zero emission to SEK 10 000 for PHEV with emission of 60g/km (ACEA, 2020).

Rebates and other tax incentives have also been used to reduce the cost of charging infrastructure. In this analysis, the cost of charging infrastructure borne by the private car owner (i.e. for home or office charging) is assumed in the upfront cost differential and thus the above options do not apply. However, a number of countries and companies have explored various incentives designed specifically around reducing private and public charging infrastructure costs (Truesdell, 2019).

Reducing the ad valorem duty and VAT on EVs have been identified as primary options given that they are technically feasible (i.e. within the capabilities and legal mandate of National Treasury to make the changes), do not require additional budget (although they would have an impact on government revenue collection), and would have the potential to reduce the upfront cost of EVs to the extent necessary to make them cost competitive (i.e. to bring the TCO/LCOT to within that of conventional ICE equivalents). These measures would still need to be coupled with awareness-raising and the package of secondary options outlined elsewhere in this report.

Rebates, feebates and adjustments to the vehicle carbon tax and company taxes are regarded as secondary options that could be considered as part of a package of options. These options could contribute to reducing the upfront capital cost of EVs but would, on their own, be unlikely to deliver the reductions needed to unlock the South African market. The following other factors relevant to the South African context are also at play:

- Rebates: there is limited fiscal space/budget to fund adequate rebates by the government and, unlike some developed country contexts, South Africa's electricity utility Eskom and the OEMs are unlikely to provide privately funded rebates;
- Feebates: This is not deemed viable in the current South African context. A feebate system would require the ringfencing of revenues (from the carbon tax on motor vehicles) to fund the rebates (on EVs), a measure which is rejected by National Treasury as a matter of principle;
- Carbon tax: the existing carbon tax on vehicles is too low to influence behaviour and would need to be increased significantly to reduce the EV price premium. The significant push back against the new carbon tax (implemented in June 2019) suggests any increase in carbon pricing would be socially unacceptable. In the short term, an increase in the carbon tax on motor vehicles would furthermore have a regressive impact on society.
- Company tax: this is likely to be relatively easy to implement but unlikely to adequately tip the scales.

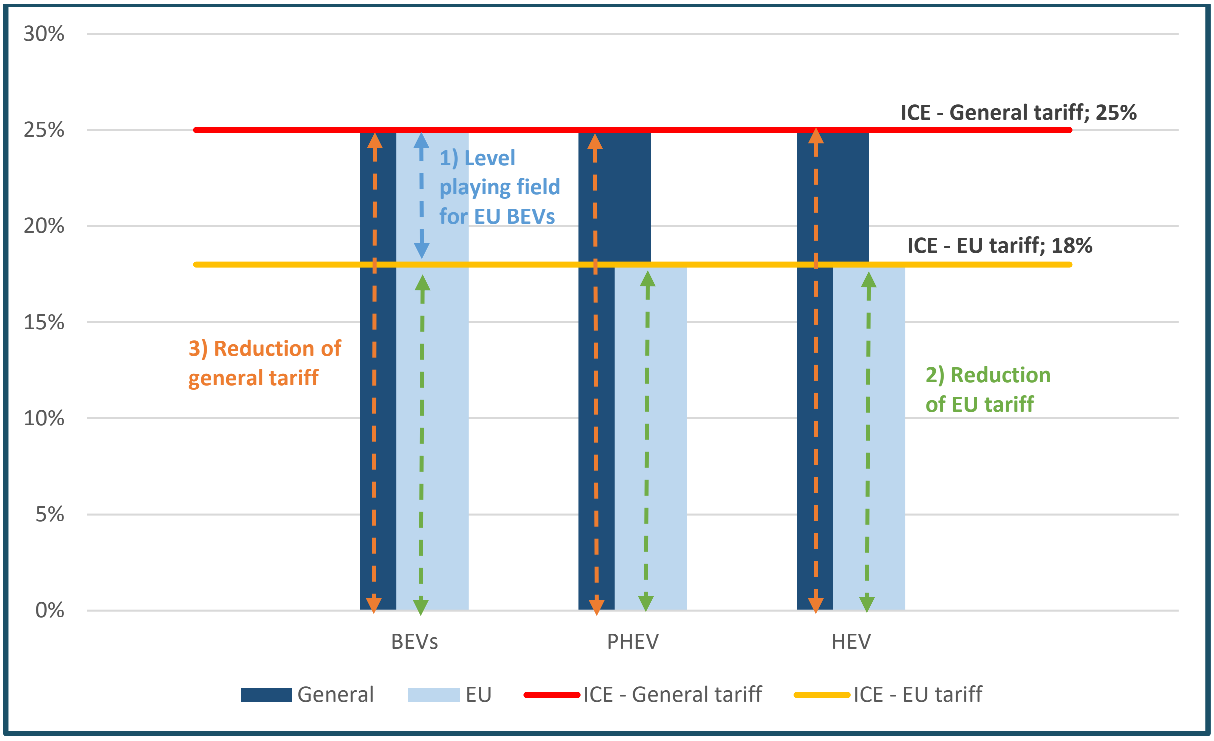
The second avenue would be to facilitate the import of EVs into the country by reducing customs duties for EVs. This option is requested by a majority of OEMs, particularly (potential) importers of EVs. This could be rapidly implemented and designed as a permanent or temporary measure. For instance, it could be an interim measure until the development of local manufacturing. The tariff regime for EVs is currently on par with the one for ICE-based vehicles, with the exception of BEVs originating from the EU, which are at a disadvantage. Tariffs could be adjusted to provide a level playing field (i.e. only reducing the tariff for EU-originated BEVs to the standard rate) or to put EVs at an advantage (i.e. reducing tariffs for EVs to a level lower than tariffs for ICE-based vehicles). An additional option would be to explore a tariff reduction or tariff exemption on the battery component of the vehicle.

Implementation could take different forms, which would, however, vary in political acceptability. Possible options are listed below, ranked from the option likely to face the least political resistance to the one likely to face the most resistance:

1) Quid pro quo reduction (most likely in exchange for an increase in the tariff for vehicles under 1000cc) in tariff to create a level playing field (primary option);
2) Unilateral reduction in tariff to create a level playing field (primary option);
3) Quid pro quo reduction most likely in exchange of an increase in the tariff for vehicles under 1000cc) in tariff to provide an advantage to EVs (secondary option); and
4) Unilateral reduction in tariff to provide an advantage to EVs (secondary option).

Importantly, EVs fall under a variety of tariff lines, differentiating between BEVs, PHEVs (petrol and diesel), and HEVs (petrol and diesel). Tariff reductions could be applied to all or only some (e.g. BEVs) technologies. A coherent approach, i.e. encompassing all technologies, would send a stronger signal as well as limit the distorting effect of tariffs on the market. Irrespective of technologies, tariff reduction could range from simply rectifying the 25% anomaly for BEVs originating from the EU, to scrapping duties on EVs, to anything in between. Figure 12 illustrates the range of unilateral options.

Figure 12: Illustration of possible unilateral reduction in customs duties for EVs



Source: Authors

Adjusting tariffs to provide a level playing field has been identified as a primary option, as this would rectify an anomaly in the tariff structure and contribute to reducing the EV price premium. Further reducing the tariff (i.e. below 18%) is regarded as secondary, for the time being, given ITAC's rejection of such an application in line with the potential negative impact on the local automotive industry.

The third avenue would be to leverage vehicle finance. Indeed, vehicle interest rates in South Africa are high relative to high-income, lower-risk, countries. This barrier could be addressed through low-interest loans, interest rate buy-downs and other innovative financing options (GreenCape, 2019). Development finance institutions, working through commercial banks, could facilitate such developments by providing concessional finance. See Section 3 for further details on innovative finance solutions that could suit vehicle fleets with relatively predictable and known applications.

Developing preferential interest rates for EVs is regarded as a primary option as a reduction in the cost of capital would have a significant impact on the cost-competitiveness of EVs (particularly as any cost of capital penalises the relatively higher EV upfront cost more than its ICE equivalent). This option would require partnerships between government and financial institutions so that this can translate into adequately low interest rates to drive demand.

Innovative financing models are regarded as secondary options, given a lack of evidence that the South African market would take up alternative ownership models (e.g. lease agreements, battery leasing). They are likely to remain on the fringe. Further, variable use patterns and the possibility of increasing use as a result of savings limit the potential to leverage savings-based models such as Pay-As-You Save (PAYS) (see Section 3 for more details on this).

Further to these three main interventions, an additional, complementary stream would be to foster the local manufacturing of EVs. In addition to contributing to local socio-economic development, locally produced vehicles, by circumventing import duties, could be brought into the market at more affordable prices than currently imported EVs. As government does not have a direct influence on the type of vehicles which are produced by OEMs in the country, fostering EV production in South Africa would require an agreement with local producers (and the value chain) on the basis of a renewed sector development programme. This could include EV-specific support (through for example an addendum to the APDP) and/or dedicated targets for EV sales in South Africa. Given the investment cycles and existing commitments of OEMs (both locally and globally), this avenue would, however, be more realistic in the medium rather than short term. See Section 4 for more details.

Fostering the manufacturing of EVs is considered a secondary option. This would result in lower cost vehicles but the price benefit would, on its own, be unlikely tip the scales and is not a short-term option. This is particularly true in a market where EVs are competing with lower purchasing price ICE vehicles. Further, as discussed in Section 4, in the case of private passenger vehicles, domestic demand is considered a precursor for local manufacturing, rather than the other way around.[7]

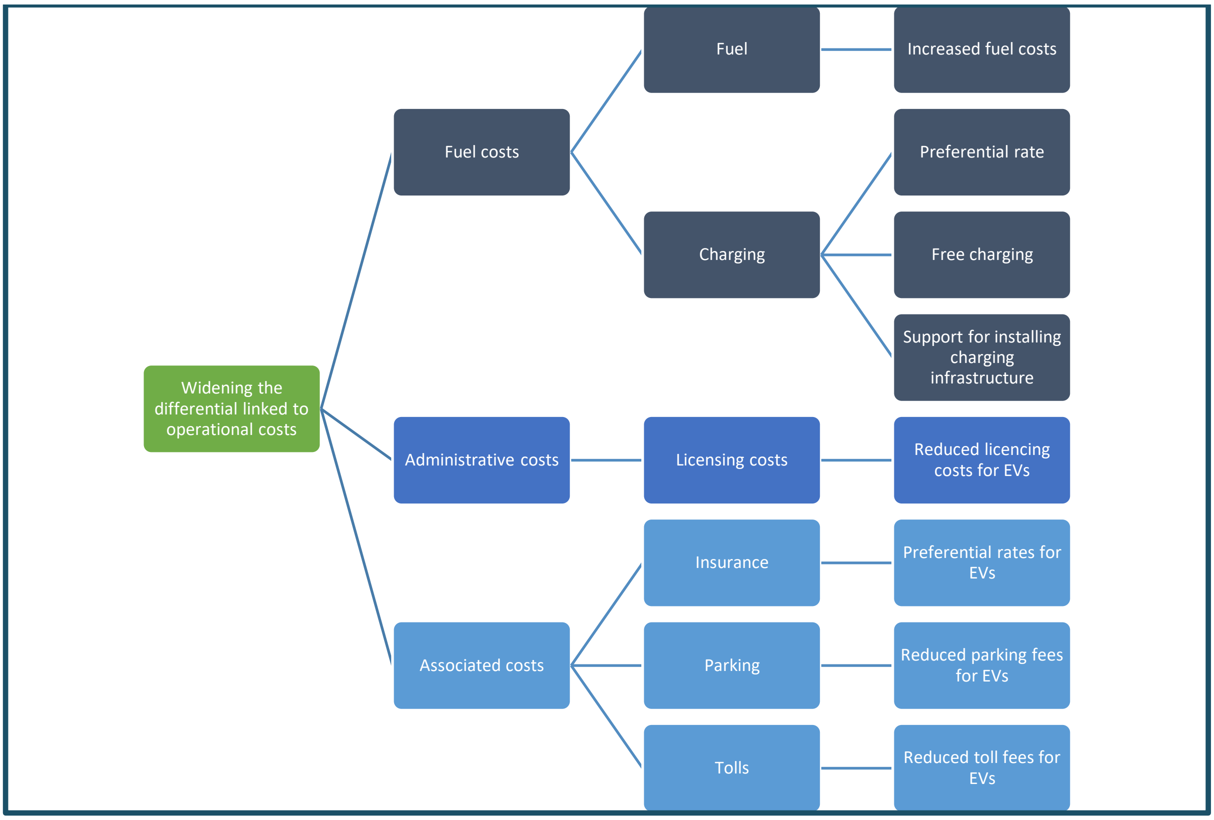
2.3.2. Widening the operational cost differential of EVs compared to ICE equivalent

The second main lever would be to alter operational costs. Running costs of EVs are already materially lower than equivalent ICE vehicles. A number of measures could be implemented to widen this differential further. This would contribute to shortening the payback period/ kilometrage required by EV drivers to offset the higher upfront purchasing cost. Figure 13 summarises the universe of options to widen the operational cost differential of EVs and how they link to other sections. Different avenues for reducing the differential are discussed below.

Overall, the LCOT analysis (assessing the potential impact of various measures to widen the operational cost differential in terms of the overall cost competitiveness of EVs relative to ICE vehicles) suggests that measures to widen the operational cost differential between EVs and ICE equivalents would contribute to the offer. However, on their own, these are unlikely to fundamentally change the cost competitiveness of any of the vehicles currently available or planned to be available in 2020. Results are summarised in Box 5. As such, these are considered complementary options.

[7] As discussed in Section 4, this is not necessarily the case for public passenger vehicles.

Figure 13: Possible options to widen the operational cost differential of EVs compared to ICE equivalent



Source: Authors

Note: all options are regarded as secondary interventions.

The first avenue would be through the "fuel" costs. Two key mechanisms, which could be implemented together, are possible: increasing the cost of petroleum products (i.e. petrol and diesel) to increase the running costs of ICE vehicles; and/or providing low-cost electricity charging (or hydrogen in the case of FCEVs).

The fuel price is highly regulated and thus any changes would need to be negotiated at the national level. Electricity prices are regulated at the national level but distributors (Eskom and municipalities) have some level of discretion with the prices they charge end customers. Commercial customers have access to Time-of-Use (ToU) electricity tariffs that enable low-cost, off-peak charging. Some residential customers have access to ToU (e.g. in the City of Tshwane) and more and more municipalities are working to offer this to residential customers in the future. There is no regulatory constraint to developing electricity tariff structures that can incentivise or promote the use of EVs.

However, the LCOT analysis (see Box 5) indicates that reducing the electricity price plays a limited role in improving the cost competitiveness of EVs, largely due to the energy efficiency of EVs. Such tariffs are nevertheless likely to play a useful role in managing charging behaviour and thus helping to mitigate any negative impacts on the network infrastructure (Change Pathways, 2018). Such benefits are more likely in the future as local network operators increasingly look to invest in smart grids.

Second, administrative costs could be reduced for EVs owners. This could be done by reducing the cost of vehicle registration and licensing for EVs, either to zero or a reduced amount. Implementing such an intervention would fall directly within the control of government entities and could be put in place relatively quickly (in line with government budget cycles).

Third, other non-administrative costs could also be decreased for EV owners. These are insurance premiums, parking fees and toll fees. In each case, preferential rates (up to zero) could be provided for EV drivers. The implementation of such measures would, in all cases, require a partnership with the private sector and demand, most likely, a degree of subsidisation by the state. Insurance services and parking facilities are provided by private companies. Tolled routes are managed by a mix of public entities (such as the South African National Roads Agency, SANRAL) and private consortium under contract with government. A concerted approach around toll fees for EVs would require a renegotiation of management contracts currently in place.

Many countries have in place EV charging incentives "elsewhere" on the bill. This has been particularly prevalent in Europe where parking fees, congestions charges and tolls are high or where congestion is at a level where preferential access is highly valued. These benefits are less valuable in the context of South Africa but should still be considered as part of a package of options.

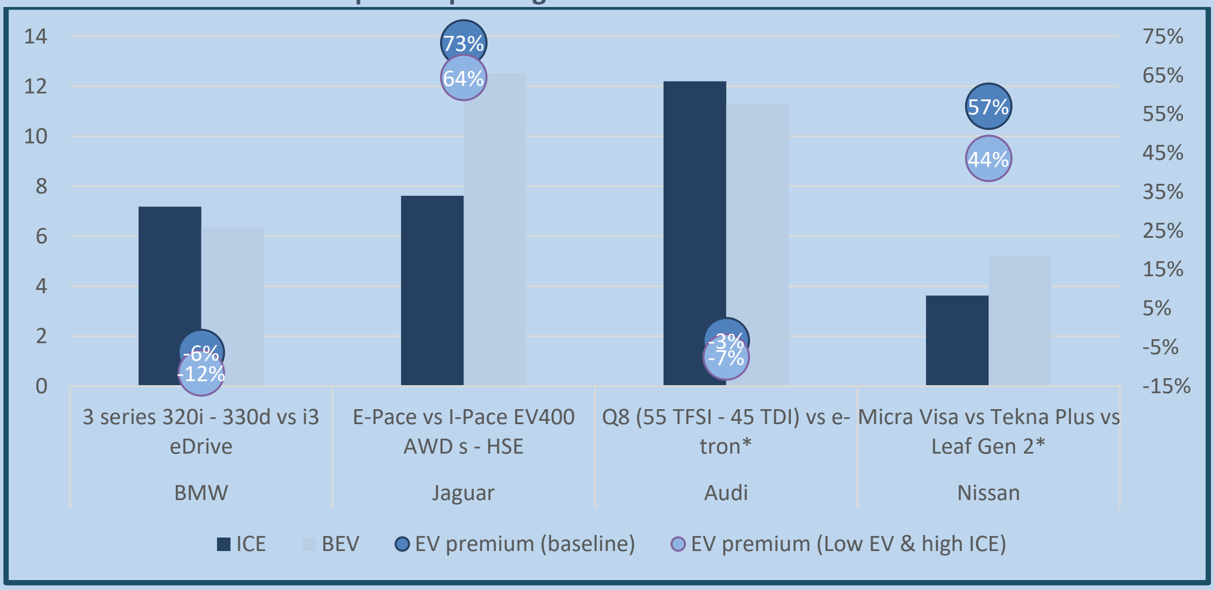
Box 5: LCOT assessment of measures to widen the operational cost differential of EVs compared to ICE equivalents

The following measures were assessed using the LCOT model described in Annex A:

- Low electricity tariffs (assumed 95% off-peak commercial and charging overnight and 5% public fast charging);
- No licensing fees; and
- A 30% increase in liquid fuel costs.

When comparing results to the base case, the measures were found not to have changed the cost competitiveness of any model but, in all cases, the measures have improved the offer (see Figure 14). Across the four vehicles included in the assessment, the average decrease in premium was 22% (but the range is substantial).

Figure 14: Low EV and high ICE operational cost comparison of private passenger vehicles in South Africa



Source: Authors, based on SEA's LCOT model. More details can be found in Annex A.

All the options available to widen the operational cost differential of EVs compared to ICE equivalents are regarded as secondary. These options are all feasible (sometimes very cost effective) and would deliver the intended benefits but would, on their own, not contribute significantly to the cost competitiveness of EVs. They should, however, be considered as part of a package of options.

2.3.3. Non-financial incentives and enhancing customer awareness

The third main lever would be to create non-financial incentives and enhance customer awareness. Figure 15 and Figure 16 summarise the universe of options in this regard. These options are all considered complementary.

Figure 15: Possible options to provide non-financial incentives in favour of EVs compared to ICE equivalent

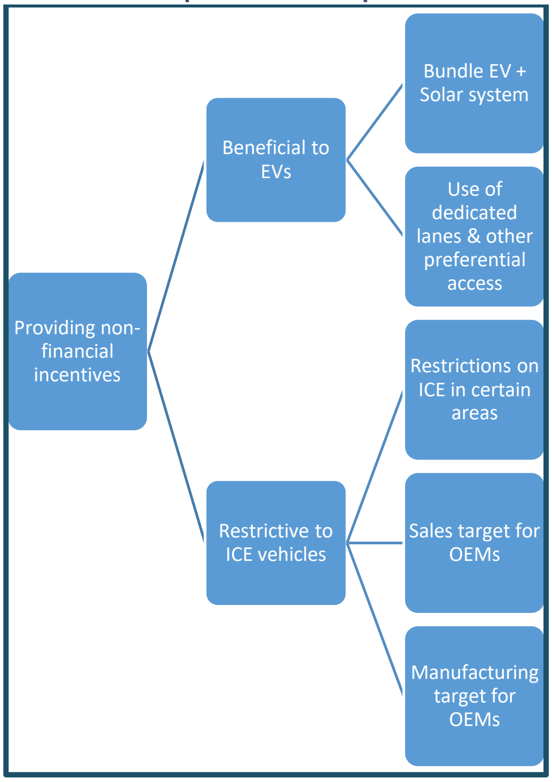
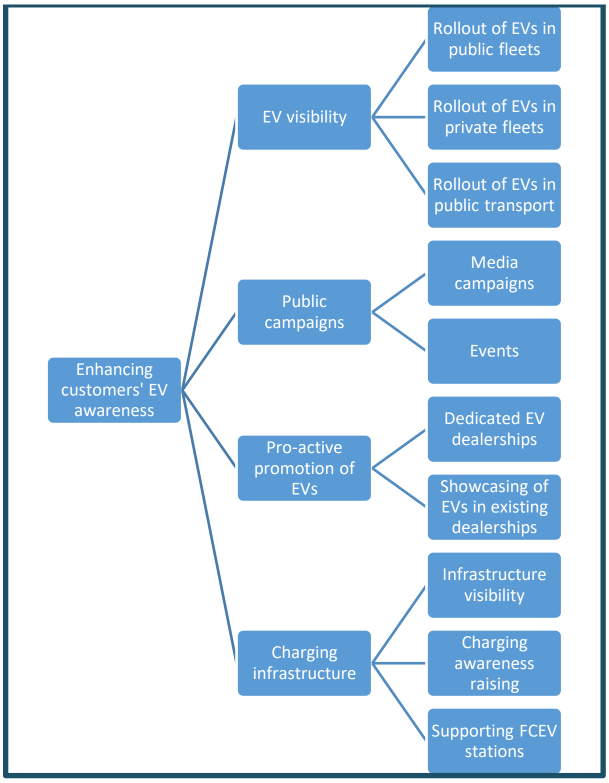


Figure 16: Possible options to enhance the customers' EV awareness



Source: Authors
Note: all options are regarded as secondary interventions.

With providing non-financial incentives, the options centre around access benefits for EVs and restrictions, quotas and targets imposed on ICE vehicles and the OEMs producing and selling ICE vehicles in the South African market.

A programme to bundle EV and solar photovoltaic (PV) system support could represent an integrated option that drives multiple development objectives. This could enable lower GHG emissions, by leveraging renewable energy technologies rather than the coal-intensive power grid, and contribute to objectives by cities to facilitate small-scale embedded generation (SSEG) and mitigate charging pressure on the network. Such an option could be made available to both residential and commercial customers. Mitsubishi has, for example, made public announcements about this (Meehan 2019). A key challenge would be around funding the programme.

EVs could be afforded preferential access to dedicated lanes or public parking bays. This would be at the discretion of local governments. For example, Germany provided special privileges in traffic and public places (e.g. free parking, special lanes privileges, and access to special zones). Conversely, access bans could be placed on ICE vehicles. For example, driving bans are being considered on old diesel vehicles in some German cities (Letmathe & Suares, 2020). However, South Africa does not face the space constraints and congestion challenges to the extent of many cities in Europe where access benefits have played a significant role in the development of EV markets.

ICE-related restrictions would contribute to EVs becoming relatively more attractive. These could take the form of access restrictions or the imposition of quotas or targets relating to the number of ICE vehicles that can be produced and sold in the South African market. Space restrictions are possible but unlikely to be acceptable or deliver any significant benefits. Targets and quotas are likely to put existing production at risk and therefore are not considered viable options in the short term.

As raised in Section 4.3, regulatory measures could take the form of targets, either at the manufacturing and/or fleet levels, as done respectively in China and the EU. However, given the second-tier position (22nd) of South Africa's automotive manufacturing worldwide, regulatory measures forcing the local production of EVs could be counterproductive and lead to the closure of existing factories. As a result, only fleet-level targets are considered viable in South Africa. Fleet-level regulatory measures, provided they can be enforced, have the advantage of fast-tracking changes. They do come with challenges, as presented in Section 4.4.2.

Enhancing customers' EV awareness is crucial. Evidence internationally has shown that a lack of information has been key in driving barriers such as range anxiety. Within this avenue, options could include increasing EV visibility through a targeted campaign to electrify highly visible public or private fleets (possibly with accompanying branding); undertaking marketing and education campaigns designed to raise awareness; and, importantly, getting consumers to experience EVs; promoting EVs through dedicated dealerships and other channels; and ensuring adequate and visible charging infrastructure. The 2013 South African EV Industry Road Map (not formally adopted) proposed that government develop policies to ensure that 5% of total annual fleet requirements by both the state and state-owned enterprises be comprised of EVs, increasing by 5% a year thereafter (until 2020) (the dti, 2013). While also increasing visibility, this was seen primarily as a way to kickstart industry. Public fleet targets are also aligned with government objectives related to GHG emissions, the Sustainable Development Goals (SDGs) and other development commitments and ambitions. This represents an important secondary option and an opportunity to demonstrate leadership, as evidenced by the number of countries committing to increasing the share of EVs in their public fleets (see Box 1).

In the short term, there is more than adequate public charging infrastructure to meet private passenger demands. Therefore, the focus should be on raising customers' awareness about the availability of public charging infrastructure, what public charging infrastructure can do (i.e. the speed of charging), and to what extent public charging is typically used (in relation to home and work charging). This would serve to allay fears and instil confidence that EVs can meet consumers' needs. Additional efforts may be needed to facilitate greater investment in FCEV "refuelling" infrastructure should South Africa experience a significant penetration of private passenger FCEVs in the market or should government see the promotion of FCEVs as a priority. FCEVs require hydrogen refuelling infrastructure before they can be rolled out in large numbers. Beneficially, hydrogen refuelling stations are analogous to today's petrol stations and therefore government support retrofitting petrol stations as this could contribute to maintaining the jobs and value added associated with this component of the current liquid fuels value chain.

Awareness-raising would not, on its own, deliver significant investments in EVs and is thus considered a secondary but important intervention in ensuring an adequate enabling environment to facilitate the success of the primary options.

2.4. Exploring the costs and benefits of key options

Based on the review of the universe of options to support the rollout of passenger EVs, this section zones in on the following primary options:

- Reducing the VAT and/or ad valorem excise duties on EVs;
- Changing the customs duties to deliver a "level playing field" for EVs; and
- Facilitating access to a preferential interest rate for EV finance.

For each considered intervention, implementation requirements, costs and benefits are reviewed with the aim of providing an understanding of the viability of various options from a technical, socio-economic and political perspective.

2.4.1. Changing the VAT and/or ad valorem

The ad valorem excise duty could be reduced by government over time. Similarly, government could reduce VAT on EVs. In both cases, the implementation requirements and the impacts on different stakeholders would be similar and hence the two avenues are considered together but could be implemented separately.

The period over which the reductions are made would depend on the speed and scale at which the national government would look to support the deployment of EVs. These mechanisms become less powerful as EVs move to price parity with ICE alternatives from 2025-2035 onwards (depending on the analyst projections).

Table 5: Socio-economic implications of changing the VAT and/or ad valorem

STAKEHOLDERS	IMPLEMENTATION REQUIREMENTS	EXPECTED BENEFITS	EXPECTED COSTS
OEMs (manufacturers)	Pass-through benefit to customers.	Increased demand for EVs Stimulation of local market to extent that local EV production can be supported (medium to long term).	Increased competition from imported EVs (short term).
OEMs (importers)	Pass-through benefit to customers.	Increased demand for EVs	None
Middle- to high-income households	None	Reduced price of EVs	None
Low-income households	None	Limited/none (only benefit for private car owners).	Reduction in government revenue affecting low-income targeted government spending.
Companies	None	Reduced price of EVs Enables an option to contribute towards GHG risk mitigation.	None
Government (national)	Negotiation of changes to the national budget and tax system. Manage fiscal revenue impacts over time.	Positive signal to OEMs Higher penetration of EVs in the local market.	Reduction in government revenue. Threat to the long-term sustainability of the local automotive industry if not coupled with incentives for local EV production.
Government (local)	None	Enables conversion of city car fleets (direct) and private cars (indirect) to EVs.	None

Source: Authors

Given the above costs and benefits, changing the VAT and/or ad valorem is unlikely to elicit opposition other than from stakeholders concerned about the potential impacts on government revenue. Importantly, impacts on government revenue would be very limited initially. As EV numbers start to increase significantly, alternative sources of revenue would need to be explored. The extent of the VAT and/or duty reduction could also be adjusted over time, in line with rising sales, to reduce the fiscal impact. Impacts would moreover be partially offset by increases in revenue from electricity levies; the reduced spend burden associated with positive health and safety impacts; and potential indirect economic growth impacts facilitated by cheaper transport (in the longer term).

Table 6 lists the main arguments for and against changing the VAT and/or ad valorem. Ultimately, the relative strength of key arguments depends on the extent to which the measures stimulate EV deployment and over what time period. A gradual process would enable costs to be mitigated to a large extent. These measures would still need to be coupled with awareness-raising and the package of secondary options outlined elsewhere in this report.

Table 6: Principal arguments for and against changing the VAT and/or ad valorem

FOR	AGAINST
- Technically feasible (i.e. no regulatory or institutional changes required). - No additional budget required. - Significant potential to reduce EV costs to a level that can make them cost competitive. - Potential to stimulate demand to levels necessary to support local manufacturing.	- Limited benefit for low-income households (this may be regarded as subsidising a luxury product). - Negative impact on government revenue. - Threat to sales of locally manufactured ICE vehicles in the short term.

Source: Authors

2.4.2. Changing the customs duties to deliver a 'level playing field'

Changing the tariff regime to facilitate the import of EVs into the country would be relatively easy to implement, through a SARS decision, in concordance with ITAC. The primary option suggested would be to 'level the playing field' either through a 1) quid pro quo reduction (most likely in exchange for an increase in the tariff for vehicles under 1000cc), or a 2) unilateral reduction in tariff.

Table 7 details the key implementation requirements, expected benefits and expected costs of changing the tariff regime for key stakeholders. Implementation requirements are relatively low, particularly in the case of a unilateral reduction in tariff.

Table 7: Socio-economic implications of changing the tariff regime

STAKEHOLDERS	IMPLEMENTATION REQUIREMENTS	EXPECTED BENEFITS	EXPECTED COSTS
OEMs (manufacturers)	Pass-through cost savings to customers Possibly negotiate quid pro quo with government.	Reduced customs duty on imported EVs. Increased profits through the sale of export credits. Quid pro quo case only: - Increased protection for the local manufacturing of vehicles >1000cc.	Unilateral case: - Weakened protection for the local manufacturing of EVs. Quid pro quo case: - Weakened protection for the local manufacturing of EVs - Higher tariff on >1000cc vehicle. Change in policy could lead to policy uncertainty affecting investor sentiment.
OEMs (importers)	Pass-through cost savings to customers.	Reduced customs duty on imported EVs.	Unilateral case: - None Quid pro quo case:

	Possibly negotiate quid pro quo with government.		- Higher tariff on >1000cc vehicle Change in policy could lead to policy uncertainty affecting investor sentiment.
Middle- to high-income households	n/a	Reduced price of imported EVs	Unilateral case: - Reduced probability of locally manufactured EVs Quid pro quo case: - Reduced probability of locally manufactured EVs - Higher price of imported >1000cc vehicle
Low-income households	n/a	n/a	n/a
Government	Reduce tariffs. Possibly negotiate quid pro quo with OEMs. Monitor the pass-through of cost savings to customers.	Positive signal to OEMs. Higher penetration of EVs onto the local market.	Reduced revenues from customs duties as well as the ad valorem excise duty, particularly in the unilateral case. Reduced probability of locally manufactured EVs.

Source: Authors

Given the above costs and benefits, *c*hanging the customs duties to deliver a "level playing field" does not garner unanimous support from stakeholders. Ultimately, the lack of a level playing field does, however, represent an anomaly. Providing that customers reap direct savings from the tariff reduction, the benefits of rectifying the situation furthermore appear to outweigh the costs. Table 8 lists the main arguments for and against it.

Table 8: Principal arguments for and against changing the tariff regime

FOR	AGAINST
- The 25% tariff on BEVs originating from the EU appears as an anomaly in the tariff regime, - A reduction in tariff would send a positive signal to OEMs (both the local branch and their head offices), - If passed through to customers, the reduction in tariff would reduce the price of imported EVs on the local market, - A reduction in tariff is easy to implement and relatively inexpensive to the fiscus,	- The reduction in tariff would reduce the protection for the local manufacturing of EVs - OEMs manufacturing vehicles in South Africa can already offset customs duty through the APDP system - No certainty exists that the reduction in tariff will be passed through to customers, particularly from OEMs benefiting from the APDP. - A change in the policy could lead to policy uncertainty affecting investor sentiment

Source: Authors

2.4.3. Facilitating access to a preferential interest rate for EV finance

Government could play a role in brokering partnerships between local financial institutions and development finance institutions (DFIs) to provide concessional funding on the condition that banks provide low-interest finance to EV purchasers.

Table 9: Socio-economic implications of facilitating access to a preferential interest rate for EV finance

STAKEHOLDERS	IMPLEMENTATION REQUIREMENTS	EXPECTED BENEFITS	EXPECTED COSTS
OEMs (manufacturers)	None	Stimulation of local market to extent that local EV production can be supported (medium to long term).	Increased competition from imported EVs (short term).

OEMs (importers)	None	Increased demand for EVs	None
Middle- to high-income households	None	Reduced cost of finance for EVs	None
Low-income households	None	Limited / none (only benefit for private car owners and particularly higher income earners).	None
Companies	None	Reduced cost of finance for EVs Enables an option to contribute towards GHG risk mitigation.	None
Local banks	Negotiate conditions with DFIs. Develop a programme that translates concessional finance into low interest rate EV finance.	Increased revenue from finance offered to EV purchasers. Demonstrable and measurable lending activities in favour of the transition to a low-carbon economy (in response to increasing stakeholder expectations).	Reduced earnings from finance offered to ICE vehicle purchasers.
Development Finance Institutions	Negotiate conditions with local banks. Facilitate access to the cheapest possible concessional finance.	Opportunity to deliver development benefits at scale through lending.	Opportunity cost of capital
Government (National)	Collaborate with local banks to facilitate access to concessional finance.	Positive signal to OEMs Higher penetration of EVs onto the local market.	None
Government (Local)	None	Enables conversion of city car fleets (direct) and private cars (indirect) to EVs.	None

Source: Authors

Given the above costs and benefits, the willingness of DFIs and local financial institutions to facilitate access to these lower interest rates is likely to exist. The key issue is whether the effective interest rates will be low enough to make EVs cost competitive. Table10 lists the main arguments for and against it.

Table 10: Principal arguments for and against facilitating access to a preferential interest rate for EV finance

FOR	AGAINST
- Technically feasible (i.e. no regulatory or institutional changes required). - No additional budget required. - Significant potential to reduce finance EV costs to a level that can make them cost competitive. - Potential to stimulate demand to levels necessary to support local manufacturing. - Contributes to DFI objectives and local bank's sustainability objectives.	- Limited benefit for low-income households (may be seen as subsidising a product which initially at least would be only purchased by high income earners). - Threat to sales of locally manufactured ICE vehicles in the short term.

Source: Authors

2.5. Policy implications

In conclusion, supporting the passenger EV offering in South Africa hinges on implementing one or more of three key strategies:

- Reducing the VAT and/or ad valorem excise duties on EVs;

- Changing the customs duties to deliver a “level playing field”; and
- Facilitating access to a preferential interest rate for EV finance.

These avenues are not mutually exclusive. They should be implemented in conjunction with a package of secondary options that would help tip the cost competitive scales of EVs but also contribute to the necessary enabling environment that would support more private passenger EVs on South Africa's roads once they become more cost competitive.

All the key strategies would contribute to addressing the main barrier to private EV deployment in South Africa: high upfront costs. Reducing the VAT and ad valorem excise duties would be technically feasible and not require any additional budget but, at high levels of penetration, would have a negative impact on government revenue. A phasing mechanism would be recommended to address such concerns. Changing the tariff regime to a “level the playing field” should be undertaken as the current penalty on EVs equates to an anomaly. Managing policy uncertainty would be important and therefore any proposed amendments to the APDP should be discussed with industry, recognising that amendments will affect different OEMs differently and any potential change could disturb the balance of the programme. Further preferencing EVs would, however, threaten local industry. Facilitating access to preferential interest rates is contingent on maximising development benefits to secure concessional finance and translate the benefits into lower interest rates for EV finance.

These key strategies could be implemented in parallel and should be supported by a package of secondary options, such as purchasing EVs for government fleets, that can contribute to a more attractive EV offer. Cutting across these options is the need for a more enabling environment facilitated by a coherent and coordinated policy environment. This requires a vision and commitment by government to enable coordinated policies and measures that can give effect to the broad objectives included in the Green Transport Strategy, for example. Support programmes could be differentiated by technologies (i.e. BEV, PHEV, HEV and FCEV), although the nascent nature of the market would recommend a non-discriminative approach in the short term.

Importantly, the country needs to take practical steps forward. Government should look to implement options on a trial-and-error basis and build in the expectation to iterate or amend based on South African-specific experience.

3. HOW CAN THE SHIFT TO EVS IN PUBLIC TRANSPORT BE SUPPORTED?

Similar to passenger cars, the second question relates to improving the nature (quantity and quality) of the public transport EV offering in South Africa. The focus of this analysis is on the primary modes of road public transportation in South Africa: buses and minibus taxis (MBTs). Two intertwined questions need to be addressed around a) the availability of electric buses and MBTs on the local market; and b) the competitiveness of the offer. This corresponds to a threefold approach aimed at a) getting electric buses and MBTs available in South Africa; b) improving their financial attractiveness; and c) strengthening the overall ecosystem for EVs.

3.1. Problem statement

Public transport is responsible for transporting most of the South African population. Public transport is particularly important for low- to middle-income households, especially those not able to afford private vehicles, who spend a disproportionate share of their income on mobility. Available statistics report that 70% of South Africa's population is dependent on public transport, including buses, MBTs and the railway network for its mobility needs (MegaBus, 2016). The National Household Transport Survey of 2013 revealed that, of public transport users, 69% of South African households use MBTs daily, followed by buses (20%) and 10% were rail commuters. There are more than 200 000 MBTs in South Africa.

The sector suffers from several challenges including a history of underinvestment, servicing low-density urban settlements, poor reliability and safety, and fragmented networks. To ensure efficient, reliable and equitable mobility across income groups in South African cities, public transport needs to play a central role. As such, the provision of safe, reliable and most importantly affordable public transport in South Africa is a vital requirement for the socio-economic development of the South African population. Substantial investment and innovative solutions are required to realise this goal, to which EVs can make a valuable contribution.

Electric buses and minibuses are emerging as an effective and practical option for reducing GHG emissions and air pollution, provided the electricity is generated from renewable energy sources. In addition to these environmental benefits, e-buses and e-minibuses can also help cities improve energy efficiency, reduce noise in cities, and lower operating costs resulting in lower long-term costs for customers.

Accordingly, led by the aggressive e-bus growth rate in China for full-battery and hybrid buses, e-buses are surpassing the growth of every other EV segment globally with a compound annual growth rate of 100% since 2013, compared to 60% for passenger vehicles.

In 2019, it was reported that of 425 000 e-buses in the world, 421 000 (99%) were in China, 2 250 in Europe and 385 in India (BNEF, 2019). China's stock of FCEVs is escalating, reflecting a rapid deployment of fuel cell electric buses (from 3 400 in 2018 to 4 300 in 2019) and commercial vehicles (from 1 300 in 2018 to 1 800 in 2019). Fuel cell electric buses account for almost 70% of the current FCEV stock in China (IEA, 2020). Available information on minibuses is limited and is, in various analyst reports, often included in "e-bus" statistics (IEA, 2019). There are limited e-minibus options available in the market and major manufacturers have yet to release their models. Most are leading with electric vans, but passenger electric minibuses are expected to follow (Ansell, 2019).

In South Africa, the electrification of public transport remains at its infancy. South African cities are, however, looking to develop electric public transportation as part of their green initiative strategies.

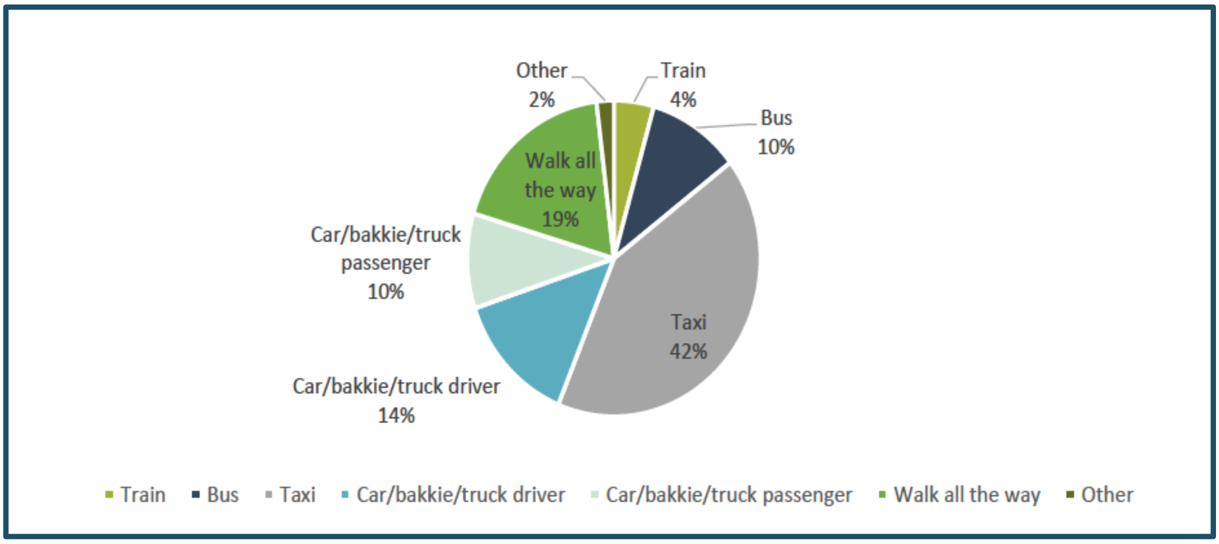
3.2. Context

3.2.1. Public transport in South Africa

Over half of South Africans rely on public transport as the main means of commuting, the modal split of which is shown in Figure 17. There are three main forms of public transport namely MBTs, buses and trains. Of commuters that rely on public transport for their mobility, 69% use minibus taxis, 20% use buses and 10% use trains (DoT, 2013).[8]

Most public transport users are captive users, meaning that those using public transport are predominantly those that are unable to afford a private vehicle. Broad trends in the country show that commuters with the means to buy a private vehicle mainly choose this option over public transport due to the challenges experienced by public transport users.[9]

Figure 17: Percentage of main mode of transport used by households in South Africa



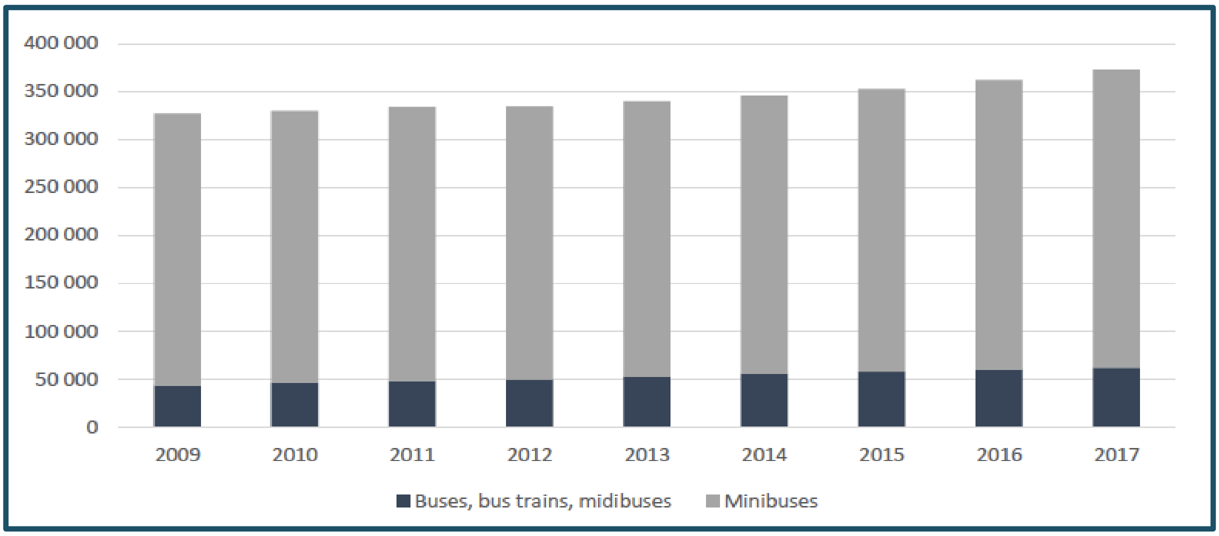
Source: Deonarain and Mashiane, 2019, based on data from Statistics South Africa

To meet the demands of the South African population, the number of MBTs and buses has continued to increase over the past decade, as shown in Figure 18.

[8] These official statistics date back to the National Household Travel Survey of 2013. An updated survey is being conducted in 2020, which will reflect new trends in the sector.

[9] The sector is plagued by numerous challenges, such as inefficiency, unreliability, high costs of travel and unsafe commutes, which have reduced commuter satisfaction. A process of cannibalisation rather than complementarity can also be witnessed between various services (Deonarain, 2019).

Figure 18: Public transport live vehicle population for the period April 2009-April 2017



Source: National Traffic Information System (eNaTIS), via Deonarain and Mashiane, 2019.

Historically, growth in the taxi industry came at the expense of state-subsidised buses (Walters, 2014), a pattern which continues to date. The origins of the subsidy system in the bus industry dates as far back as the 1940s. Bus subsidies were provided to ensure workers could access commuter buses at reasonable rates. Financial support for MBTs is lacking and challenges with regulating the industry given its extensive, fragmented nature. MBT operators do not benefit from any operational subsidies (Competition Commision, 2020). The TRP, introduced in 2006, offers a R50 000 scrapping allowance as a deposit for a new, more efficient vehicle. The programme has failed to meet expectations, and many have continued using old, inefficient vehicles (Deonarain and Mashiane, 2019). This suggests challenges should government look to incentivise the purchase of e-MBTs.

While MBTs account for most of the fleet, a shift in trend can be witnessed in recent years. New taxi registrations have been decreasing while, at the same time, new bus registrations have been growing from 2010 onwards. Deonarain and Mashiane (2019) attribute this to the introduction of BRT services in several municipalities across South Africa, which compensated and integrated a number of taxi operators into the BRT systems on condition that they give up their routes and MBTs (Deonarain, 2019). Indeed, a notable development in public transport in the country has been the introduction of BRT systems alongside existing municipal bus services. BRT systems, such as the Rea Vaya in Johannesburg and MyCiti in Cape Town, were launched for the 2010 FIFA World Cup and have since been extended. New BRT systems have been introduced in other cities in the country, such as Tshwane (A Re Yeng launched in 2014), Durban (Go!Durban), Nelson Mandela Bay Metropolitan Municipality as well as other networks in smaller cities around the country. Despite the travel efficiency, safety, reliability and sophistication of South Africa's BRT network, these systems have, however, been implemented with varying degrees of success (Deonarain and Mashiane, 2019)[10]

[10] South Africa's bus systems are not operating optimally. The majority of South African's are choosing MBTs over many of the new BRT systems. As a result, BRT systems have had higher than anticipated losses, only able to recover around 40% of operating costs in Johannesburg (National Treasury, 2017), while Cape Town's MyCiti has recovered around 49% of operational costs Deonarain and Mashiane, 2019). Limited bus occupancy rates and other inefficiencies negatively impact the business case for electric buses. For example, eThekwini's GO!Durban Programme has suffered from disputes between the taxi industry, the business forums and the municipality leading to the municipality returning allocated budget to National Treasury (in February 2020).

In addition, there is cannibalism rather than complementarity in different public transport service offerings. The fragmented and uncoordinated bus (privately owned, publicly owned, BRT and parastatal owned), MBT and taxi (metered taxis and e-hailing services) services tend to cannibalise routes rather than provide a complementary service. Examples are the ongoing tension between metered taxis and e-hailing services and between MBTs and BRT systems. Uneven subsidies for the different modes of public transport have resulted in varied fares, thereby posing a challenge to the development of integrated transport networks (Deonarain and Mashiane, 2019).

Fragmented public transport networks servicing low-density urban settlements, characterised by urban sprawl, have resulted in low-income households spending as much as 20% of their income on transport, as many employees reside on the peripheries of cities away from centres of economic opportunities. For rural residents, 34% of monthly household income is allocated to transport costs (Deonarain, 2019). Various cities, such as Johannesburg, Cape Town and Durban, are exploring the development of Integrated Rapid Pubic Transport Networks (Arnoldi, 2019). This is tailored according to the specific urban form of a city, offering a network of different transport modes in an integrated manner to offer efficient and reliable mobility for its users. The intended modes of integrated transport include Metrorail services, conventional bus services, MBTs, feeder bus services, improved pedestrian and bicycle access, metered taxis and park-and-ride facilities (SARS, 2019).

The electrification of public transport would need to be considered within the context of these challenges but could potentially contribute to improving the cost, safety, customer experience and impact of public transport in the country. EVs would benefit the vast majority of citizens who use public transport, including South Africa's low-income households, through lower transport costs (in the future), improved safety and reduced environmental impact (including impacts on health and noise pollution). Importantly though, the extent of EV adoption in public transport and especially the impact of replacing current MBT fleets with electric MBTs remains not well understood. There has been some assessment of the nature and potential for rolling out electric buses but there is very little data in the South African operating context on electric mobility fleet conversion more generally.

3.2.2. Key barriers to electrification of public transport

In addition to the lack of a coherent policy environment for public transportation in South Africa, there are a number of barriers that need to be overcome to create an enabling environment for the deployment of e-buses and e-MBTs. Key barriers relate to high upfront costs, concerns around scalability (given that most e-buses in the US and Europe relied on grant funding), lower flexibility and limited operational experience, delayed procurement decisions due to expected technology cost declines (particularly of batteries), changing electricity tariffs and grid stability concerns, and a lack of charging infrastructure standardisation (BNEF, 2018. An assessment of these and other barriers, and their potential relevance within the e-bus and e-MBT context in South Africa, is provided in Table 11.

Table 11: Major barriers for e-buses and e-MBTs and their importance in South Africa

BARRIERS		E-BUSES	E-MBTS
Fleet operations	Uncertain residual value	No policies regulating end-of-life treatment for batteries	No policies regulating end-of-life treatment for batteries
	Lower flexibility of vehicles	Certain applications are constrained	Initial analysis suggests vehicle characteristics could meet use requirements, especially in cities.
	Lack of experience in operating EVs	Training and awareness are needed	Training and awareness are needed
	Cold weather – higher energy consumption	Unclear in the South African context	Unclear in the South African context
	Underdeveloped public transport network	Further benefits possible if the bus network was maximised	Lack of formality and conflict around routes impeding potential shift to EVs
Vehicle	Underdeveloped supply chain	Very limited penetration but options available globally	No e-MBTs on South African roads and limited options available
	Lack of local supply chain	Very limited penetration	No e-MBTs on South African roads
	Limited skills to maintain vehicles	Skills development required as scale is reached	Skills development required as scale is reached
	Capital costs	High cost of capital but some grants and innovative finance models available	High cost of capital but some support available through the TRP
	Operating costs	Some operating subsidies in place	Lack of operating subsidies but EVs enable lower operating costs than ICE
Battery	Potential battery failures affecting the fleet	No indication of this being a concern	No indication of this being a concern
	Falling battery prices	No evidence of waiting for lower battery prices	No evidence of waiting for lower battery prices
Charging infrastructure	The cost and time of installation	Cost adds to the EV premium No indication of time being a constraint	Cost adds to the EV premium No indication of time being a constraint
	Capital cost	Adds to the EV premium	Adds to the EV premium but most charging slow (off-peak)

	Underdeveloped supply chain	Not identified as a constraint currently	Not identified as a constraint currently
	Public perception and space restrictions	Limited dedicated "bus stops" reducing potential for en-route charging	Limited space at ranks Limited dedicated "bus stops" reducing potential for en-route charging
Electricity grid	Location of supply	Current constraint but can be overcome with adequate planning	Current constraint but can be overcome with adequate planning
	Constrained grid areas	Current constraint but can be overcome with adequate planning	Current constraint but can be overcome with adequate planning
Financing	Uncertainty for finance companies	Mismatch between needs and lender criteria	Owners already exposed to very high interest rates
	Lack of financing options	Mismatch between needs and lender criteria	Limited existing finance options
Government support	Lack of indirect support (e.g. Low Emission Zones)	No commitments, support or incentives	No commitments, support or incentives
	Lack of direct support (grants, fleet targets)	No commitments, support or incentives	No commitments, support or incentives Ineffective communication channels between the taxi industry and the transport authorities Outdated licensing system
Modal shifts	Falling use	Mixed implementation of existing systems	Demand remains high
	Competition from alternatives (metro)	Competition between modes (conflict)	Competition between operators and with new modes, such as BRT (conflict)

Source: Authors, informed by BNEF, 2018; IEA, 2019; and Deonarain and Mashiane, 2019.

Note:	*High Barrier*	*Medium Barrier*	*Low Barrier*

Fleet operation

There are some concerns regarding the applicability of vehicles in the South African context. The IEA notes a key challenge is that certain public transport services face range limitations and limited access to overnight/off-peak charging and are therefore not suited for electrification. A lack of available fast-charging public chargers can mean revenue foregone due to time-consuming charging, further contributing to the challenge for certain segments (IEA, 2019). However, there is a lack of experience in piloting e-buses and e-MBTs to fully appreciate the extent to which vehicle characteristics meet South Africa's public transport needs or not.

GreenCape also suggests a lack of skills in South Africa to support the rollout of EVs generally. This includes the skills of first level emergency responders, dealerships, and aftermarket services (Greencape, 2019).

Overall, bus operators would need to change. Bus routes, stops as well as driver duties and shifts are based on capabilities and requirements of diesel vehicles (e.g. ability to fill up quickly). Electric buses would require system changes to accommodate different capabilities and requirements, notably the need for longer refuelling (charging) time for BEVs. The rollout of FCEVs, which can refill like ICE vehicles, could alleviate such challenges.

The informal structure of the MBT industry presents a further challenge to change. Key to South Africa's transformation to a sustainable transport system is the need to reform and formally integrate the MBT industry. As an example of the scale of the challenge, the number of unlicensed and unroadworthy MBT vehicles stands at more than one million and keeps increasing (Deonarain, 2019).

On the vehicle front, as in other geographies, the higher purchasing price of EVs (capital premium) represents the biggest barrier (see again the LCOT analysis in Box 5). for a more detailed explanation). From an operating cost perspective, the lack of any support in this regard would affect the MBT industry but given the lower operating costs enabled by more efficient EVs, this is not seen to be a significant barrier.

For buses, the Preferential Procurement Policy Framework Act No 5 of 2000 prescribes local content requirements (70% and 80% local content of the bus body for city and commuter buses respectively). As batteries are not clearly excluded from the bodywork, this creates an import barrier which could foster the development of local manufacturing (Greencape, 2019). Bus manufacturers in South Africa have indicated willingness to create and expand plants to produce gas- and electricity-powered buses if guaranteed commitment of purchase is signalled by the government (Deonarain, 2019).

There is no electric MBT currently available in South Africa, but models are expected to appear in the market within the next few years. Vehicles are being developed internationally and some options are available in the market already (typically accommodating fewer occupants than the MBTs on the roads in South Africa). Due to the nature of the domestic MBT market (see Section 4), the potential to develop a vehicle for the South African market is apparent.

Taxis (and ride-sharing fleets) use vehicles in the medium and large market segments and require sufficient range (in excess of 250km/day up to 400km/day). There are few EVs available to meet these operational requirements (IEA, 2019).

In addition, the intensive use patterns of fleets can affect battery durability. More frequent and more rapid charge cycles of fleet vehicles could degrade the battery more quickly (compared to private cars), adversely affecting range over the lifetime of the vehicle (IEA, 2019).

Charging infrastructure

There are three main types of infrastructure for charging electric buses: plug-in systems, inductive charging, and conductive pantograph (overhead) charging. FCEVs use a different system based on a hydrogen supply chain, closer to traditional ICE-based refuelling.

Traditional plug-in charging is the most common and the cheapest charging system in use with e-buses today (BNEF, 2018). Pantograph (overhead) charging is growing in popularity for new e-bus fleets in Europe and the US. It also offers a range of charging rates, but rapid charging for battery top-ups makes most sense with this technology. Wireless charging is the most expensive option and used only in pilot projects with e-buses. Stationary wireless charging is available commercially, but dynamic wireless charging is still only in the demonstration phase. Slow, overnight charging at the depot is the most popular option today, followed by the combination of depot charging and fast charging top-ups – pantograph or plug-in – at the terminal and bus stops (BNEF, 2018).

In this category, cities surveyed by Bloomberg New Energy Finance (BNEF) identified capital costs, installation costs, public perception and space restrictions as the main barriers to e-bus adoption (BNEF, 2018). In South Africa, the public charging network currently consists of 223 charging stations based along the major routes.[11] Evidence suggests that the private sector is responding to demand and, at current levels, charging infrastructure is not a significant constraint (see Section 1). However, in the context of public transport, centralised charging at depots would require additional investments in infrastructure. If charging is required in areas where the network is constrained, then additional network capacity would add significantly to the charging infrastructure costs. If FCEVs become more cost competitive, or if government choses to support the deployment of public transport FCEVs, then additional investment in hydrogen refuelling stations would be required. Charging infrastructure also creates potential space challenges. Planners in Cape Town estimated that the charging infrastructure and new parking schematics may require depots to be up to 30% to 40% larger to accommodate new e-buses and charging infrastructure (WRI, 2019).

The South African grid is currently constrained, and the electricity systems faces numerous challenges in ensuring adequate supply of electricity. However, due to the efficiency of EVs, the increased demand for electricity generation capacity would not require significant additional investment in generation capacity, if properly managed. If EV users can be incentivised to charge during off-peak periods, the impact on the demand curve would be positive: this would result in the sale of surplus capacity and reduce the need to invest in the network infrastructure. This is expected as, internationally, most charging (80%-90%) takes place during off-peak periods and mainly at home for private passenger vehicles (Dane, Wright and Montmasson-Clair, 2019).

Importantly, the transition to greater vehicle deployment would take place over time. Any negative impacts could be managed with adequate planning. The most significant concern would be associated with clustered charging of fleets at centralised depots, which could put the network at risk. Again, adequate planning coupled with incentives, standards and good communication between fleet owners and network operators, could mitigate these risks.

Financing and government support

Enabling finance products available for EV projects are limited at present. The risk profile does not match lenders' criteria, resulting in short tenors of debt and high interest rates (Greencape, 2019).

The high risk associated with repayments by MBT operators and the limited number of institutions providing finance mean that the cost of capital in this segment is extremely high. This further compounds the challenges associated with the high upfront capital costs of e-MBTs.

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[11] https://www.plugshare.com/

Lack of a clear and coherent policy framework and a specific electromobility strategy makes it difficult for transit agencies to develop and roll out plans for electric public transport vehicles (WRI, 2019). Any efforts to transition to EVs in the MBT sector specifically would be challenging, given the existing ineffective communication channels between the taxi industry and the transport authorities as well as an outdated licensing system. This is not specific to e-MBTs but would contribute to the challenge.

3.2.3. Financial analysis

The higher purchase price of EVs (capital premium) is the most significant barrier currently. However, on a TCO basis, electric buses can be financially attractive with the business case improving in an increasing number of applications.

The IEA estimates that electric buses travelling 40 000- 50 000 km/year are competitive in regions with high diesel taxation regimes for battery prices below US$260/kWh (IEA, 2019). BNEF, in 2018, found that "a typical bus with a 250kWh battery charging slowly once per day at the depot and operating around 166 km/day has a lower [TCO] than diesel (US$1.05/km) or [compressed national gas] (US$1.19/km) buses at US$0.99/km. However, a bus with a 350kWh battery using the same charging configuration would not yet be competitive. Its competitiveness improves significantly in large cities, where buses travel above 220 km/day."

The TCO improves significantly in comparison to diesel buses as the annual number of kilometres increases. The business case depends on operating conditions, charging arrangements, diesel costs and the cost of electricity in local contexts. BNEF suggests with electricity prices at US$0.10/kWh, for the most expensive 350kWh e-bus, using slow, overnight charging at the depot, diesel prices would need to be around US$0.66/litre (in 2018 US$) for the e-bus to potentially have a competitive total cost of ownership (BNEF, 2018).

(Lebeau, Macharis, & Mierlo, 2019) reviewed TCO for 18 different electric vans compared to equivalent petrol and diesel vehicles in Belgium. They found the TCO of electric vans to be marginally higher than ICE equivalents in small vans, significantly lower in medium vans, and significantly higher in large vans. For example, in the medium segment (characteristic of the MBT industry in South Africa), they found the TCO of an electric Nissan NV200 to be 15% lower than the diesel NV300 (Lebeau, Macharis, & Mierlo, 2019).[12]

The business case is expected to improve. A number of technological developments are facilitating greater deployment of electric public transport vehicles. The cost of batteries and EVs is dropping and EV infrastructure is being installed in many places, which supports the case for EVs across transport modes including buses, MBTs, taxis and shared vehicles. Technology is progressing for chargers, partly because of increasing interest in EVs for heavy-duty applications (primarily buses, but also trucks). Standards have been developed for high power chargers (up to 600 kilowatts [kW]) (IEA, 2019).

BNEF predicts that electric buses will reach unsubsidised upfront cost parity with diesel buses by around 2030. By then, the battery pack in the average e-bus should only account for around 8% of the total e-bus price, down from around 26% in 2016. If demand were higher, then e-bus battery prices would come down faster (BNEF, 2018). Once upfront costs reach parity, the lower operating costs of e-buses will be a major advantage in South Africa, given the struggles of existing bus operators to meet their operational costs.

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[12] A study in Sweden found that e-taxis have a similar or lower TCO and slightly higher profitability than the investigated conventional taxis (Hagman & Langbroek, 2019).

Studies in the South African context (including the analysis conducted as part of this study) suggest that currently the TCO and the LCOT[13] of battery electric buses and MBTs is higher than ICE alternatives. There are also limited vehicle options. A key challenge is in making more public transport EVs available in South Africa. This study conducted an assessment of the financial business case (of BEVs only[14]) using a LCOT model. A summary of the results is provided in Table 12 and Table 13.

Table 12: LCOT of electric and ICE buses and MBTs in South Africa: variable electricity prices (in 2019 prices, Rands per passenger.km)

	Current		2030	
	High electricity price	**Low electricity price**	**High electricity price**	**Low electricity price**
ICE MBT	0.61	0.61	0.61	0.61
BEV MBT	0.73	0.71	0.53	0.51
ICE bus	0.95	0.95	0.95	0.95
BEV bus	1.76	1.71	0.88	0.83
BEV MBT benefit			-12%	-16%
BEV Bus benefit			-8%	-13%

Source: Authors, based on SEA's LCOT model. More details can be found in Annex A.

Table 13: LCOT of electric and ICE buses and MBTs in South Africa: variable fuel prices (in 2019 prices, Rands per passenger.km)

	Current		2030	
	High liquid fuel price	**Low liquid fuel price**	**High liquid fuel Price**	**Low Liquid fuel Price**
ICE MBT	0.63	0.61	0.63	0.61
BEV MBT	0.73	0.73	0.53	0.53
ICE bus	1.01	0.95	1.01	0.95
BEV bus	1.76	1.76	0.88	0.88
BEV MBT benefit			-16%	-13%
BEV bus benefit			-13%	-8%

Source: Authors, based on SEA's LCOT model. More details can be found in Annex A.

The analysis shows that, on a LCOT basis, ICE MBTs (petrol) and ICE buses (diesel) are currently cheaper than their battery electric counterparts. Importantly, this analysis assumes average cases. It is likely, given the small margin (especially in the case of MBTs) that BEVs would be more cost-effective in certain applications. From 2030, upfront capital cost parity is assumed. At this point, BEVs are more cost competitive in both the MBT and bus contexts. The benefits are presented as a percentage saving relative to ICE technologies.

[13] A LCOT model establishes the cost of supplying the public transport service (bus and MBT) over the life of the vehicle and is expressed in units of Rands per passenger.km (R/pkm), i.e. the net present cost to transport a passenger one kilometre. The details of the methodology and assumptions are provided in Annex A.

[14] There is limited data available on FCEV bus and MBT options in South Africa from which to undertake such an assessment.

3.2.4. Electrification of public transport

Most activity in the electric bus market has been in China, Europe and North America, with key large manufacturers in this field including Chinese OEMs BYD, Yutong and Zhongtong and European manufacturer Solaris Bus. From 2018, policy action and increased interest in bus electrification spread widely across other regions in South America, Southeast Asia and Africa. Momentum is building due to pressures to improve air quality and cut GHG emissions. Other drivers include noise reduction and reduced downtime as well as opportunities related to industrial development.[15]

The global stock of electric buses increased by 25% in 2018 relative to 2017, reaching about 460 000 vehicles.[16] China accounts for 99% of the global market for electric buses. Infrastructure dedicated to electric buses reached an estimated 157 000 chargers globally in 2018. Again, most are in China. Depot charging (overnight) is the most common regime followed by fast charging along bus routes (IEA, 2019).

Experience in deploying electric public transport vehicles is limited in South Africa. In Cape Town, Chinese-owned company BYD SA was awarded a tender in 2016 to produce electric buses and related equipment for the MyCiTi BRT bus fleet. Certain bidders claimed that the public tender had favoured BYD by including very specific requirements (such as a 70% local content requirement) that only BYD would have been able to meet. Furthermore, allegations of irregularity around the tender, and accusations of maladministration and corruption in the city government, led an appointed law firm to recommend that the tender be cancelled (although the city has taken delivery of all 11 buses). The elected officials who were seen as being involved in the alleged corruption have since resigned, and the Transport and Urban Development Authority commissioner remains on suspension. The matter remains unresolved, and the pilot programme has been unable to advance (Sclar et at, 2019).

The City of Johannesburg, with support from the IDC, commissioned the Initial Financial and Economic Comparison of Different Public Transit Vehicle Options for the City of Johannesburg study in 2017 (Short, 2017). The City wanted to consider technological alternatives to the proposed base case of diesel Euro V as it expands its BRT system. The analysis included an assessment of electric buses in terms of capital cost of the bus, the fuel cost, maintenance cost, and the associated infrastructure costs. The study considered environmental impacts (air pollution and GHG emissions) but did not consider broader socio-economic impacts of different vehicle technologies. The electric bus option came in as the second-best option when considering the financial impacts and the third-best technology option when also considering emissions costs (behind Diesel – Euro V and IV) (Short, 2017). It is not clear how the City plans to use the study going forward.

The private sector has started to explore opportunities to invest in the electrification of public transport. One company has conducted electric bus economic feasibility studies using an existing private fleet as an example.[17] In 2019, a small Limpopo-based company launched Mi-Power, an electric-powered bus at the Chartered Institute of Government Finance Audit and Risk Officers'

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[15] Fleet vehicles could, in the longer term, provide ancillary grid services to complement renewable energy deployment. This potential provides additional revenue to fleet operators.

[16] The emerging mobility revolutions of sharing and automation could significantly reshape road transport over the coming decades, with major implications for vehicle electrification. A transition to shared and/or autonomous vehicles and services with high utilisation rates could put EVs at a competitive advantage in the public passenger segment. However, adoption rates have been slow. EV shares on the major ride-sharing platforms remain below 1.5% (IEA, 2019).

[17] Additional data cannot be shared publicly at this stage.

conference at the Durban International Convention Centre (Bhengu, 2019). In case Mi-Power e-buses get stuck due to their limited range, a phone call from the bus driver to Mi-Power gets a power bank sent to the exact location of the bus (eNCA, 2019). The company aims to sell Mi-Power bus units to municipalities once the full fleet is out. EV-Green is another South Africa company supporting the development of EVs. Based in Vereeniging in Gauteng the company mainly focuses on producing locally manufactured components for EVs as well as doing electric bus conversions. For further information, see Section 4.

The use requirements of many of the country's MBTs could be well suited to electric drivetrains. From a range and charging requirements perspective, a slow charger (15 to 22 kW) can charge an electric bus in about 10 hours and a fast charger (50 to 120kW) in about two to six hours (BloombergNEF, 2018). According to a company evaluating the business case for electrifying MBTs and buses in South Africa,[18] a vehicle in the MBT fleet in Cape Town would operate 11 hours a day including 5 hours break during the middle of the day. Assuming an average range of 100 km per day, and given charging times, EVs could meet the operational requirements of many MBTs. Ford revealed internationally a new Transit Smart Energy Concept, 10-seater minibus, in 2019. This vehicle, Ford suggests, would deliver 150km driving range from a four-hour charge.[19] This may, however, require changing the vehicle management from drivers keeping vehicles overnight to a centralized storage facility. A depot or centralized facility would be required for effective overnight charging.

From an industry appetite perspective, there is evidence that an MBT association would be open to purchasing electric MBTs if government provided a battery leasing programme to assist with the high upfront costs.

3.2.5. Policies to support public transport electrification

International experience has shown that promoting the deployment of EVs requires policy interventions guided by a vision statement and a set of targets (IEA, 2019). Policies and standards are also crucial for managing the costs and benefits of EVs for society.

Deployment has been driven significantly through major electric bus procurement schemes. Mandates to promote electrification of bus fleets from public transport agencies have influenced recent procurements, often supplemented with subsidies for EVs. This, coupled with the lower operational costs, can result in a lower TCO, making electric buses an increasingly financially attractive option (IEA, 2019). A number of examples are shown in Box 6.

South Africa lacks a vision as well as a clear and coordinated policy environment to support the deployment of public transport electric vehicles. For example, the Department of Transport's Green Transport Strategy (2018 – 2050) does not explicitly include any actions related to the electrification of public transport services beyond a commitment to driving EV adoption through a public procurement programme (Department of Transport, 2019). Various countries have implemented a range of measures to incentivise the purchase of electric buses. A selection of examples is provided in Box 7.

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[18] Investigations are currently under way and the company did not wish to be named at the time of writing.
[19] http://www.techsmart.co.za/news/Ford-working-on-getting-electric-minibus-taxis-to-travel-further.html

Box 6: A selection of international electric bus procurement schemes

- **Shenzhen and other cities in China**: In the city of Shenzhen, 16 000 electric buses operate, the largest-scale electric bus transition observed in a city. The city government mandated operators to go electric. Operators received subsidies from both the national and municipal governments. Beijing aims for more than half of its bus fleet to be electric by 2020 (over 11 000 vehicles) (IEA, 2019).
- **Schipol Airport and cities in the Netherlands:** 100 electric buses were introduced. Tenders to operate the lines required that the buses be emissions free. The fleet size will increase to about 260 vehicles by 2021 (IEA, 2019).
- **Santiago de Chile and cities in Latin America.** Santiago de Chile rolled out 200 electric buses in 2018. Chile's aim is to electrify 100% of its public transport by 2040 and 40% of private transport by 2050 (IEA, 2019). Cost Rica established mandates for the state to electrify at least 5% of the bus fleet every two years and to deploy electric charging infrastructure. It also opened the door to public-private partnerships for the deployment of charging points (IEA, 2019).
- **Cities in India:** Government funding for 390 electric buses made available in late 2017 under the first phase of the Faster Adoption and Manufacturing of Hybrid and EV scheme drove adoption of electric buses in India in 2018 (IEA, 2019). Cities were free to announce tenders, either to purchase buses or to pay for their operation on a per-kilometre basis for a certain period.
- **Europe**: The EU's revised Clean Vehicles Directive provides for the public procurement of electric buses.[20] Incentives supporting the rollout of EVs and chargers are common in many European countries.
- **Global**: as part of the C40 Fossil Fuel Free Streets Declaration, more than 20 cities around the world committed to procure more than 40 000 electric public buses by 2020 (in 2015). Currently, Paris, London, Los Angeles, Copenhagen, Barcelona, Mexico City, Tokyo and Rome together with 19 other cities have committed to only purchase zero-emissions buses as from 2025, indicating that they will reach an all-electric fleet (BEV or FCEV) in the first-half of the 2030s (C40, 2020).

The private sector is responding proactively to the EV-related policy signals and technology developments. For example, Chinese manufacturers, such as BYD and Yutong, have been active in Europe and Latin America deploying electric buses. European manufacturers, such as Scania, Solaris, VDL, Volvo and others, and North American companies (Proterra, New Flyer) have been following suit (IEA, 2019).

[20] See https://ec.europa.eu/transport/themes/urban/clean-vehicles-directive_en for more information.

Box 7: Examples of options to address the high upfront cost of e-buses relative to ICE counterparts

Economic incentives for fleet owners

In India, the second phase of the Faster Adoption and Manufacturing of Hybrid and EV programme includes a purchase incentive scheme for electric buses (IEA, 2019).

In China, until the end of 2016, national and regional subsidies combined were able to bring the initial capital cost of an e-bus below that of a similar diesel bus, removing the main barrier to e-bus adoption: high upfront costs (BloombergNEF, 2018).

In the UK, a total of £30 million (US$39.5 million) was made available under the Low Emission Bus Scheme to be spent on new buses (between April 2016 and March 2019) (BNEF, 2020) (BloombergNEF, 2018). In February 2020, the UK government issued a call for expressions of interest associated with £50 million that has been made available to develop an all-electric bus town or city. This would see an entire place's bus fleet changed over to vehicles that are fully electric, or capable of operating in electric, zero-emission mode (UK Department of Transport, 2020). This would include, for successful bidders, a contribution of 75% of the cost difference between a zero-emission bus and a standard conventional diesel bus equivalent of the same total passenger capacity (UK Department of Transport, 2020).

The US's Low or No Emission competitive programme provides funding to state and local governmental authorities for the purchase or lease of zero-emission and low-emission transit buses as well as acquisition, construction, and leasing of required supporting facilities. Under the Fixing America's Surface Transportation (FAST) Act, US$55 million a year is available until 2020 fiscal-year (Federal Transit Administrator, 2020).

Lease agreements

Lease agreements can enable off-balance sheet acquisitions of electric buses and MBTs. For example, the rollout of electric buses in Chile has seen three operators lease the buses from the energy companies Enel X and ENGIE which own the vehicles (IEA, 2019).

This option was first introduced by Proterra in the US. BNEF suggests that the scalability of such initiatives may be limited for smaller e-bus manufacturers. With the increasing size of e-bus orders, there will be new opportunities for larger third-party financiers (BloombergNEF, 2018).

A capital lease agreement has been adopted in Warsaw, Poland. Operators lease buses for six years after which they become the owners (BloombergNEF, 2018). Operating leases keep all the risks and advantages of ownership on the side of the leasing company. These can also include maintenance contracts.

Joint procurement

Joint procurement enables economies of scale. Joint procurement agreements have been explored in the US (BloombergNEF, 2018). However, there can be challenges associated with different technical requirements for e-buses, different timelines as well as complex and time-consuming processes associated with drafting collaboration contracts (BloombergNEF, 2018).

Innovative financing

Cities/Municipalities are already looking at mechanisms to finance electric buses. PAYS present an attractive innovative finance approach that transit companies can employ to finance electric buses cost effectively (Greencape, 2019).

Government-guaranteed loans could lower the cost of capital. For example, in the US, the Department of Energy offers loan guarantees for projects that employ new technologies that are not yet supported at a commercial level (BloombergNEF, 2018).

3.3. The universe of possible solutions

To support a shift to EVs in public transport, multiple, complementary avenues are possible. They include:

- Reducing the upfront price tag of EVs;
- Further improving the comparative advantage of EVs in terms of operational (i.e. running) costs; and
- Providing non-financial incentives (which could be positive or negative) in favour of the use of EVs and other complementary measures.

As highlighted in Section 1, for passenger cars, achieving a meaningful penetration of EVs in the South African public transport sector would require active policies and measures. This needs a coherent and coordinated policy environment. This is a necessary requirement for all the options described.

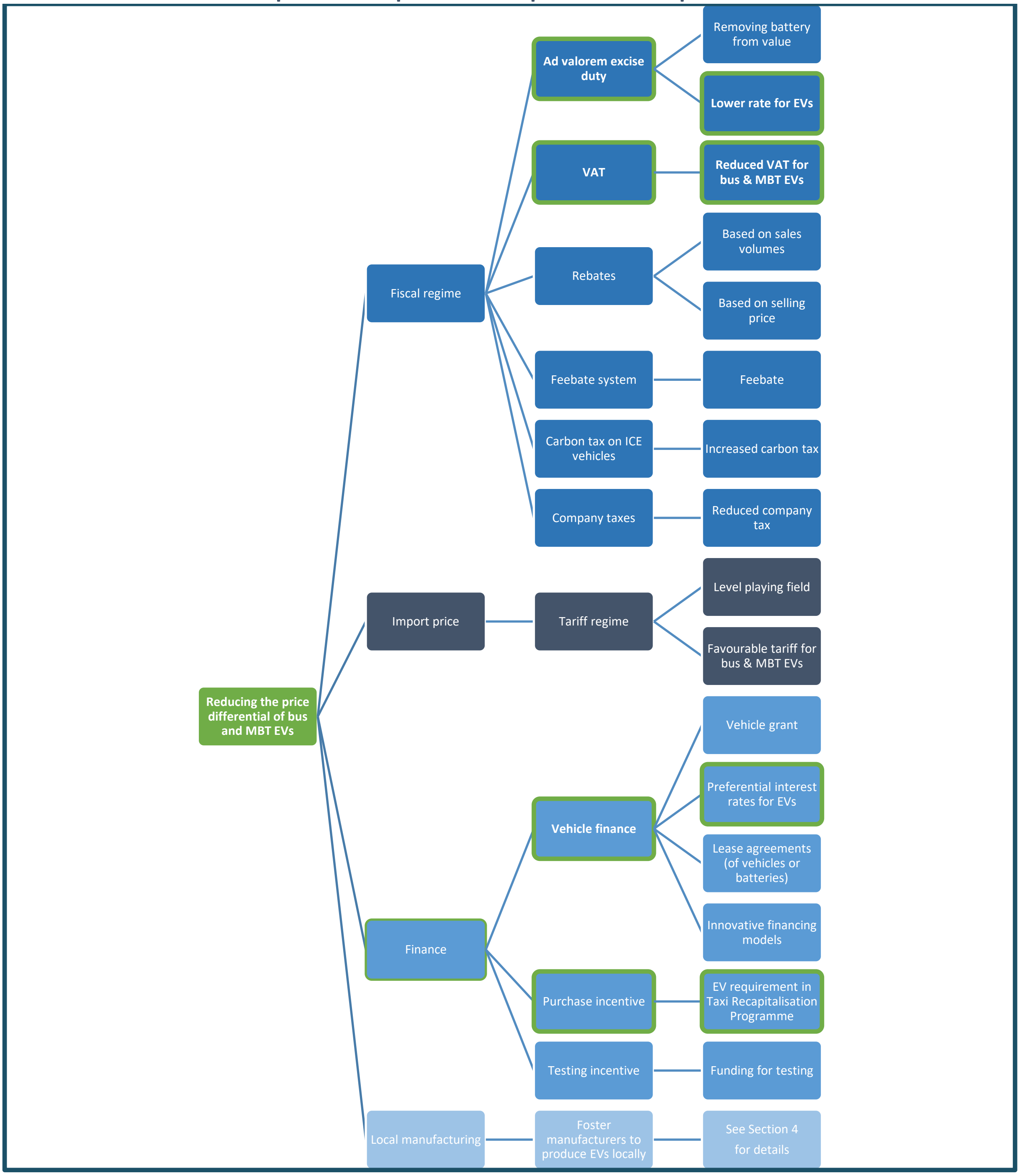
3.3.1. Reducing the upfront price differential of EVs compared to ICE equivalent

The high upfront costs of electric buses and MBTs are still the single largest barrier holding back mass adoption of the technology. Many cities lack funding to support higher spending when faced with a technology choice for fleet replacement. However, some are deliberately delaying the purchase decision because they know battery prices are falling, and they expect e-buses to be cheaper in the future compared to diesel buses (BloombergNEF, 2018).

This is further compounded in the South African context where the cost of capital (borrowing) is high due to repayment risks, adding to the overall cost of electric public passenger transport vehicles. BNEF demonstrated the role of interest rates in its TCO comparisons: they found that the TCO for a 250kWh e-bus was USD$1.04/km if paid upfront (compared to USD$1.09/km for a diesel equivalent). At a rate of 15% per annum, the TCO advantage of e-buses is eroded and the TCO for the two vehicles was the same (subject to various assumptions) (BloombergNEF, 2018).

Figure 19 summarises the universe of options to reduce the upfront price differential of e-buses and e-MBTs and how they link to other sections. Different avenues for reducing the differential are discussed below.

Figure 19: Possible options to reduce the upfront price differential of public transport EVs compared to ICE equivalent



Source: Authors

Note: primary interventions are circled in green and highlighted in bold text.

The first avenue would be to adjust the fiscal regime pertaining to the sale of public transport EVs. This could take different forms, which could be applied separately and complementarily. These options would be subject to the same conditions and characteristics of private passenger vehicles and therefore the nature of these options would largely be the same as discussed in Section 2. With company taxes, the option to reduce company tax associated with the conversion of fleets to EVs would be more limited given the lesser role of tax paying companies in the sector. Such options would be applicable to private sector bus service providers, such as Golden Arrow Bus Services, for example.

As with private passenger vehicles, reducing the ad valorem excise duty and VAT on e-buses and e-MBTs would provide one of the best mechanisms to significantly reduce the up-front cost and improve the cost competitiveness of EVs. Rebates, feebates and increasing the carbon tax on ICE public transport vehicles are considered secondary due to challenges associated with funding rebates, political and social acceptability of feebates and increasing the carbon tax, and the expectation that these measures, on their own, would not adequately tip the scales in favour of EVs (see Section 2 for more details). Reducing company tax is feasible but is unlikely to deliver adequate benefit and would be limited to a relatively small number of role players in the industry and is thus also considered a secondary option.

The second avenue would be to facilitate the import of public transport EVs into the country by reducing customs duties for EVs. As with private passenger vehicles, this could be rapidly implemented and designed as a permanent or temporary measure. Unlike private passenger vehicles, there is no import tariff anomaly that creates an unfair playing field with the import of public transport EVs versus ICE equivalents (see Section 4 and Table 21). The remaining option would be to reduce the import tariff to the benefit of EVs. This is not considered a viable option given the potential negative impact on local manufacturing. See Section 4 for further detail.

The third avenue would be to facilitate access to finance, either in the form of access to affordable capital, purchase incentives and incentives aimed at getting more vehicle options available in the market: this would include testing incentives.

MBTs are considered high risk and face high interest rates when financed[21] (Competition Commision, 2020). The high capital cost of vehicles is already a significant challenge for operators and thus any efforts to reduce the upfront cost of electric MBTs would be critical to achieving market penetration.

The TRP could be leveraged with clauses stipulating the mandatory procurement of taxis within the programme to electric (BEV, PHEV, HEV or FCEV) or offering more attractive, differentiated, incentives associated with EVs. The Competition Commission recommended that the MBT industry should be subsidised through increased funding for the TRP to address the misalignment between ridership volumes and the allocation of subsidies (Competition Commision, 2020). This could be linked to an electrification objective. Additionally, specific efforts to reduce the cost of capital could include government-guaranteed loans.

To help with the upfront cost issue, new business models are emerging, involving battery leasing, joint procurement and bus sharing. Most of these are being implemented in North America and Europe, where e-bus purchase prices are typically much higher than in China (BloombergNEF, 2018). However, most of the e-buses on the road in the US and Europe were still paid for up-front, either by the municipality or the bus operator. The most popular method of financing e-bus projects in Europe has been a combination of self-funding and various levels of grants, including EU, national, regional or municipal grants. The grant funding covers much of the cost with the rest coming from state and local

[21] The National Taxi Alliance submits that SA Taxi Finance charges interest rates of about 26.5% compared to 12% to 17.25% from traditional credit providers.

governments and the bus operator itself (BloombergNEF, 2018). Various options have been explored in different countries. Some examples are in Box 8. Of most relevance to South Africa would be:

- A vehicle grant that pays for the e-bus up front. This could leverage donor grants, or be delivered through the budget or covered with debt;
- Purchase of buses by government and leasing of the batteries (e.g. Park City Transit in the US) (BloombergNEF, 2018);
- Joint purchases by two or more bus operators to leverage buying power and reduce costs (e.g. San Francisco Municipal Railways and King County joint purchase) (BloombergNEF, 2018);
- Operational or capital lease with different timeframes and ending conditions (e.g. used by a bus operator in Warsaw and the New York Metropolitan Transportation Authority) (BloombergNEF, 2018); and
- Innovative finance options, such as PAYS (Greencape, 2018).

PAYS is an innovative finance approach that could facilitate the rapid rollout of electric buses in transit fleets (Greencape, 2018). It is a proven financing approach that has been used in multiple countries to facilitate investment in a range of climate-smart solutions. PAYS is now being used to reduce the upfront capital costs of transitioning from ICE vehicles to EVs, starting with public transport. The utility would finance batteries and the chargers and collect revenues via an on-bill PAYS tariff. The bus service provider would therefore pay the PAYS tariff and not be responsible for purchasing batteries and chargers. In many cases, the utility/municipality is able to access cheaper capital and therefore improve the transaction by offering better financing terms than the bus operator would have been able to access, optimising tariff costs to the bus operator (municipality secures electricity offtake) and improving repayment security through the ability to disconnect a customer in the case of non-payment. An additional benefit is that this structure helps the utility/municipality gain new revenue from electricity sales that improve the fiscal health of the municipality utility, and which also help the bus service provider save money from the start, thereby increasing the number of electric buses in cities (Greencape, 2018). This model still needs to be explored within the South African context.

The South African bus industry notes that electric bus testing is prohibitive and suggests that incentives or funding from government to assist in the testing phase would improve the speed at which these new technologies are incorporated into the South African market (Venter, 2016). Lease agreements would enable short-term testing periods without requiring the significant up-front capital. Government could facilitate the availability of such short-term leases to operators in the country.

Developing preferential interest rates for EVs is seen as a primary option as a reduction in the cost of capital would likely have significant impact on the cost-competitiveness of e-buses and e-MBTs (particularly as any cost of capital penalises the relatively higher EV upfront cost more than its ICE equivalent). This option would require partnerships between governments and financial institutions to translate into an adequately low interest rate to drive demand. The option is likely to be more attractive than in the case of private passenger EV finance given the greater developmental benefits associated with public transport, and thus the likelihood of DFIs offering attractive concessional finance is greater. Furthermore, MBTs face very high interest rates and any reduction in rates would not only improve the cost competitiveness of e-MBTs but, if significant, could enable more operators to afford repayments and therefore increase access to finance.

Leveraging the TRP to drive e-MBTs should also be considered as a primary option given that the mechanism exists, changes are technically feasible, and that, if the scrapping allowance can be increased, this could incentivise a large-scale adoption of EVs. Importantly, measures would need to reduce the up-front capital cost of e-MBTs by 25% to reach parity (on a LCOT-basis) with ICE vehicles currently. This equates to a sum of R162 000, which is significantly higher than the current R50 000 scrapping allowance.[22] As the cost of vehicles decreases (due to expectations on declining battery prices, in particular), this differential would reduce. In the short term, however, additional measures beyond the TRP incentives would be required to stimulate significant investment into e-MBTs.

Grants raise the question of whether adequate funding could be secured to meaningfully tip the scales in favour of EVs and to reach enough of the market to have a significant impact on public transport EV penetration. This should be considered a secondary option.

Unlike private passenger transport, public transport applications are often more predictable or fixed and operators are sensitive to operating costs. This lends itself to alternative models, such as lease agreements, PAYS and other models that look to leverage operational savings to cover capital finance costs. While there are examples internationally, the lack of evidence of these models being ubiquitous and taken up at scale suggests they are unlikely to play a significant role in the South African market in the short term. Lease agreements and innovative finance should therefore be considered as a secondary option.

The final avenue would be to foster the local manufacturing of public transport EVs with the potential of delivering more appropriate EVs for the local environment and, by circumventing import duties, offering more affordable vehicle options. See Section 4 for further details. This is considered a secondary option. It would result in lower-cost vehicles but the price benefit would, on its own, unlikely tip the scales and is not a short-term option. As discussed, in Section 4, a demand-led strategy would, however, be adequate to support the local manufacturing of electric buses and minibuses in the country. This in the long run would bring multiple benefits to the economy, society and the market.

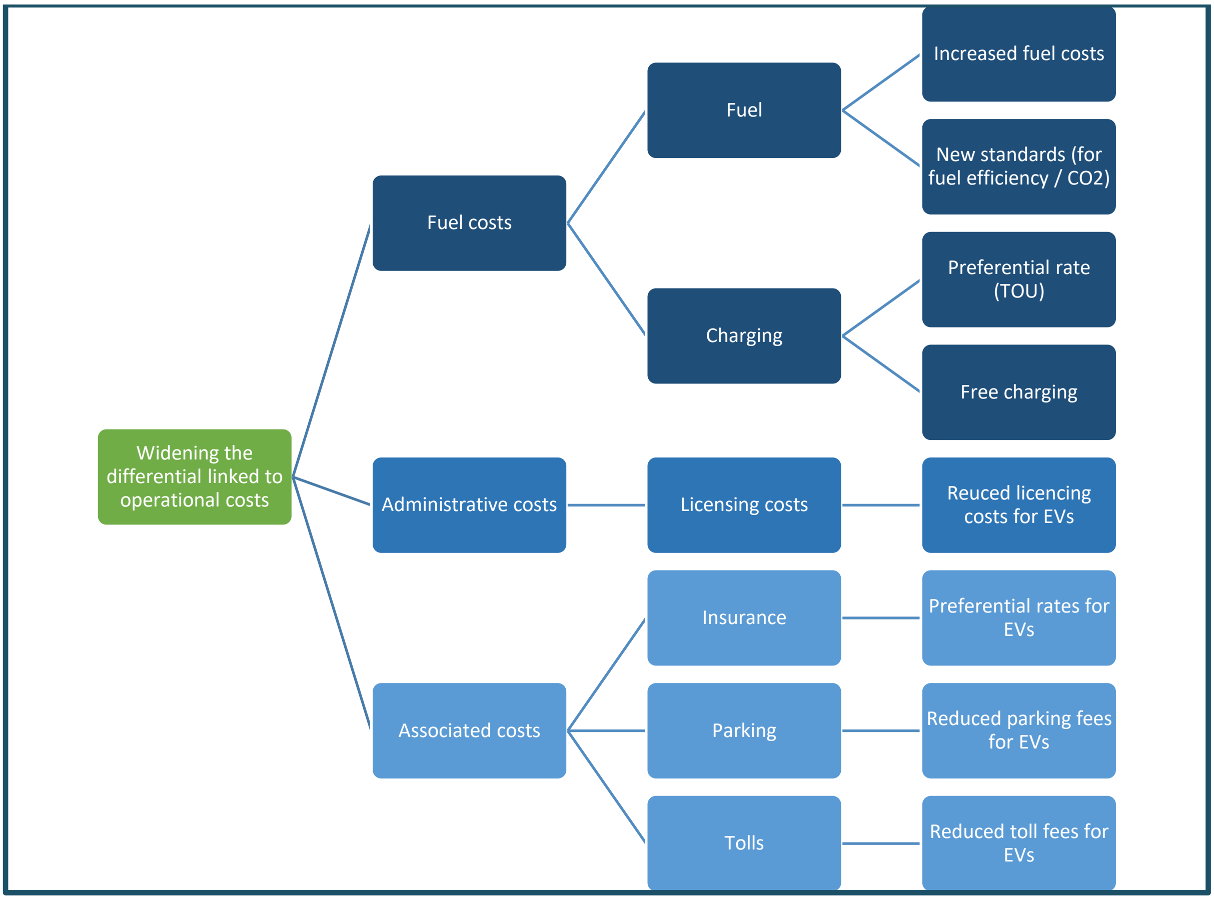
3.3.2. Widening the operational cost differential of e-buses and e-MBTs compared to ICE equivalent

The second main lever would be to alter operational costs. Running costs of EVs are already materially lower than equivalent ICE vehicles. A number of measures could be implemented to widen this differential further. This would contribute to shorten the payback period/kilometrage required by EVs to offset the higher upfront purchasing cost.

Figure 20 summarises the universe of options to widen the operational cost differential of EVs and how they link to other sections. Different avenues for reducing the differential are discussed below.

[22] This analysis excludes any need to invest in charging and additional infrastructure by the fleet owners.

Figure 20: Possible options to widen the operational cost differential of e-buses and e-MBTs compared to ICE equivalent



Source: Authors

Note: all options are regarded as secondary interventions

The main avenue would be through the "fuel" costs. Two key avenues, which could be implemented together, are possible: increasing the cost of petroleum products (i.e. petrol and diesel) to increase the running costs of ICE vehicles; and/or providing low-cost electricity charging, or hydrogen in the case of FCEVs. In this regard, government can, through the highly regulated fuel levy, increase liquid fuel taxes. Additionally, governments can also set standards that effectively increase the cost of ICE vehicles. For example, Japan has legislated a 14.3% improvement in fuel economy for buses compared to 2015 levels. Sweden has set CO_2 standards by committing to net zero transport GHG emissions by 2045.

ToU electricity tariffs and favourable off-peak rates offer a mechanism to reduce the operational costs of EVs. Off-peak electricity tariffs offer low energy costs for overnight depot charging as well as not needing to adjust operations or to train drivers for charging procedures. However, buses that use this charging method require larger batteries than buses that also charge during operating hours, which comes with higher battery costs and vehicle purchase prices. The development of battery costs may impact market trends for bus charging regimes, in which decreasing battery costs can drive the industry further to overnight charging at depots (IEA, 2019).

A special EV tariff with lower prices during off-peak times can incentivise EV off-peak charging. Although electricity tariffs provide indirect control of EV charging, detailed analyses of such schemes are limited (Forum of Regulators, 2017).

In the absence of other measures incentivising the purchasing and use of EVs in the country, setting favourable tariffs represents an important lever by which government could influence EV penetration particularly of fleet vehicles with more predictable use patterns (Change Pathways, 2018).

Section 2 provides a summary of the LCOT analysis that provides an indication of the potential role of widening the operational cost differential for battery electric buses and MBTs specifically. The analysis shows that measures to reduce electricity costs and/or increase liquid fuel costs would not, on their own, fundamentally change the cost-competitiveness of BEVs relative to ICE counterparts. However, the analysis shows that there would be a positive impact and these measures should therefore be considered as part of a package of options.

Reducing administrative costs would complement efforts to reduce relative fuel costs. Such options may be particularly favourable in the context of MBTs when incentives that overcome challenges associated with operating licences may be particularly attractive. In addition, other, non-administrative costs could also be decreased for EVs. See Section 2 for additional details.

All the options available to widen the operational cost differential of e-buses and e-MBTs compared to ICE equivalents are regarded as secondary. These options are all feasible (sometimes very cost effective) and would deliver the intended benefits but would, on their own, not contribute significantly to the cost competitiveness of e-buses and e-MBTs. The impacts of these options are, however, more pronounced than in the case of private passenger vehicles due to greater use (generally higher mileage) and a greater sensitivity to operating costs than experienced in the private passenger vehicle market. The options should, therefore, be considered as part of a package of options.

3.3.3. Non-financial incentives and other complementary measures

Numerous other measures can contribute to promoting the adoption of EVs in public transport fleets. Various examples are provided in Table 14.

Public procurement programmes are regarded as a primary option. Experience internationally has shown that this represents a practical avenue for directly increasing the number of EVs on the roads as well as creating demand and delivering the necessary signals to support local manufacturing (see Section 4). The primary opportunity lies in converting municipal bus fleets to electric as government has control over these decisions. This would require strong leadership and commitment as the option comes with risks and additional costs (as demonstrated by the City of Cape Town's experience in investing in a fleet of e-buses). However, this is an important intervention that would allow cities to get more EVs on the roads, learn from the experience, and, significantly, kickstart the local manufacturing industry. In the longer term, such risk would decrease as price parity would make e-buses the logical choice in most applications and local manufacturing adjusts to market realities.

Government has limited influence over bus companies that bid to deliver transport services and over MBT associations. There is the potential to impose requirements through the awarding of operating licences, but this would likely see significant push back from stakeholders. The focus initially should therefore be on the public procurement of municipal bus fleets.

All other non-financial and complementary measures are regarded as secondary as they would, on their own, not contribute to any significant deployment of EVs in the public transport sector. They should be considered in a package of supporting measures.

Table 14: Examples of non-financial and other complementary measures to promote electric public transport adoption

OPTION		DESCRIPTION / EXAMPLES
Restrictions	ZEV mandates	Requirements for licences and awarding tenders that drive public transport EVs deployment. Various countries have adopted this approach.
	Setting target requirements	Revision of the EU's Clean Vehicles Directive including minimum requirements for urban buses (24%-45% in 2025 and from 33% to 65% in 2030) (IEA, 2019).
	Requirements	MBT operators and bus service operators could be forced to convert to electric as a requirement for obtaining an operating licence. Such an approach would likely face significant pushback by operators, particularly the MBT taxi industry.
	Bans	Ireland's ban on sales of ICE diesel-only buses in 2019
Incentives	Access benefits	This could include zero-emission zones (typically grounded on better environmental performance, such as local air pollution), road pricing, high occupancy vehicle and transit lanes and preferential access (IEA, 2019).
	Making e-buses and e-MBTs more attractive.	Support the delivery of value-adding services in electric public passenger vehicles (e.g. Wi-Fi).
	Procurement programmes	Procurement programmes are important instruments to kickstart demand for EVs and stimulate automakers to increase the market availability of EVs. They also help to enable an initial rollout of publicly accessible infrastructure (IEA, 2019). There is a significant opportunity for local governments to show leadership by procuring EVs for the bus fleets.
Ensuring EV readiness	Minimum requirements	Ensuring EV readiness in new or refurbished buildings and parking lots, and the deployment of publicly accessible chargers on highway networks and in cities are also crucial to achieve increased EV adoption and to boost consumer confidence (IEA, 2019). For example, this has been driven by the EU through the European Energy Performance Buildings Directive.[23]
	Increasing the availability of public transport EVs.	Crucial instruments include fuel economy standards, zero-emissions vehicle mandates and ratcheting up the ambition of public procurement programmes (IEA, 2019).
	Communication and awareness raising.	Raising awareness is one of the most important needs in the transition to EVs Kolokathis and Hogan, 2018).

[23] See https://ec.europa.eu for more information.

		Good communication is also crucial for managing grid impacts and maintaining trust needed to overcome range anxiety and other issues associated with consumer uptake of EVs as a new technology. Standardised and easy to understand tariffs and payment systems are also part of the simple and effective communication required. People like to know what they are paying for and how much it costs. It also helps with transparency and building trust, especially as e-mobility is still a young industry (Fishbone, Electric Vehicle Charging Infrastructure: Guidelines for Cities, 2017).
Vehicle 'rightsizing'	Invest in data	Adapting battery sizes to travel needs (matching the range of vehicles to consumer travel habits) is also crucial for reducing costs by avoiding "oversizing' of batteries in vehicles (IEA, 2019). For example, instruments allowing real-time tracking of bus or MBT positioning to facilitate rightsizing of batteries.
	Develop partnerships with manufacturers	Close co-operation between manufacturers to design purpose-built EVs are not only relevant for freight transport, but also for meeting range, passenger capacity and cargo space requirements for vehicles used in shared passenger fleets (e.g. taxis and ride-sharing) (IEA, 2019). The IEA notes examples of electric bus designs using the opportunity charging concept (i.e. placing chargers at the end of urban bus lines, rather than at the bus depots) that are based on the optimisation of the battery capacity of vehicles to fit the required route. Co-operative arrangements, such as the coalition formed by E.ON, H&M group, Scania and Siemens, to accelerate the decarbonisation of heavy transport can be useful to build knowledge in this innovative area of technology development (IEA, 2019). Ride-sharing fleet operators (e.g. Didi) are increasingly working with EV manufacturers to design purpose-built EVs to address issues around range, passenger capacity and cargo space.
Other	Addressing concerns around the residual value of e-buses	BNEF outlines a key challenge expressed by a number of cities as being the uncertainty around the residual value of buses, driving uncertainty around the lifetime of the battery and end-of-life options (BloombergNEF, 2018). BNEF suggests that policies can be introduced to regulate the end-of-life requirements for batteries and provide clear responsibilities to the different parties involved. Further, as the market for e-buses and lithium-ion batteries matures, some of these concerns will be reduced (BloombergNEF, 2018).

Source: Authors

3.4. Exploring the costs and benefits of key options

Building on the universe of possible interventions available to support e-buses and e-MBTs in South Africa, this section zones in on four key options:

- Changing the VAT and/or ad valorem excise duty;
- Promoting the deployment of e-MBTs through the Taxi Recapitalisation Programme;
- Facilitating access to a preferential interest rate for e-bus and e-MBT finance; and
- Public procurement.

Implementation requirements, costs and benefits for each of the considered interventions are reviewed with the aim of providing an understanding of their viability from a technical, socio-economic and political perspective.

3.4.1. Changing the VAT and/or ad valorem excise duty

The ad valorem excise duty could be removed by government over a period of time. Similarly, government could reduce VAT on EVs. In both cases, the implementation requirements and the impacts on different stakeholders would be largely similar and would be identical to the private passenger vehicle case. One key difference, however, emerges. While difficult to defend from a socio-political perspective for passenger cars, a reduction in the VAT and/or ad valorem excise duty for public transport vehicles would have clear progressive outputs and be much easier to justify.

Refer to Section 2 for an assessment of the socio-economic implications of changing the VAT and/or ad valorem as well as a summary of the arguments for and against these measures.

3.4.2. Promoting the deployment of e-MBT through the Taxi Recapitalisation Programme

The TRP could be adjusted to promote e-MBTs by stipulating conditions that replacement vehicles be EVs ("condition") and/or offering a more attractive incentive in the form of a higher scrapping allowance for EV replacements ("greater incentive"). Section 3.3.1 provides an indication of the extent of the scrapping value that would be required to tip the scales in favour of e-MBTs. Importantly, such a measure would need to be accompanied by awareness-raising and other secondary options to contribute to the EV business case for MBT operators.

Table 15 details the implementation requirements, expected benefits and expected costs for key stakeholders of promoting the deployment of e-MBTs through the TRP. Implementation requirements are relatively low. The acceptability of the "condition" option with no additional financial benefit is unlikely to be attractive until e-MBTs become more cost competitive (i.e. in the medium term). The success of the "greater incentive" hinges on securing additional funding and securing buy-in of operators through awareness-raising and addressing any additional behavioural barriers specific to this context.

In the short term, vehicles would need to be imported unless local manufacturing of e-MBT can be rapidly initiated locally (there are no e-MBT currently available in the market). See Section 4 for further information on the manufacturing of MBTs in South Africa.

Table 15: **Promoting the deployment of e-MBTs through the Taxi Recapitalisation** Programme

STAKEHOLDERS	IMPLEMENTATION REQUIREMENTS	EXPECTED BENEFITS	EXPECTED COSTS
MBT owners	Investment in e-MBT. Negotiation of TRP incentive. Availability of centralised charging or hydrogen refuelling. Awareness-raising (to address concerns around performance) Identification of appropriate routes for e-MBTs.	Lower operating costs.	Some changes to MBT operations and use patterns (e.g. drivers not able to pick up passengers as they leave their homes if centralised charging). Higher vehicle costs if scrapping values are not increased ("condition").
OEMs (manufacturers)	None	None in the short term Demand may enable local manufacturing in the longer term.	None
OEMs (importers)	None	Increased sales of imported vehicles in the short term.	None
Automotive value chain	None	None in the short term. Increased support and demand for EV-specific components in the longer term.	None
Middle- to high-income households	None	Reduced pollution and associated environmental and health benefits.	None
Low-income households	None	Reduced price of public transportation if cost savings are passed through to customers Improved safety. Reduced pollution and associated environmental and health benefits.	No direct cost
Government (National)	Adjustment to the TRP "Greater incentive: Capital raising to accommodate the need for greater incentives to overcome EV premium (may need to explore development / climate finance).	Reduced transport externalities (environmental damage, increased health care costs, road accident costs). Increased energy security.	Increase TRP costs Threat to the long-term sustainability of the local automotive industry if not coupled with incentives for local EV production.
Government (Local)	Contribution to MBT operator awareness-raising.	Reduced transport externalities Contribution to meeting GHG targets.	None
Eskom / Local network operator	Develop preferential electricity tariffs (optional).	Increased electricity sales.	Pressure on the grid infrastructure.

Source: Authors

Given the above costs and benefits, promoting the deployment of e-MBTs through the TRP is unlikely to face significant opposition when higher scrapping allowances are provided ("greater incentive") but would likely face opposition or achieve limited success if the TRP imposes a condition that replacement vehicles be EVs without providing any additional support ("condition"). The greater incentive option appears to be the only viable route. Capitalising the system would be the primary challenge. The secondary challenge would be the need for significant awareness-raising to get operators to understand the LCOT/TCO implications and also to agree on applications (routes) when EV capabilities are likely to meet the use requirements. Table 16 lists the main arguments for and against it.

Table 16: Principal arguments for and against promoting the deployment of e-MBTs through the Taxi Recapitalisation Programme

FOR	AGAINST
- The TRP represents an existing mechanism that can be adjusted. - Low-income households could benefit from lower transport costs if savings are passed onto the consumer. - Demand could stimulate local manufacturing of e-MBTs. - Development / climate finance may be a route to securing additional budget given the mechanism for deployment is well established.	- The scrapping allowance would need to be significantly higher to incentivise investment in e-MBTs, requiring additional budget / alternative revenue sources. - Mobilising the MBT industry to embrace change is very challenging and significant awareness-raising and trust-building would be needed to ensure success.

3.4.3. Facilitating access to a preferential interest rate for e-bus and e-MBT finance

Government could play a role in brokering partnerships between local financial institutions and DFIs to provide concessional funding, on the condition that banks provide low-interest finance to e-bus and e-MBT purchasers. A 48% reduction in the interest rate for e-MBTs (from an assumed 25% to 13%) would make e-MBTs comparable to ICE MBTs on a LCOT basis.

Table 17 details the implementation requirements, expected benefits and expected costs for key stakeholders of facilitating access to a preferential interest rate for e-bus and e-MBT finance.

Table 17: Socio-economic implications of facilitating access to a preferential interest rate for e-bus and e-MBT finance

STAKEHOLDERS	IMPLEMENTATION REQUIREMENTS	EXPECTED BENEFITS	EXPECTED COSTS
MBT operators / owners	Investment in e-MBT Availability of centralised charging or hydrogen refuelling Awareness raising (to address concerns around performance) Identification of appropriate routes for e-MBTs.	Lower vehicle costs. More operators able to access finance (if rate reductions are significant enough) and become owners. Additional revenue options through Vehicle to Grid (V2G) opportunities in the longer term.	Some changes to MBT operations and use patterns (e.g. drivers not able to pick up passengers as they leave their homes if centralised charging).
Bus owners	Investment in e-buses Availability of centralised charging or hydrogen refuelling Awareness raising (to address concerns around performance) Identification of appropriate routes for e-MBTs.	Lower vehicle costs. For cities: enables conversion of city bus fleets to low-carbon options.	None
OEMs (manufacturers)	None	Stimulation of local market to extent that local e-bus and e-MBT	Increased competition from imported e-buses and e-MBTs (short term).

		production can be supported (medium to long term).	
OEMs (importers)	None	Increased demand for imported e-buses and e-MBTs.	None
Middle- to high-income households	None	Reduced price of public transportation (e.g. BRTs) if cost savings are passed to customers. Reduced pollution and associated environmental and health benefits.	None
Low-income households	None	Reduced price of public transportation if cost savings are passed through to customers. Improved safety Reduced pollution and associated environmental and health benefits.	No direct cost
Local Banks	Negotiation of conditions with DFIs. Develop a programme that translates concessional finance into low interest rate e-bus and e-MBT finance.	Increased revenue from finance to e-bus and e-MBT purchasers. Demonstrable and measurable lending activities in favour of the transition to a low carbon economy (in response to increasing stakeholder expectations).	Reduced earnings from finance offered to ICE vehicle purchasers.
Development Finance Institutions	Negotiation of conditions with local banks. Facilitate access to the cheapest possible concessional finance.	Opportunity to deliver development benefits at scale through lending.	Opportunity cost of capital.
Government (National)	Collaborate with local banks to facilitate access to concessional finance.	Positive signal to OEMs. Higher penetration of EVs onto the local market. Long-term ancillary grid services from V2G opportunities (e.g. grid balancing and greater renewable energy deployment).	None

Source: Authors

Given the above costs and benefits, and as was the case in facilitating reduce interest rates for private passenger EV finance, the willingness of DFIs and local financial institutions to facilitate access to these lower interest rates is likely to exist. The key issue is whether the effective interest rates will be low enough to make EVs cost competitive. Table 18 lists the main arguments for and against it.

Table 18: Principal arguments for and against facilitating access to a preferential interest rate for EV finance

FOR	AGAINST
- Technically feasible (i.e. no regulatory or institutional changes required). - Reduces transport costs for low-income (and some middle-income) households if operational cost savings are passed onto the consumer. - No additional budget required. - Significant potential to reduce finance e-bus and e-MBT costs to a level that can make them cost competitive.	- Threat to sales of locally manufactured ICE vehicles in the short term if leads to increased imports.

- Potential to stimulate demand to levels necessary to support local manufacturing. - Contributes to DFI objectives and local bank's sustainability objectives.	

Source: Authors

3.4.4. Public procurement

Public procurement represents a powerful mechanism to drive government objectives. In the short term, the primary opportunity lies in the procurement of e-buses for municipal bus fleets. This would allow municipalities to learn and better understand the role of EVs and their potential impacts on the city and its people, and would represent an important mechanism and signal to kick-start the local e-bus manufacturing industry (see Section 4 for more detail on manufacturing).

Table 19 details the implementation requirements, expected benefits and expected costs for key stakeholders to enter into early public procurement of e-buses.

Table 19: Socio-economic implications of e-bus public procurement programmes

STAKEHOLDERS	IMPLEMENTATION REQUIREMENTS	EXPECTED BENEFITS	EXPECTED COSTS
OEMs (manufacturers)	Negotiation of procurement conditions and bus designs	Stimulation of local e-bus market	Investment in new model development
OEMs (importers)	n/a	n/a	n/a
Middle- to high-income households	None	Reduced price of public transportation if cost savings are passed through to customers Reduced pollution and associated environmental and health benefits	None
Low-income households	None	Reduced price of public transportation if cost savings are passed through to customers Improved safety (longer term) Reduced pollution and associated environmental & health benefits	No direct cost
Government (National)	Set the policy intent (create a vision and framework to which local governments can align)	Additional benefits associated with a greater share of alternative fuel passenger vehicles on South Africa's roads: reduced noise and air pollution (and associated health care costs); reduced GHG emissions; increased safety (reduced accidents and associated road accident fund claims) Long-term ancillary grid services from V2G opportunities	None
Government (local)	Take a leadership position: be willing to take on risk and incur greater costs (in the short term) Investment in charging/refuelling infrastructure	Reduced transport externalities Potentially significant contribution to meeting GHG targets Long-term ancillary grid services from V2G opportunities	Higher fleet costs (in the short term), compounded if existing fleet is replaced before the end of its economic life. City carries additional risk (as evidenced in the City of Cape Town's experience)

	Identification of appropriate routes for e-buses Navigate public procurement requirements (MFMA)		

Source: Authors

Given the above costs and benefits, the key requirement is a commitment from cities to play a leadership role. The e-buses would not represent a least-cost option for delivering transport services in the short term but can play an important near-term role in stimulating the local industry, making EVs visible and creating awareness, and enabling lessons to be learned. Table 20 lists the main arguments for and against it.

Table 20: Principal arguments for and against facilitating access to a preferential interest rate for EV finance

FOR	AGAINST
- Stimulates local manufacturing - Makes EVs more visible and creates EV awareness - Enables lessons that can inform optional electric public transport rollout in cities - Direct mechanism to get more EVs on the roads, reducing transport externalities and contributing to cities' targets and commitments.	- e-buses (in the near term) incur a price premium - Cities carry additional risks - Complexities in navigating public procurement requirements

Source: Authors

3.4.5. Secondary options to include in a package of options

Various options would not, on their own, contribute significantly to the deployment of EVs in the public transport sector. However, in the public transport sector in particular, many of these options are feasible to implement and could be considered within a package of possible options. These could include:

- Further reducing operating costs; and
- Leveraging non-financial and other supportive mechanisms in the MBT sector (notably incentivising investment in EVs tied to operating licences and preferential access to routes, ranking facilities, lanes, etc.)

Further reducing operating costs

Local municipalities could potentially further reduce the operating costs of e-buses and e-MBTs by providing options for lower-cost charging/refuelling. For instance, slow depot charging during off-peak periods could be incentivised if fleet owners can access lower ToU electricity tariffs.

This could present infrastructure challenges: if too many fleets look to charging in this way, this would require additional investment in charging infrastructure and, depending on the capacity of the grid network, may require additional investment to accommodate clustered electricity demand.

Over time, cities may look to develop tariff structures and incentives related to fast and super-fast wireless or pantograph (overhead) charging as well as hydrogen refuelling. However, given that plug-in charging is currently the most economical and preferred option in cities, such investigations have a longer-term horizon (linked to these technologies being more competitive and implementing worldwide).

However, the LCOT analysis showed that this option, on its own, would not make EVs cost competitive today (largely due to the fuel efficiency of EVs) (see Section 2). It does, however, represent an important option to consider as part of a suite of options and one that will over time play a more significant role in improving the relative LCOT of public transport EVs.

Leveraging non-financial and other supportive mechanisms in the MBT sector

Given the significant challenges in the industry, mechanisms that could ensure operating licences as well as preferential access to routes and ranking facilities could be attractive to the industry. Further engagement with the industry would be required to understand the extent to which the sector would value such options and thus the role these would play in incentivising investment in e-MBTs. These mechanisms would not likely stimulate significant investment on their own but could contribute significantly if coupled with other measures to reduce the upfront capital cost. The attempts of the BRT systems around the country provided important learnings of factors to consider when trying to incorporate MBTs in the public transport system. These learnings should be taken into consideration so as not to repeat the same shortcomings and to enhance the efficacy of options that are pursued.

3.5. Policy implications

In conclusion, supporting the shift to EVs in public transport in South Africa hinges on implementing one or more of four key strategies:

- Changing the VAT and/or ad valorem excise duty;
- Promoting the deployment of e-MBTs through the TRP;
- Facilitating access to a preferential interest rate for e-bus and e-MBT finance; and
- Public procurement.

Changing the VAT and ad valorem excise duty would be technically feasible, would not require additional sources of funding, and would likely be one of the most effective ways of addressing the main EV public transport barrier: higher upfront costs. A challenge is that significant EV penetration would have a negative impact on government revenue. This could be mitigated by adjusting the mechanism over time.

Leveraging the TRP to drive e-MBT deployment should be seriously considered but is contingent, in the short term, on securing additional funds to cover the high EV price tag. Similarly, a lower interest rate could have substantial impact, particularly in the case of MBTs when the cost of capital is very high. This would be contingent on reducing risk, maximising sustainable development outcomes, and then translating benefits to the end consumer.

A public procurement programme is one of the most straightforward ways to get e-buses on South Africa’s roads in the short term. This would help to catalyse further deployment of e-buses and stimulate local industry. This requires strong leadership and commitment by cities.

Secondary options should be explored as part of a package of options to support the primary strategies. In the case of public transport, two secondary options in particular should be included in such a package. The first is to enable the lowest possible electricity costs to fleet owners that can charge during off-peak periods. Preferential rates should be considered, particularly given the safer and cleaner transport services that public transport EVs could deliver. The second is to leverage operating licences for selected routes awarded to private bus companies and to MBTs by including conditions that vehicles be electric (more likely to be viable in the medium term).

Cutting across these options are several requirements. First, partnerships are key to realising the potential benefits associated with public transport EVs. Cities and fleet owners need to work closely with manufacturers to show specific demand for e-buses and e-MBTs. This could include setting targets and commitments and would be needed to ensure the right signals are in place.

The MBT industry poses unique challenges and opportunities. The success of interventions would be dependent on cities developing robust and transparent partnerships with taxi associations and operators to come up with relevant solutions based on in-depth knowledge of the industry.

Involving local utilities and grid operators from the beginning of the planning of EV deployment should be the first step to electricity supply and network capacity challenges associated with cluster charging and increasing demand. Adequate planning could minimise the need for additional investment and ensure adequate power to meet growing demands expected in the future. Depots and other centralised charging stations provide an opportunity to facilitate investment in SSEG (particularly solar-based systems). Further work is required to establish what a hydrogen refuelling network for public transportation would look like.

Cities need to work with fleet owners and operators to design e-routes from the ground up. Cities should also collaborate to put pressure on national government, and also to provide recommendations and solutions that national government can implement.

Second, it is also important to recognise that there is limited experience of EV technologies in the public transport sector in South Africa. It is therefore important to encourage learning-by-doing and iterative approaches that ensure appropriateness of interventions within the local context.

This should include the exploration of pilots. Better understanding the role of e-buses and e-MBTs in the South African context, in all their forms, is needed. The significant uncertainty about future EV penetration rates, use behaviour (charging/refuelling and driving), preferences of the local market, and developments in technology and evolutions in the regulatory environment require an iterative approach to designing and implementing the EV tariff. This will allow learning-by-doing and, as uptake will likely be slow, this is unlikely to have any significant negative impacts. The trade-off between stability/certainty (required for private sector investment) needs to be balanced against the need to design the most optimal structure.

4. HOW CAN THE LOCAL MANUFACTURING OF EVS BE SUPPORTED IN SOUTH AFRICA?

On the manufacturing side, the issues revolve around developing the local EV value chain. This ranges from the mining and beneficiation of minerals to the manufacturing of parts and components, to the manufacturing of vehicles. This section focuses on the development of motor vehicle manufacturing by OEMs. In line with the overall scope of the report, it considers only passenger cars, MBTs and buses.

Given the existing domestic automotive value chain centred on a limited number of large, foreign OEMs, developing EV manufacturing hinges on three related dynamics:

1) How can the existing manufacturing base be leveraged and expanded to manufacture EVs in South Africa?
2) How can the existing manufacturing base progressively transition from the manufacturing of ICE vehicles to EVs? and
3) How can the emergence of new local manufacturers be fostered?

4.1. Problem statement

The transition to EVs is progressively reshaping the automotive market. As discussed in Sections 0 and 3 on market development, while still marginal, the demand for EVs is rising exponentially. This has direct implications on manufacturing capacity worldwide. To respond to the increase in demand, OEMs are developing EV manufacturing capacity. As of March 2020, this is essentially centred on current demand hotspots (EU, China) as well as large OEMs' home countries (Japan, USA) but will become more prevalent as the transition to EVs intensifies.

South Africa hosts a vibrant automotive manufacturing industry thanks to long-standing support from government (see Box 8 for details). Local production ranges from passenger cars and light commercial vehicles, to MBTs, to buses and trucks. However, existing EV manufacturing is currently limited to one hybrid mass-market passenger vehicle as well as an array of local entrepreneurs targeting niche markets. Besides local sales, current local manufacturing has traditionally focused on servicing the EU and US markets with ICE vehicles, two markets that are rapidly shifting to EVs. In the short term, implications appear limited, offering the opportunity to prepare. In the medium term, these dynamics would require the domestic manufacturing industry to a) change its production (from ICE vehicles to EVs) and/or b) change its target markets (from the EU and the USA to Africa for instance). The extent to which such a transition is conditioned on the development of local demand for EVs remains a point of contention.

Box 8: Summary of the policy framework in support of automotive manufacturing

South Africa has developed and maintained a world-class automotive manufacturing value chain through ongoing state support and collaboration with key global OEMs, component manufacturers and labour.

The APDP was introduced in 2013, and will run until the end of 2020. A second phase of the APDP will run from 2021 to 2035, in line with the South African Automotive Masterplan (SAAM). While the overall structure of the programme remains unchanged, a number of important changes have been introduced and are highlighted below.

The APDP framework consists of four key pillars aimed at supporting local manufacturing:

1. Customs duty on imported vehicles and components;

2. A rebate mechanism for OEMs, the Vehicle Assembly Allowance, to be replaced with a Vehicle Assembly Localisation Allowance from 2021;

3. A rebate mechanism linked to the supply chain, the Production Incentive; and

4. A cash grant for investment, the Automotive Investment Scheme.

Customs duties aim to protect local manufacturing production by raising the costs of automotive-related imports. General tariffs are set at 25% on Completely Built-Up (CBU) passenger cars (18% from the EU, except for BEVs) and 20% on original equipment components used in the manufacturing of motor vehicles. Buses and minibuses operate under a different tariff regime, highlighted in Table 21. Assembly operations of trucks and buses receive the benefit of the duty-free importation of all driveline components, including the engines, differential parts, transmissions, drive-axles and gearboxes. Table 3, in Section 2, details the tariff regime on passenger motor vehicles. No changes to the tariff regime in respect of vehicles have been announced as of March 2020 but, according to (Lamprecht 2019: 31), South Africa seeks to negotiate with the EU (through the SADC-EU Economic Partnership Agreement (EPA)) "a single tariff regime across all light vehicles, including electric vehicles" and vehicles with engines below 1000cc.

Table 21: Tariff regime for the import of buses and minibuses into South Africa

Buses and minibuses	Heading	General	EU	EFTA	SADC	MERCOSUR
ICE bus	8702.10.10	20%	15%	15%	free	20%
ICE minibuses (under 2000 kg)	8702.10.81 & 85	25%	20%	20%	free	25%
ICE minibus (over 2000 kg)	8702.10.87 & 90	20%	15%	15%	free	20%
Diesel hybrid bus	8702.20.10	20%	15%	15%	free	20%
Diesel hybrid minibus (under 2000 kg)	8702.20.81 & 85	25%	20%	20%	free	25%
Diesel hybrid minibus (over 2000 kg)	8702.20.87 & 90	20%	15%	15%	free	20%
Petrol hybrid minibus (under 2000 kg)	8702.30.81 & 85	25%	20%	20%	free	25%
Petrol hybrid minibus (over 2000 kg)	8702.30.87 & 90	20%	15%	15%	free	20%
BEV minibus (under 2000 kg)	8702.40.81 & 85	25%	20%	20%	free	25%
BEV minibus (over 2000 kg)	8702.40.87 & 90	20%	15%	15%	free	20%

Source: Authors, based on Schedules to the Customs and Excise Act, 1964, downloaded in November 2019 from SARS at www.sars.gov.za

The VAA provides a rebate to OEMs (manufacturing light vehicles only) for importing components and vehicles into South Africa free of duty. In the current framework, the value of the rebate obtained by OEMs is calculated on the ex-factory vehicle price. From 2015, the rebate granted to OEMs is equivalent to 3.6% of the ex-factory vehicle price. From 2021, the VAA will be replaced with the VALA. The value of the rebate will be calculated on local value addition rather than manufacturing sales value. The qualifying threshold will also be reduced to 10 000 units per year.

Like the VAA, the PI provides a rebate to OEMs for importing components and vehicles into South Africa free to duty. Unlike the VAA, the PI is available to all OEMs manufacturing locally (i.e. from light vehicles to buses and trucks). The incentive is calculated through the supply chain and is earned by the end user, which is the OEM, or, in the case of component exports or replacement parts, the component manufacturer.[1] In addition, the PI focuses on value addition in the production process. It is meant to encourage the localisation of component manufacturing. The rebate equates, from 2018, 4% to 10% of value-added on components. The value of the rebate will increase by five percentage points from 2021. Certain vulnerable products were granted higher rebate rates (alloy wheels, aluminium products, such as engine and transmission components, heat exchangers and tubes, suspension components and heat shields, cast iron components, such as engine, axle, brake, transmission and related types of components, catalytic converters, flexible couplings, leather interiors, machined brass components, steel jacks). Benefits to vulnerable products will be removed from 2021. In addition to components, a number of locally-beneficiated minerals (aluminium, brass, leather, PGMs, stainless steel and steel) were included in the programme as well.

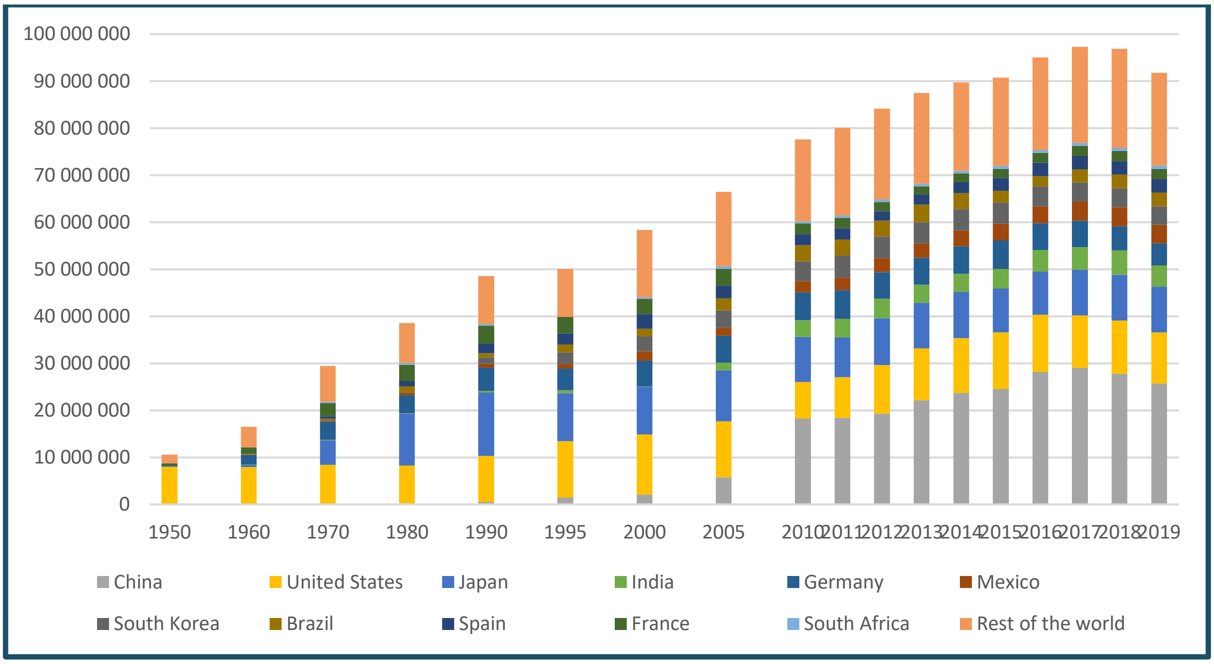
The AIS is a cash-based incentive. It provides a non-taxable cash grant of 20% of the value of qualifying investment in productive assets by light motor vehicle manufacturers, and increased support of 25% of the value of qualifying investment in productive assets by component manufacturers and tooling companies. In addition, by achieving certain performance objectives, companies can earn an additional 5% or 10%. While originally focused on light vehicles and component manufacturing, the AIS became available to people-carrier manufacturers as well as automotive tooling companies in 2014. From 2021, the AIS will be reduced (by 5 percentage points) for investment not relying on locally-manufactured tooling. According to (Lamprecht 2019, 31), the AIS will also be "augmented to include an incentive for investments in new technologies, including investments related to the introduction of electric or hybrid drive trains." However, as of April 2020, no official announcement has been made to this effect. Since inception in July 2009 until March 2020, 528 projects have been approved under the AIS, for a total investment of R69.6 billion, including government support of R19.3 billion (Lamprecht 2020).

[1] In the case of heavy commercial vehicles, the PI is earned by the component manufacturer and not passed through to the heavy commercial vehicle manufacturer, as it done on light vehicles.

4.2. Context

Automotive manufacturing is concentrated in a few countries, as illustrated in Figure 21. In 2019, South Africa was ranked 22nd for global vehicle production with a market share of 0.7%. On the African continent, South Africa remained the dominant manufacturer, accounting for more than half (57%) of total vehicle production (Lamprecht 2019). However, Morocco, conveniently positioned next to the EU market, produced more passenger cars than South Africa for the third successive year.

Figure 21: Global production of automotive vehicle (in units)



Source: Authors, based on data from the Organisation Internationale des Constructeurs d'Automobiles (OICA), Series on Production Statistics, downloaded in June 2020 at http://www.oica.net.

State of manufacturing in South Africa

Seven South African-based OEMs, located in automotive clusters across three provinces in the country (see Table 22 and Figure 22), dominate South Africa's automotive industry:

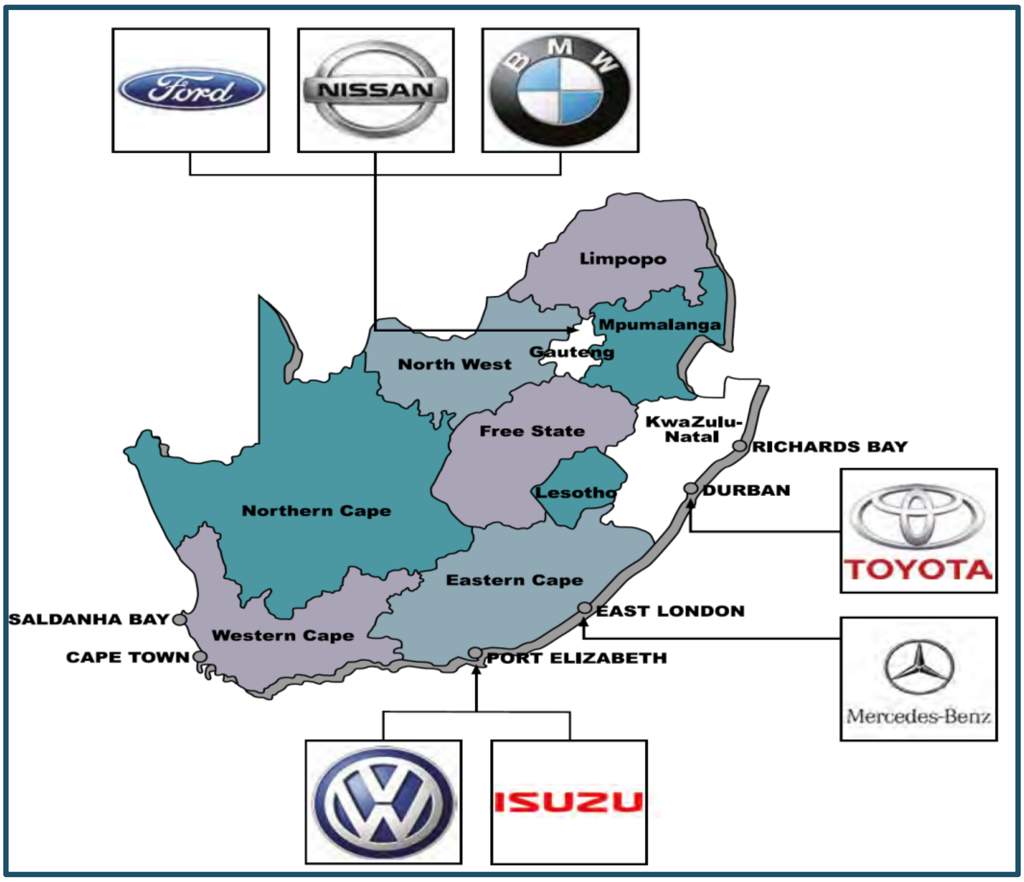
- Rosslyn, Silverton and Ekurhuleni in Gauteng, which has the largest concentration of automotive manufacturing in South Africa, with three automotive OEMs (BMW, Ford and Nissan) and approximately 40% of the South African automotive components industry;
- Port Elizabeth and Uitenhage in the Eastern Cape, home to Volkswagen and General Motors, and about 30% of the automotive components industry;
- East London, in the Eastern Cape, which hosts Mercedes Benz's assembly plant, and roughly 6% of the automotive components industry; and
- Durban and Pietermaritzburg in KwaZulu-Natal, which host Toyota, South Africa's largest producer of vehicles accounting for 24.2% of market share, and approximately 20% of the automotive components industry (Lamprecht 2019).

Table 22: Key features of automotive manufacturing clusters in South Africa

KEY AUTOMOTIVE FEATURES	GAUTENG	KWAZULU-NATAL	EASTERN CAPE
Number of OEMs (manufacturing plants)	BMW SA Nissan SA Ford Motor Company of Southern Africa	Toyota SA Motors	Volkswagen Group SA, Mercedes-Benz SA, Isuzu Motors SA, Ford Motor Company of Southern Africa engine plant
Medium, heavy, extra-heavy commercial vehicle and bus companies	Babcock, Eicher Trucks, Fiat Group, Ford, Hyundai, Iveco, JMC, MAN Truck & Bus, MarcoPolo, Peugeot Citroen, Powerstar SA, Scania, Tata Trucks and Volvo Group Southern Africa	Bell Equipment, MAN Truck & Bus and Toyota (Hino)	FAW Trucks, Isuzu Truck, Mercedes-Benz SA (Freightliner and Fuso) and Volkswagen Group SA
Number of auto component companies	200	80	150
Share of light vehicle production	33.2%	23.1%	43.7%
Share of light vehicle export	36.5%	13.7%	49.8%

Source: Lamprecht, 2020.

Figure 22: Map of key automotive clusters in South Africa



Source: Lamprecht 2019.

Manufacturers are complemented by a wide array of importers, such as the Fiat Chrysler Automotive Group, Hyundai, Kia Motors, TATA Motors, Honda, Renault, Jaguar Land Rover and European Automotive Imports South Africa. In terms of market share for light vehicles, the leading four brands in the country, namely Toyota, Volkswagen, Ford and Nissan, all have manufacturing operations in the country, as shown in Table 23. They accounted for close to two-thirds of local sales in 2018.

Table 23: Top OEMs in South Africa by market share for light vehicles (2019)

OEM	Type	Ownership	Market share
Toyota	Manufacturer	100% Toyota Motor Corp	24.2%
Volkswagen	Manufacturer	100% Volkswagen AG	16.7%
Ford	Manufacturer	100% Ford Motor co	9.5%
Nissan	Manufacturer	100% Renault-Nissan-Mitsubishi Alliance	9.2%
Hyundai South Africa	Importer	100% Hyundai Motor Company	6.3%
Renault	Importer	100% Renault-Nissan-Mitsubishi Alliance	5.1%
Mercedes Benz	Manufacturer	100% Daimler AG	3.9%
Isuzu Motors South Africa	Importer	100% Isuzu Motors Ltd	3.8%
Kia South Africa	Importer	100% Kia Motors Corporation	2.9%
Suzuki Auto	Importer	100% Suzuki	2.9%
BMW Group	Manufacturer	100% BMW Group	2.8%

Source: Lamprecht, 2020.

Currently, no mass-market BEV and only one hybrid vehicle is manufactured or assembled in South Africa. Mercedes-Benz manufactures the C-class 350e petrol-based PHEV at its East London plant. This is part of Mercedes-Benz's global strategy, which posits that a plant manufacturing a particular model must be in a position to produce all drivetrain options. The C350e is available in the local market, however, the PHEV is mainly destined for exports.

Toyota announced investment of R4.28-billion in its local operations up to the end of 2020. The lion's share of the investment (R2.43-billion) has been earmarked for gearing up for the production of a new passenger-car model at the Prospecton plant, in Durban, which will start in October 2021. The new passenger model, which will replace the Corolla production line, should include a Toyota hybrid synergy drive model (Venter 2020).

Besides private cars, which account for the bulk of the vehicles (in volume) on the road, public transport systems are instrumental in moving the majority of the population around the country. As a result, both the market for MBTs and buses is strongly linked to local manufacturing.

South Africa's transport system is heavily structured around the MBT industry. Indeed, 42% of households rely on minibus taxis as their main mode of transport, as highlighted in Section 3. According to SANTACO, in 2019, the legally-operating MBT fleet consisted of approximately 130 000 vehicles, with 95 000 taxis used for short- and medium-distance trips in the urban environment, and the remainder for rural and inter-city transport. The actual number of operating MBTs in the country is unknown but the Department of Transport's eNaTIS database suggests that 310 000 minibuses (irrespective of their usage) were on South African roads in 2017 (see Deonarain and Mashiane 2019).

The MBT market is concentrated around a limited number of brands and models. Toyota indicates that the HiAce (known as Quantum Ses'fikile locally) controls 96% of the market share, an increase from 77% in 2015 (Parker 2019). Other minibuses available in the country include Nissan's Impendulo, Mercedes-Benz's Sprinter, and BAW's Sasuka.

Minibus manufacturing in South Africa is a duopoly made of Toyota and BAW. Overall, according to the Department of Trade and Industry (the dti), "more than 80 000 taxis have been assembled locally" since 2012 (the dti 2019).

It is dominated by the local production by Toyota at its plants in Durban, KwaZulu-Natal. Toyota has been assembling HiAce minibuses since 2012. Toyota has, over time, increased the local content of the HiAce vehicle from 38% to 44%. In October 2019, Toyota announced R500-million investments to expand domestic production (the dti 2019). The latest injection adds to investments of R74-million in 2012 and R505-million in 2015 as Toyota moved away from importing the HiAce to assembling the vehicle. In seven years, Toyota has gone from importing CBU vehicles to a completely knocked down (CKD) manufacturing, progressively increasing production capacity from 9 300 units per year to 14 000. Plans are underway to increase the capacity to 18 000 units per annum by 2021 (Venter 2020).

BAW is the second OEM assembling MBTs in South Africa. It has produced the Sasuka 16-seater taxi for the South and Southern African market since 2012 at its MBT taxi plant, in Springs, Gauteng. The plant is a joint venture between BAW (51%), the IDC (24.5%) and James Chung's Golden Gate Trust (24.5%). The initial investment cost R196 million. In 2017-2018, BAW, in partnership with the IDC, invested R250 million to expand and upgrade the plant. With this investment, the facility moved from assembling the Sasuka from semi knocked down (SKD) kits to CKD kits. The capacity at the plant, on a single shift, stands at 500 units a month. With the move to CKD, local content was announced to reach 35% (Venter 2017).

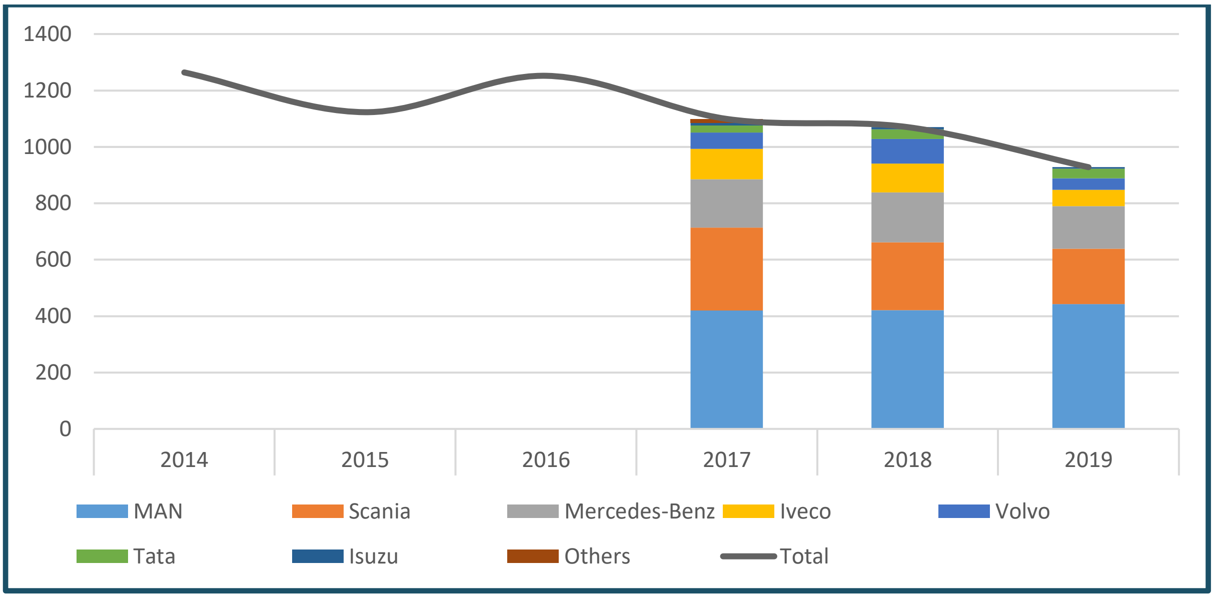
In addition to Toyota and BAW, South African entrepreneurs are active in this market, developing local products. Hala Motors, based in Soweto in Gauteng, is one example. The firm is developing electric MBT manufacturing.

Complementarily, some entrepreneurs are developing last-mile EV solutions. MellowCabs, based in the Western Cape, is an example. The firm developed a small-scale BEVs for public transport. However, homologation and certification issues[24] led the company to adapt its product to serve as a small utility vehicle for delivery-focused businesses, such as DHL and Takealot.

In addition to MBTs, there are approximately 25 000 buses in South Africa, of which 19 000 are for public transportation, while the other 6 000 buses are mostly used for in-house purposes in industry and government institutions (Mega Bus 2016).

Figure 23 details annual sales of buses in South Africa. In 2018, eight bus companies were represented in the country, namely Isuzu Motors SA, MarcoPolo, Tata, Iveco, Mercedes-Benz, Volvo Group Southern Africa, MAN and Scania. OEMs rely on a number of local body manufacturers, such as Busmark, MCV-SA, Irizar, CNH Industrial SA, Busco and Real African Works (RAW).[25] Most assembly is, however, on a SKD basis with minimal local parts. Production is exclusively focused on diesel drivetrains. The vast majority (more than 90%) of locally-manufactured buses are sold locally while the remainder are exported to neighbouring countries.

Figure 23: Annual sales of buses produced in South Africa (in units)



Source: Authors, based on data obtained from NAAMSA

As of March 2020, a number of initiatives are under way to develop local manufacturing of e-buses. Both existing manufacturers and entrepreneurs are active in the field.

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[24] New vehicle models, built-up vehicles and modifications of vehicles, whether locally manufactured or imported, must conform to the compulsory specifications for vehicles of the relevant class, and in particular the standards affecting Safety Critical Characteristics of the vehicle and its components. Different standards exist for passenger vehicles, goods vehicles, trailers and agricultural tractors. See https://www.nrcs.org.za for more details on this.

[25] RAW launched in Johannesburg in 2018 as South Africa's first 100% black-owned vehicle manufacturer in the automotive industry, and has a special focus on buses.

Busmark,[26] in partnership with a number of local universities, government departments, the Council for Scientific and Industrial Research (CSIR) and Hydrogen South Africa (HySA), investigated the possibility of developing a hydrogen fuel cell bus. Unfortunately, the initiative did not move forward due to funding challenges. Busmark is also busy building a fully electric bus as part of a government programme, and is considering using a battery pack developed by Nelson Mandela Metropolitan University (Venter 2019a).

Chinese manufacturer BYD[27] manufactured 11 electric buses for the MiCiti public transport service in response to a 2016 tender from the City of Cape Town. Delivered at a cost of R128 million, manufacturing achieved 70% local content as per the dti's requirements (Malinga, 2019).[28]

In 2019, a Gauteng and Limpopo-based company, Mi-Power Electrical Bus, displayed an electric-powered bus at the Chartered Institute of Government Finance Audit and Risk Officers' conference at the Durban International Convention Centre (Bhengu, 2019). Mi-Power Electrical Bus is a division of Masala Ramabulana Holdings, which provides power solutions for communication, commercial, industrial and renewable energy markets in Africa. It aims to set up a local assembly plant in Limpopo.

EV-Green is another local outfit involved in the electric bus market. It focuses on electric bus conversion and manufacturing in Vereeniging, Gauteng, based on locally manufactured components.

Market dynamics

South Africa's automotive value chain is highly connected to global dynamics and is dependent on worldwide trends from an import and export perspective. As illustrated in Figure 24, South Africa is both a major importer and exporter of automotive-related goods, i.e. vehicles and components. Importantly, the country has a positive trade balance for vehicles. This is offset by a negative trade balance for components, used in local production and maintenance. Overall, exports of automotive products (vehicles and components) are concentrated around a few countries, as shown in Figure 25.

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[26] Busmark is South African bus body builder. The company has plants in Randfontein and Cape Town, employing around 1 400 people at these two facilities. It has supplied around 80% of the busses operational in South Africa's bus rapid transit systems, as well as the buses for the Gautrain system

[27] Led by the aggressive e-bus growth rate in China for full-battery and hybrid buses, e-buses are surpassing the growth of every other EV segment globally with a compound annual growth rate of 100% since 2013, compared to 60% for passenger vehicles. In 2019, it was reported that of 425 000 e-buses in the world, 421 000 (99%) were in China, 2250 in Europe and 385 in India, manufactured by Yutong, BYD, Zhongtong and Solaris (Bloomberg, 2019).

[28] In August 2018, it was reported that the drive motors of the electrical buses were not powerful enough to handle the city's mountainous terrains. As a result, they remained idle at a bus depot in Blackheath's industrial area. The Transport and Urban Development Authority, as part of the overall acceptance testing of the electric buses, undertook multiple tests and inspections. The Transport and Urban Development Authority confirmed that the buses met the city's requirements. There are still plans in place by the City of Cape Town to finance and procure e-buses in the near future.

Figure 24: Value of automotive-related imports and exports (in nominal ZAR value)

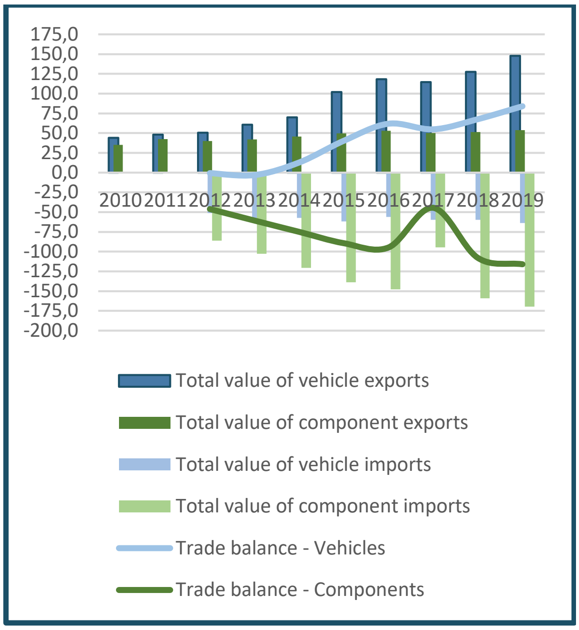
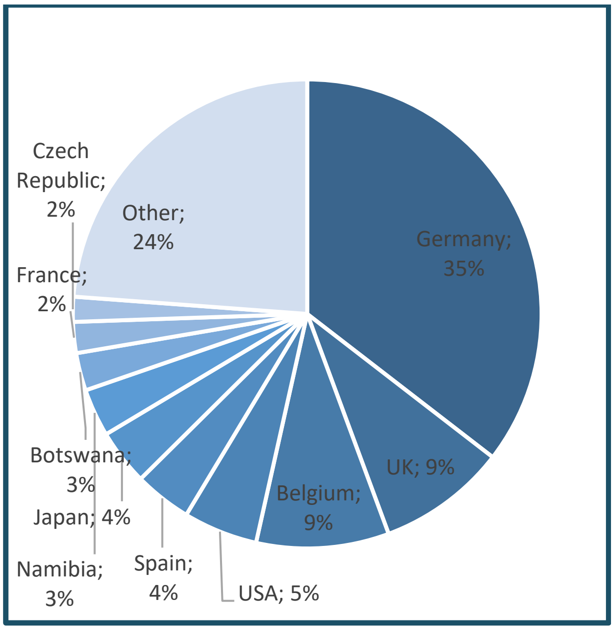


Figure 25: SA exports of automotive products (vehicles and components) by destination (in 2019)



Source: Authors, based on Automotive Industry Export Council (AIEC) data

As shown in Figure 26, more than half the vehicles produced are exported, essentially to the UK, Japan, Germany, France, Australia and the US. As mentioned earlier, with the exception of the Mercedes-Benz C350e, a plug-in-hybrid passenger car (petrol-electric), all vehicles produced and exported are ICE-based (either petrol or diesel).

Overall, vehicle exports out of South Africa have grown steadily over the years, both in volume and in real Rand terms (see Figure 26 and Figure 28). Due to the structure of the domestic production, which focuses on a limited number of models, a large share of the vehicles sold in the country is correspondingly imported, as depicted in Figure 27.

Figure 26: South Africa's production and exports of light vehicles (in units)

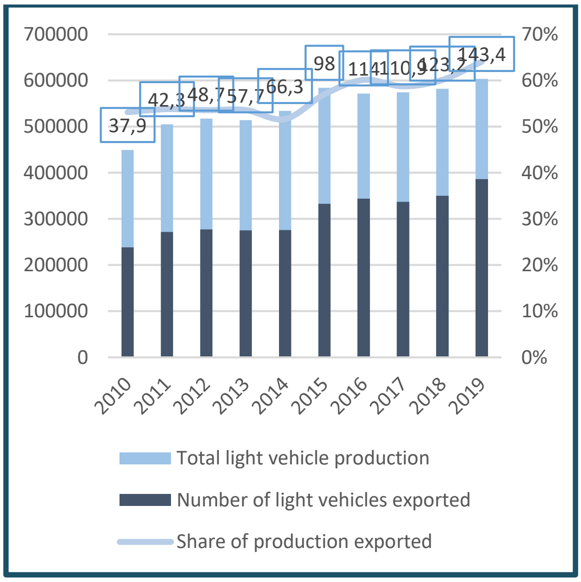
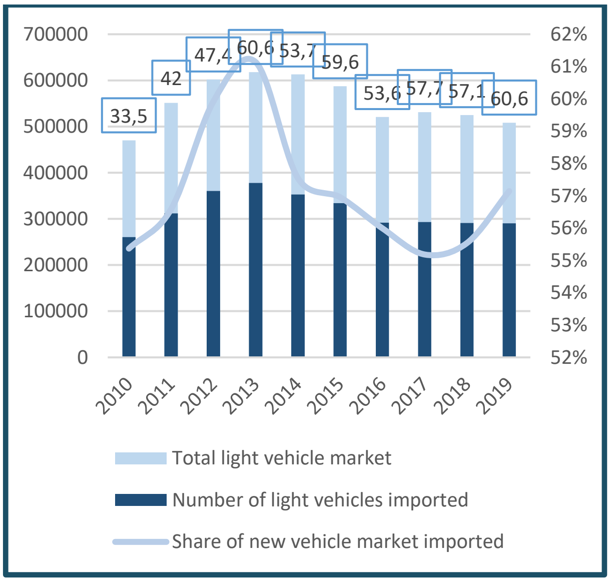
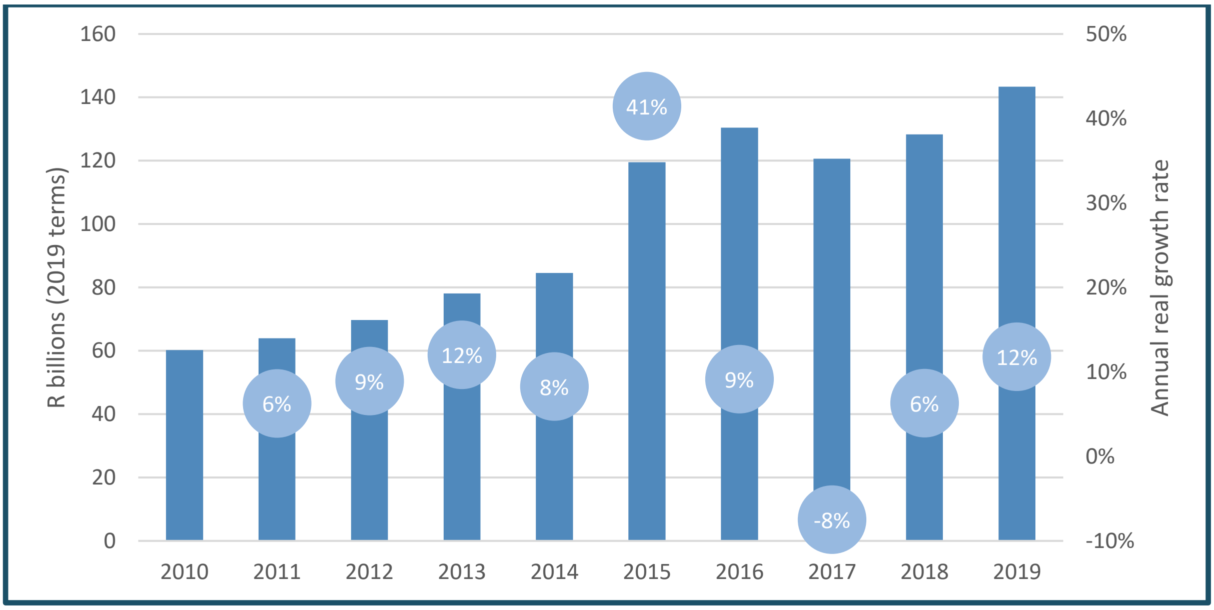


Figure 27: South Africa's market and import of light vehicles (in units)



Source: Authors, based on AIEC data

Figure 28: South Africa's export of vehicles (in real 2019 terms and annual growth rates)



Source: Authors, based on data from AEIC

South Africa's leading destination markets, i.e. the EU, the UK, Japan and the USA, have all aggressively embarked on the transition to e-mobility. While forecasts predict different tipping points (i.e. when ICE sales will start declining in absolute terms), they all indicate an exponential growth for EVs. The IEA, in its ambitious EV30@30 scenario, forecasts ICE sales reach their peak in 2022 at a global level (see Figure 30), but only around 2030 in its more conservative New Policies Scenario (NPS) (see Figure 29). In any event, EV sales are set to rise fast in leading countries, such as China, the EU, Japan, the US and India.

Figure 29: Global vehicle sales per year according to the IEA's NPS scenario (in million vehicles/year)

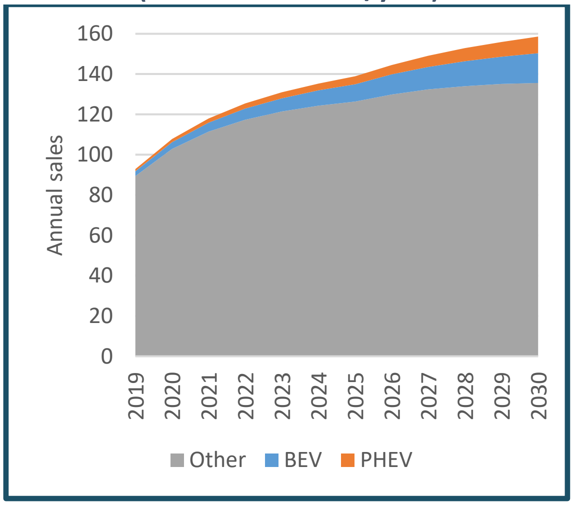
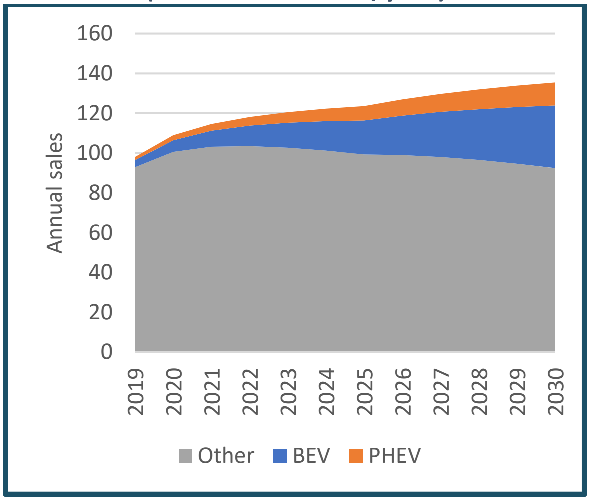
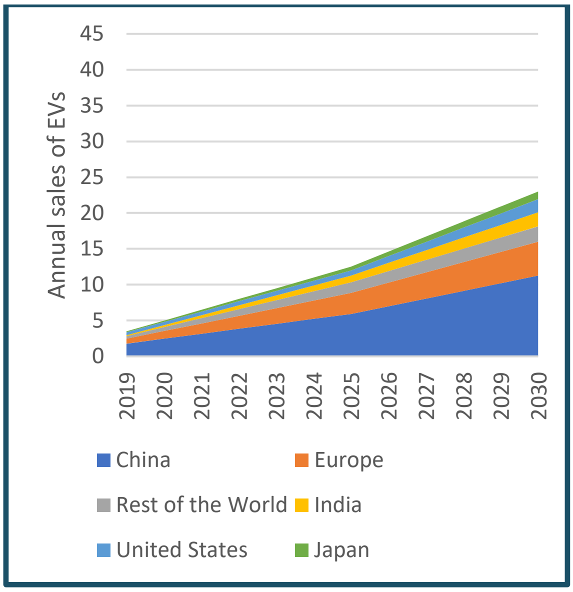
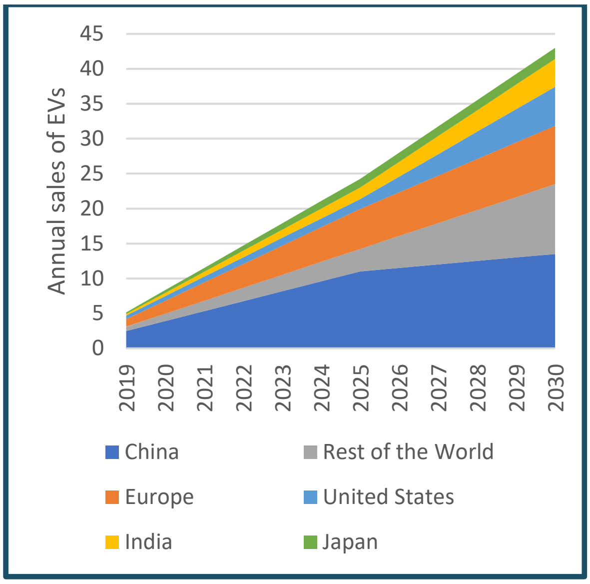


Figure 30: Global vehicle sales per year according to the IEA's EV30@30 scenario (in million vehicles/year)







Source: Authors, based on data from the IEA
Note: the data includes all vehicle types, i.e. passenger cars, light duty vehicles, buses and trucks

The evolution of the domestic market remains more uncertain, particularly in terms of timing. EV sales are set to grow in the coming years, capturing an increasing share of the market, particularly in more ambitious scenarios. However, the point at which such sales will lead to a reduction in ICE vehicle sales is unlikely to occur before 2030 for passenger cars.

Figure 31: Domestic passenger car sales per year according to a 'status quo' scenario (in thousand vehicles/year)

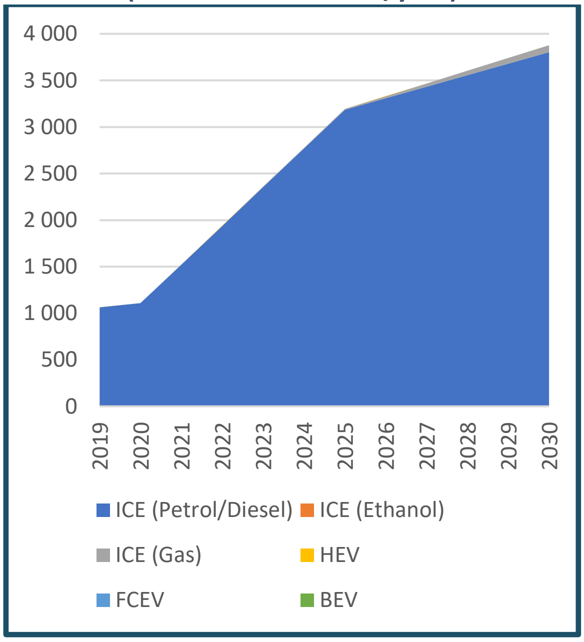
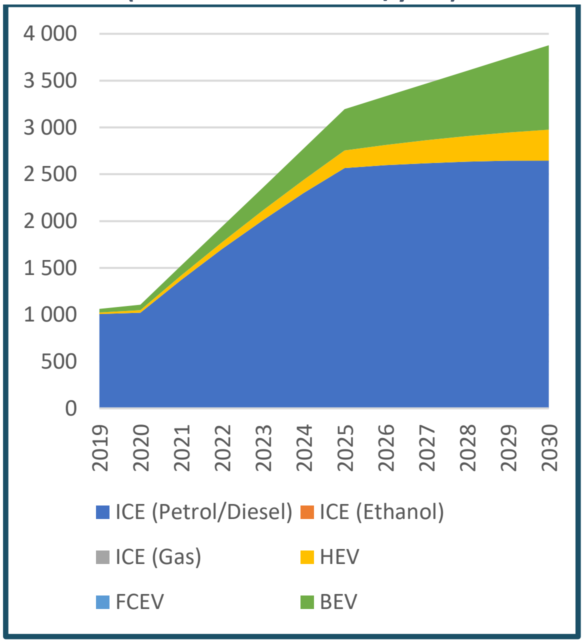


Figure 32: Domestic passenger car sales per year following the IEA's EV30@30 scenario (in thousand vehicles/year)



Source: Authors, based on data from the IEA and the University of Cape Town's Energy Research Centre

A different picture should emerge for public transport vehicles. These should transition more rapidly to new drivetrains, even in a conservative scenario. The sales of ICE-based buses should decline in the coming decade. They will be replaced partly by alternative ICE-based fuels (ethanol and gas) and partly by electric mobility. Figure 33 and Figure 34 illustrate demand forecast for buses and MBTs.

Figure 33: Domestic bus sales per year according to a 'status quo' scenario (in thousand vehicles/year)

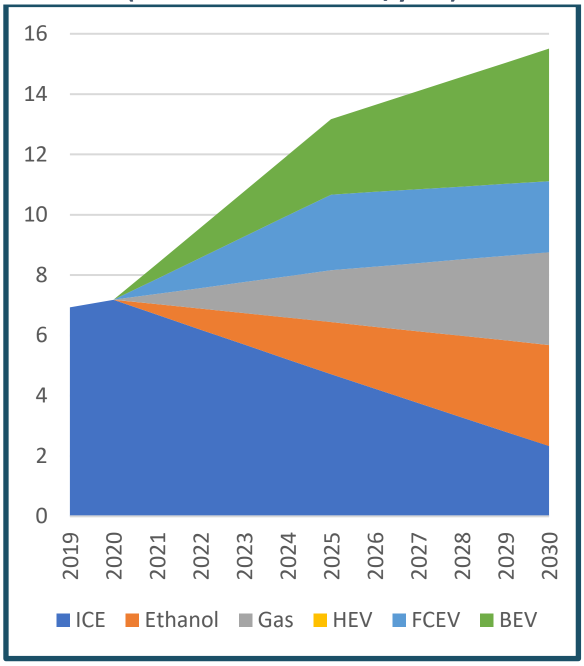
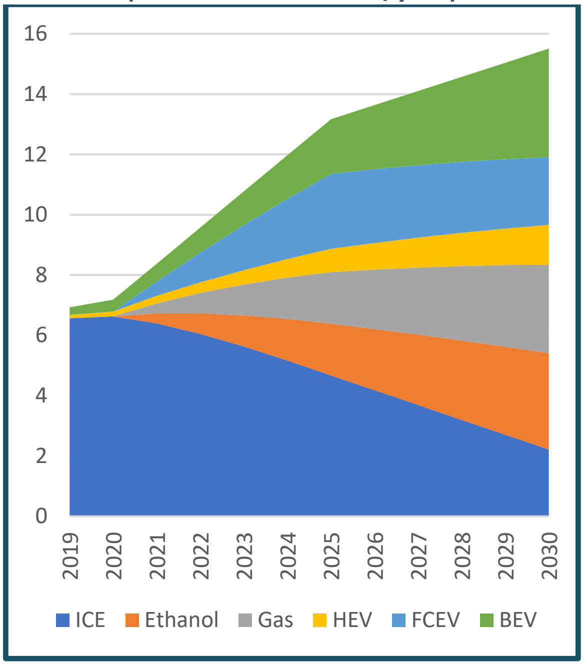


Figure 34: Domestic bus sales per year following the IEA's EV30@30 scenario (in thousand vehicles/year)



Source: Authors, based on data from the IEA and the University of Cape Town's Energy Research Centre

Figure 35: Domestic MBT sales per year according to a 'status quo' scenario ***(in thousand vehicles/year)***

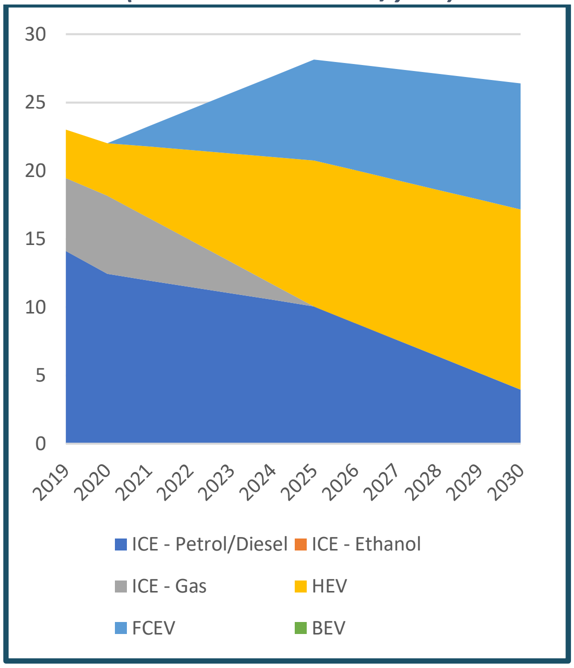
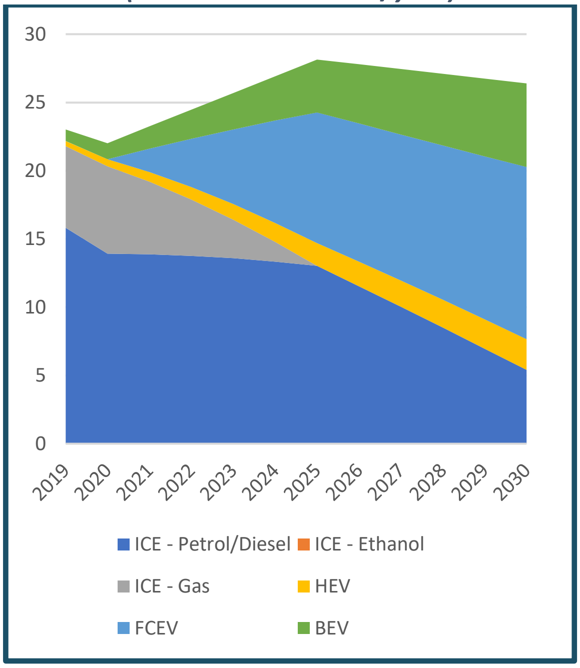


Figure 36: Domestic MBT sales per year following the IEA's EV30@30 scenario ***(in thousand vehicles/year)***



Source: Authors, based on data from the IEA and the University of Cape Town's Energy Research Centre

4.3. The universe of possible solutions

To support the local manufacturing of EVs, several avenues are available:

- Fostering an environment that enables global OEMs manufacturing ICE vehicles in the country to start manufacturing EV locally, either by adding EV manufacturing and/or converting their existing operations;
- Attracting new OEMs to manufacturing EVs locally; and
- Supporting local entrepreneurs.

Four main, complementary sets of options can be considered to incentivise local production:

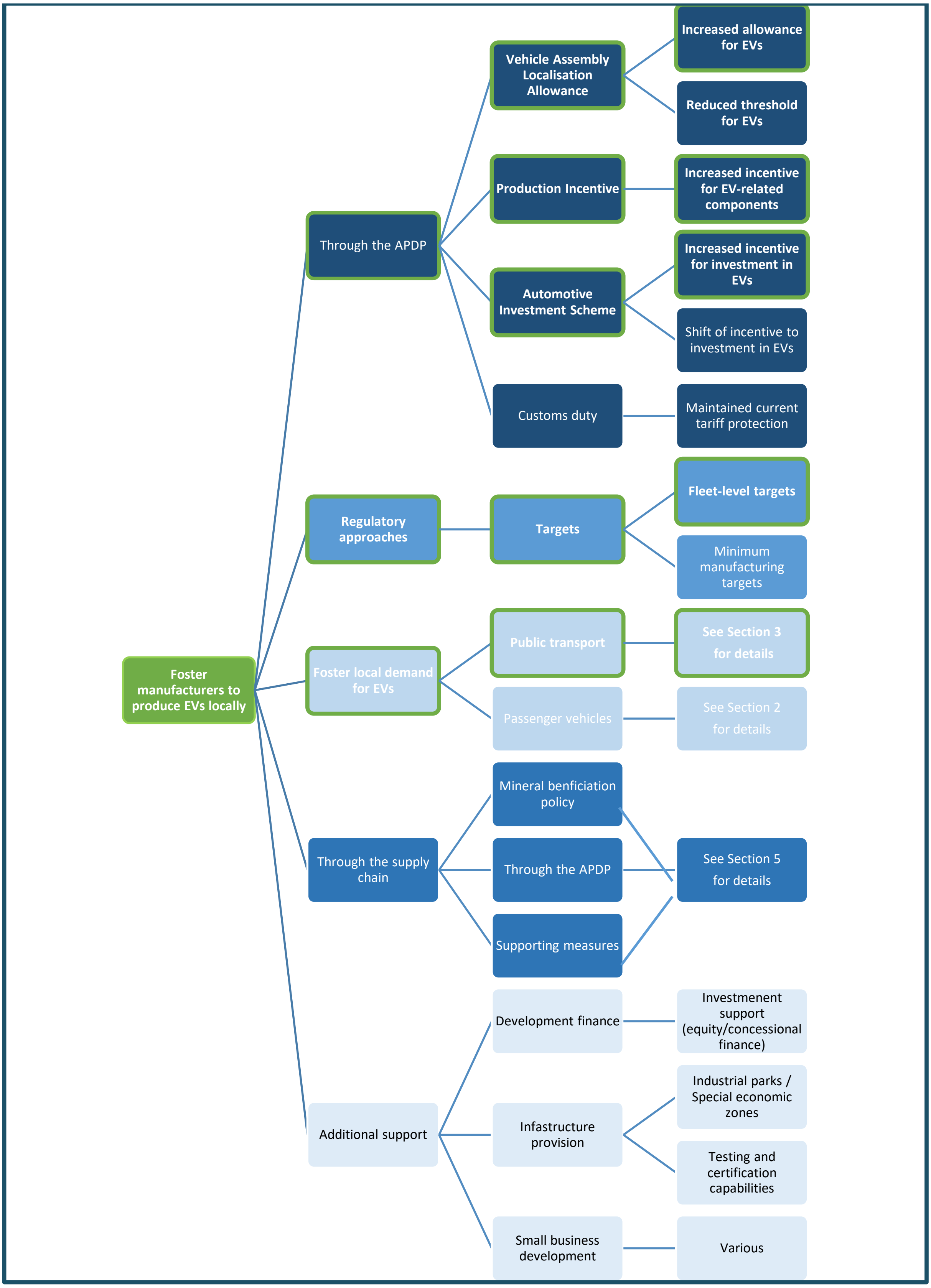
- Adjusting the current automotive support programme for EVs;
- Using regulations to set vehicle-related targets;
- Building a business case through the development of the EV supply chain; and/or
- Fostering local demand for EVs.

Realistically, in the short term, such measures are more targeted at OEMs already producing ICE vehicles in South Africa. As detailed below, some options are more potent than others. Channelling additional support through the APDP (through the VALA, PI and AIS), implementing fleet-level targets and fostering local demand for public transportation EVs emerge as the primary options for the near future.

A demand-led approach for passenger EV manufacturing would be viable only in the longer term. Other options, namely manufacturing-level targets, increased duty protection and a bottom-up approach through the value chain, do not appear viable in the foreseeable future.

Additional support, in the form of development finance, infrastructure provision and small business development assistance, could also be further provided, particularly to attract investment by new OEMs and entrepreneurs. Figure 37 summarises the universe of options and how they link to other sections.

Figure 37: Possible options to foster global manufacturers to produce EVs locally



Source: Authors

Note: primary interventions are circled in green and highlighted in bold text.

4.3.1. Using the APDP programme

The first and main avenue would be to channel support to EV manufacturing through the existing APDP programme. Given the recent review of the APDP and the implementation of revised mechanisms from 2021 (to 2035), the below discussion focuses on this new iteration of the programme, rather than the current phase ending in 2020. In line with the multi-faceted nature of the APDP, enhanced support for EVs could take different forms, as detailed in Table 24.

Table 24: Possible amendments to the APDP framework to incentivise EV manufacturing

APDP COMPONENTS	STANDARD CLAUSES (2021-2035)	POSSIBLE EV SPECIFIC CLAUSE
Customs duty	HEVs and PHEVs on par with ICE at 25% general tariff and 18% from the EU. BEVs on par with ICE at 25% general tariff except from the EU where BEVs receive higher protection (25% against 18%).	Maintained or increased tariff protection for EVs through higher custom duties.
VALA	Allowance set at 35% of local value add from 2026 (phasing down from 40% from 2021).	Increased allowance rate for EVs, *de facto* providing increased duty credits to EV manufacturers.[29] Possible sliding scale differentiating between EV technologies.
	Minimum threshold of 10 000 units per annum	Reduced threshold for EV.[30]
	Not applicable to buses.[31]	Inclusion of electric buses with a specific threshold.
PI	PI effective benefit factor set at 12.5% of value added.	Increased PI rate for EV-specific component through: - a dedicated list of products - amendment of the list of qualifying beneficiated raw materials
AIS	Non-taxable cash grant equivalent to 20% of the qualifying investment in productive assets (25% for component manufacturers and tooling companies).	Additional support (i.e. higher rate) for EV-related investments.

Source: Authors

Considering the four key components of the APDP as well as the array of EV technologies, several variants are possible. Indeed, different formulae can be envisaged, combining customs duties, the VALA, the PI and/or the AIS. In practice, only the incentive components of the APDP (i.e. the VALA, PI and AIS) could be tweaked in favour of EVs in the short term. Indeed, most stakeholders would resist any increase in tariff protection.

Similarly, any EV-specific clauses could treat all EV technologies equally or differentiate between BEVs, PHEVs, HEVs, FCEVs and other alternative vehicles. The nascent nature of the market would support an approach that does not discriminate between technologies. A more prescriptive approach is nevertheless possible, like in China where BEVs with larger range and higher energy efficiency and FCEVs with higher power ratings are privileged (IEA 2019).

[29] To be effective, such a measure would have to be coupled with the development of the local EV supply chain
[30] Such a measure would have no impact on existing manufacturers, which all already exceed the threshold.
[31] MBTs are already included in the APDP.

To provide a stronger incentive in favour of EV manufacturing, these options could be coupled with a broader shift of the APDP towards EVs. This could be done by reducing the support for the manufacturing of ICE vehicles and/or introducing ceilings for the support to ICE vehicle manufacturing. However, this would only appear possible in the medium to long term, in line with a broader review of the automotive policy support programmes and an initiated shift of the industry.

In addition, to support the development of regional value chains, clauses that allow for the cumulation of local content should be considered. Cumulation generally refers to rules of origin – the restrictions in trade agreements that define how much value a country must add to a product for that product to be said to have originated in that country. Cumulation of rules of origin allows for the value added by certain third countries to count as local value added. For example, a product that is made in South Africa, using components from Botswana, and exported to the EU could count a portion of those components as "locally-made", because all three are party to the SADC-EU EPA that allows for some cumulation of origin. The cumulation of local content would work in a similar way as it does for origin: a good would count as local whether it was produced in country or in a regional partner subject to the agreement (Wood 2017).

4.3.2. Implementing regulatory approaches

A second avenue to foster local EV manufacturing is to use regulatory approaches to introduce EV-related targets for OEMs. Targets can be introduced directly at the manufacturing level, as done in China (ICCT 2018),[32] or at the fleet level for each OEM, as done in the EU (IEA 2019).[33] In both cases, rewards (relaxed CO_2 targets in the case of the EU or ability to sell credits in the Chinese case) are granted to OEMs exceeding targets while failure to comply leads to sanctions (such as financial penalties or licensing/certification limitation).

Given the marginal nature of South Africa's vehicle manufacturing (22nd largest manufacturer with 0.7% of world production), enforcing manufacturing targets in South Africa without adequate planning and a renewed partnership with the automotive industry appears difficult and possibly counter-productive. Strict EV manufacturing targets may indeed lead to plant closures. As a result, it is not considered a viable intervention in the short to medium term.

Emissions targets at the fleet level, in line with the existing carbon tax on motor vehicles, would be possible, providing they are applied to all OEMs, both manufacturers and importers. Such emissions targets would have a positive impact on the rollout of EVs in the country. Whether they would have a positive impact on EV manufacturing domestically, however, depends on their design. Indeed, such fleet-level targets could result, particularly in the short term, in an increased import of EVs into the country.

[32] In 2018, China set a minimum requirement for the production of EVs (PHEVs, BEVs and FCEVs), with some flexibility offered through a credit trading mechanism that privileges BEVs with larger ranges and higher energy efficiency, and FCEVs with higher power ratings (IEA 2019).

[33] New EU fleet-wide CO_2 emission targets are set for the years 2025 and 2030, both for newly registered passenger cars and newly registered vans. These targets are defined as a percentage reduction from the 2021 starting points and are set by vehicle class. For passenger cars, they target a 15% reduction from 2025 onwards and a 37.5% reduction from 2030 onwards. The specific emission targets for manufacturers are based on the EU fleet-wide targets, taking into account the average test mass of a manufacturer's newly registered vehicles (European Commission 2020a).

Box 9: The EU's fleet-level targets

In order to contribute to the achievement of the EU's commitments under the Paris Agreement, reduce fuel consumption costs for consumers, strengthen the competitiveness of EU automotive industry and stimulate employment, the EU has implemented strict regulations that set mandatory emission reduction targets for new cars and vans (European Commission 2020a; 2020b).

New EU fleet-wide CO_2 emission targets are set for the years 2025 and 2030. These targets are defined as a percentage reduction from the 2021 starting points:

- 15% reduction from 2025 and 37.5% reduction from 2030 for cars; and
- 15% reduction from 2025 and 31% reduction from 2030 for vans.

Following a phasing from 2012, a target of 130 grams of CO_2 per kilometre applied for the EU fleet-wide average emission of new passenger cars between 2015 and 2019. This corresponds to a fuel consumption of around 5.6 l/100 km of petrol or 4.9 l/100 km of diesel. From 2021 (after a phasing from 2020, when the target only applies to each manufacturer's 95% least emitting cars), the EU fleet-wide average emission target for new cars will be 95 gCO2/km. This corresponds to a fuel consumption of around 4.1 l/100 km of petrol or 3.6 l/100 km of diesel.

Specific emission targets are included for manufacturers. The binding emission targets for manufacturers are set according to the average mass of their vehicles, using a limit value curve. This means that manufacturers of heavier cars are allowed higher emissions than manufacturers of lighter cars. The curve is set in such a way that the targets for the EU fleet-wide average emissions are achieved.

If the average CO_2 emissions of a manufacturer's fleet exceed its target in a given year, the manufacturer has to pay an excess emissions premium for each car registered. Until 2018, this premium amounted to €5 for the first g/km of exceedance; €15 for the second g/km; €25 for the third g/km; and €95 for each subsequent g/km. Since 2019, the penalty is €95 for each g/km of target exceedance.

To encourage eco-innovation, manufacturers can be granted emission credits for vehicles equipped with innovative technologies for which it is not possible to demonstrate the CO_2-reducing effects during the test procedure used for vehicle type approval. Such emission savings have to be demonstrated based on independently verified data. The maximum emission credits for these eco-innovations per manufacturer are 7 g/km per year. Manufacturers are given additional incentives to put on the market zero- and low-emission cars emitting less than 50 g/km through a "super-credits" system.

Manufacturers can also group together and act jointly to meet their emissions target. Manufacturers responsible for fewer than 300 000 new passenger cars registered in the EU in a given year may benefit from exemptions or derogations.

4.3.3. Pulling manufacturing through local demand

A third avenue to support the development of local EV manufacturing would be to increase demand for EVs domestically (and regionally through SADC), as discussed in Section 1. As shown in Figure 26, while exports dominates, 36% of locally-manufactured vehicles in 2019 were still sold on the domestic market. This non-negligible share of local sales is considered a key argument by OEMs, among other aspects, to produce specific models in South Africa.

The nature of the interplay between local demand and local manufacturing, however, varies between market segments. Increasing local demand is considered a primary intervention in the case of buses and minibuses but only a complementary measure in the case of passenger cars.

Indeed, in the case of buses and minibuses, a strong link exists. Local production virtually matches local demand for such vehicles in the country. The role of fleets in these two market segments furthermore reinforces the strength of the linkages, as the local manufacturing of buses and minibuses can be directly pegged to fleet procurement processes (by government entities, municipalities or taxi associations for instance).

In the case of passenger cars, the causal link between local demand and local manufacturing (and vice-versa) exists but is more tenuous. As such, while local demand undeniably plays a part, local manufacturing decisions, in terms of vehicle models, are determined by a mix of global and local demand dynamics. As shown in Table 23, leading OEMs in terms of market share have all set up local manufacturing operations. This is the case of the top four brands (accounting for about 60% of sales) as well as BMW and Mercedes-Benz, which lead on the premium market. However, as illustrated in Figure 26 and Figure 27, the passenger car market operates in a more globalised environment in which import-export dynamics play a much larger role. As a reminder, in 2019, 64% of locally produced vehicles were exported while 61% of locally-sold vehicles were imported.

In addition, local EV manufacturing would not necessarily generate a price advantage, particularly in the short term. This is particularly the case because of the inherent price premium attached to EVs. In addition, while duty protection would provide a source of price advantage to local manufacturers, other factors inherent to the local structure of production (such as nature of economies of scale; input costs, particularly batteries; and skills availability) could offset (in part or in full) such a benefit. As a result, on the passenger car market, local demand for EVs would have to be sizeable before it generates any impetus to produce vehicles locally.

4.3.4. Bottom-up approach

A fourth avenue, discussed in Section 5, would be to support EV manufacturing from the bottom up by developing the local supply chain. Leveraging the existing component industry as well as the availability of EV-relevant minerals in South Africa (PGMs, manganese, rare earths, zinc, nickel, fluorspar) and the region (such as lithium in Zimbabwe, copper in the Democratic Republic of the Congo (DRC) and Zambia, cobalt in DRC, nickel in Botswana, graphite in Namibia and Mozambique), the development of competitive components, such as batteries, electric drivetrains and fuel cells, could incentivise OEMs to manufacture EVs in the country.

It would be premised on the ability to supply adequate volume of minerals at below market prices. Policy options to achieve such an outcome as well as their impact on mineral beneficiation are discussed in Section 5. In short, a bottom-up approach would rely on either a developmental pricing policy, or the implementation of an export tax, to incentive the local beneficiation of minerals. This section focuses only on the possibility of such a strategy to spur the domestic manufacturing of motor vehicles (by opposition to components, discussed in Section 5).

On its own, such a strategy would rely entirely on harvesting a comparative advantage based on the availability of EV-related minerals. The logic would be that affordable mineral (mined by Tier 3 firms) would encourage their domestic beneficiation (by Tier 3 and Tier 2 firms) as well as their further transformation in intermediate products (by Tier 2 and Tier 1 firms), in turn incentivising OEMs to manufacture vehicles locally to benefit from cheaper inputs. With EV manufacturing, this approach centres on reducing the production costs of the BEV battery packs (i.e., in effect, the battery cells[34]) and/or fuel cells. It is less relevant for hybrid vehicles, in which the battery has a more marginal impact on the price.

Effectively, the merit of this strategy to foster EV manufacturing is limited in the short term. This is due to a variety of reasons:

- Building value chains takes time, even more so if the development of the value chain is based on activities, such as mining and refining, which require extensive licences and authorisations;
- Mineral refining is an energy-intensive activity which requires large amounts of affordable electricity to be viable. As shown in Box 11, South Africa has lost a large share of its mineral beneficiation activities in the last decade, largely as a result of fast-rising electricity prices;
- To maximise cost effectiveness, a strategy based on harnessing cost benefits from the value chain would ideally require mining, battery manufacturing, fuel cell catalyst and membrane
- MEA manufacturing, vehicle manufacturing (particularly BEVs, due to the weight of battery packs) and vehicle sales to be located close to each other.
- As shown in Figure 43 in Section 5, the price sensitivity of battery packs varies depending on minerals but is overall limited. Significant variation in the price of minerals is required to trigger meaningful changes in the cost of battery cells. This is particularly the case for manganese, the principal mineral used in battery production.

Given the overarching role of the APDP in driving the development of the value chain, such a bottom-up approach would appear to be only viable if complementing the existing support programme (in its current or a revised form) as far as vehicle manufacturing is concerned. This is particularly evident in the short term. A different picture could, however, emerge in the case of component manufacturing, as discussed in Section 5, where a bottom-up approach could be harnessed to foster local production. In the medium term, an established EV component industry could then be leveraged to strengthen the case for EV manufacturing in South Africa.

4.3.5. Additional measures

In addition to these four avenues, enhanced support could be channelled towards EV manufacturing through existing mechanisms, such as development finance and infrastructure provision. The launch in 2019 of the Tshwane Automotive Hub in Silverton, Pretoria, part of the expansion of the OR Tambo International Airport Special Economic Zone, is an example of the additional industrial policy support (i.e. over and above the APDP) aimed at the automotive industry. Linked to development finance (such as the funding provided by the IDC), it could be harnessed (as is or by providing enhanced benefits for EV production) to incentivise existing and new manufacturers to set up EV manufacturing in the country. Within this context, a broader suite of industrial policy tools would also be available to prospective investors, such as the R&D tax incentive.

Besides large-scale, global OEMs, the development of local EV manufacturers could be fostered through domestic entrepreneurial ventures. While such initiatives are more likely to target specific and/or niche markets, such MBTs, light commercial vehicles for businesses or small last-mile public

[34] According to BNEF (2019), cells account for 60% of the final price (US$ 147/kWh) of a 100kWh NMC (662) BEV pack. Other cost factors are pack components (18%), pack manufacturing (4%), research and marketing (2%), logistics, tax and other (1%), and margin (15%).

transport vehicles, than mass-market passenger vehicles, their potential has yet to be realised. As raised, multiple illustrations of such initiatives already exist in the country.

Unlocking the potential of entrepreneurs requires a different approach than for global OEMs. Such an endeavour would tap into an array of (small) business development initiatives, ranging from access to capital, financial assistance, skills development, market access and preferential procurement. The development of adequate testing capabilities, for local and international certification, would also foster local entrepreneurship in the manufacturing sector. Sector-specific interventions, in partnership with existing OEMs, could also support the growth of local entrepreneurs, particularly to develop niche markets.

4.4. Exploring the socio-economic costs and benefits of key options

Building the universe of possible interventions available to support the development of local EV manufacturing in South Africa, this section zones in on three key options:

- Enhancing the APDP for EV manufacturing;
- Setting up fleet-level target; and
- Fostering local demand for public transport vehicles.

For each considered intervention, implementation requirements, costs and benefits are reviewed with the aim of providing an understanding of the viability of various options from a technical, socio-economic and political perspective.

4.4.1. Enhancing the APDP for EV manufacturing

The APDP framework is the main avenue through which the automotive value chain in South Africa is supported. It is in itself technology neutral. Neither does it penalise EV manufacturing, nor does it incentivise it (compared to ICE vehicle manufacturing). Although there is no guarantee that additional support would trigger manufacturing, changing this situation in favour of EV would provide a preferential environment for the local production of EVs. The current APDP framework and its next iteration (from 2021 to 2035) have already been defined and approved by all stakeholders, limiting the possibility of widespread change in the short term. There is, however, room for it to evolve over time under the leadership of the dti.

The easiest option to implement would be to develop additional and/or specific rules (and incentives) for EV-related production, leaving everything else unchanged. As raised, this appears as the most appropriate option in the short term. In the long run, consideration could, however, be given to altering the programme as a whole in order to reduce the support for ICE vehicle manufacturing and increase the support for EV manufacturing. This would provide a much stronger incentive in favour of EV manufacturing.

As indicated, by combining the four elements of the APDP, a variety of options are possible. While it is impossible to review each possible variant in detail, the implications of key choices are highlighted below. Table 25 details the key implementation requirements, expected benefits, and expected costs for key stakeholders including additional support for EVs in the APDP. Implementation requirements are relatively low, given that the APDP structure is already in place. Implementation costs remain highly dependent on the design and extent to which they are used by respective OEMs, but additional costs would most likely be minimal compared to the overall costs of the programme. Over time, additional costs could furthermore be offset by shifting the support from ICE vehicles to EVs. The main benefits would be reaped by manufacturers which would receive enhanced government support to manufacture EVs. This is expected to trickle down to consumers through lower EV purchasing costs (compared to imported units). Short- to medium-term costs associated with the additional support would essentially be borne by government and, indirectly, by society at large. In the long run, co-benefits linked to the rollout of e-mobility are, however, forecast to exceed short-term costs.[35]

Table 25: Socio-economic implications of including additional support for EVs in the APDP

STAKEHOLDERS	IMPLEMENTATION REQUIREMENTS	EXPECTED BENEFITS	EXPECTED COSTS
OEMs (manufacturers)	Negotiation of additional benefit for EV manufacturing Investment in EV manufacturing domestically.	Increased support for local EV manufacturing. Increased price differential between locally manufactured and imported vehicles.	None in the short to medium term. In the long run, increased EV support may be conditioned to reduced support for ICE vehicle manufacturing. Higher cost of EV import in case of tariff protection.
OEMs (importers)	None	None	No direct cost. Indirectly, importers would be penalised compared to local manufacturers. Higher cost of EV import in case of tariff protection.
Automotive value chain	Negotiation of additional benefit for EV manufacturing Investment in EV manufacturing domestically.	Increased support and demand for EV-specific components.	None
Middle- to high-income households	None	Reduced price of EV produced domestically (compared to imported EVs).	No direct cost. Increased price differential between imported and locally made vehicles. Indirectly, increased support to automotive manufacturing industry would divert government resources from other priorities (opportunity cost).
Low-income households	None	Reduced price of public transportation if cost savings are passed through to customers.	No direct cost. Indirectly, increased support to automotive manufacturing industry would divert government resources from other priorities (opportunity cost).
Government	Negotiation of additional benefit for EV manufacturing Additional financial resources.	Increased long-term sustainability of the local automotive industry.	Increased financial requirements associated with the APDP (possibly cost neutral if support for ICE is reduced accordingly). Increased support could artificially support inefficient firms.

Source: Authors

Given the above costs and benefits, providing enhanced assistance to EV manufacturers is widely supported but does not garner unanimous support from stakeholders. Table 26 lists the main arguments for and against it. Ultimately, key arguments reflect the ideological fault lines between

[35] See Dane, Wright, and Montmasson-Clair (2019) for a discussion on macroeconomic impacts.

stakeholders on whether additional support is: a) required and justified (i.e. could the investment happen without it?); b) fair and equitable (i.e. can and should the cost bearers subsidise the beneficiaries?) and c) effective and efficient (i.e. will the support trigger investments? And do the costs outweigh the benefits in the long term?).

Table 26: Principal arguments for and against enhancing support to EV manufacturers

FOR	AGAINST
- Additional support would help attract EV manufacturing in the country. - Additional support could underpin the development of a complete EV value chain in the country. - Electric buses are not included in the VALA component despite the potential for local manufacturing. This would rectify this anomaly.	- The current APDP framework is technology neutral and should not interfere with technological and market dynamics. - The current APDP framework is sufficient to support local manufacturing of motor vehicles as exemplified by the vibrant automotive manufacturing industry in the country. - The current APDP framework already supports the automotive industry extensively and EVs should not be an avenue to further increase this support.

Source: Authors

4.4.2. Setting fleet-level targets

In addition to, or rather than, providing supplementary support to the industry to produce EVs locally, fleet-level targets could be put in place.[36]

Fleet-level regulatory measures, provided they can be enforced, have the advantage of fast-tracking changes. They also provide policy certainty to the sector by setting the rules of the game and sending clear signals to the market. If, in line with global average trends, such fleet-level targets could have minimal drawbacks and ensure that South Africa stays (at least) on par with worldwide dynamics. Fleet-level targets also have the advantage of covering all companies active in the country, rather than only focusing on local manufacturers.

However, from a manufacturing promotion perspective, targets at the fleet level (generally measured in terms of CO_2 emissions per kilometre) are less constraining than manufacturing targets as they aim to shift the sales of vehicles, irrespective of their production location. Such measures also carry non-negligible risks. Regulatory measures put the onus on the state to: a) design adequate and realistic targets; b) provide the necessary, overall ecosystem for their implementation; and c) enforce compliance. Targets that would be too low and/or unenforceable would be essentially moot. Targets that would be too high could have damaging impacts on the industry. If done at the expense of ICE vehicles, setting fleet-level targets to produce EVs locally could furthermore negatively affect exports to the rest of the continent, which is seen by industry as a future market for ICE vehicles manufactured in South Africa.

Overall, in the absence of additional EV manufacturing support as well as a level playing field for the import of EVs into the country, fleet-level targets (as for other regulatory measures) would likely be opposed by industry. While this risk could be mitigated by negotiating a renewed partnership with

[36] As raised in Section 4.3, regulatory measures could take the form of targets, either at the manufacturing and/or fleet levels, as done respectively in China and the EU. However, given the second-tier position (22nd) of South Africa's automotive manufacturing worldwide, regulatory measures forcing the local production of EVs could have counter-productive impacts and lead to the closure of existing factories. As a result, only fleet-level targets are considered.

industry around specific support programmes for EV manufacturing, this could be a lengthy process and detract the attention from the initial objective.

Table 27 details the implementation requirements, expected benefits and expected costs for key stakeholders of implementing fleet-level targets in favour of EVs. Implementation requirements are relatively low but require adequate institutional capacity to be monitored and enforced. Costs to the industry would depend on the stringency of the targets but could be limited if designed appropriately. From a government perspective, costs would be limited, besides monitoring and enforcement mechanisms. Targeted support to industry may nevertheless be required to ease implementation. Benefits would be widespread in the long run although they would remain uncertain in terms of manufacturing capacity.

Table 27: Socio-economic implications of implementing fleet-level targets in favour of EVs

STAKEHOLDERS	IMPLEMENTATION REQUIREMENTS	EXPECTED BENEFITS	EXPECTED COSTS
OEMs (manufacturers)	Negotiate targets with government. Negotiate renewed partnership and support programme Negotiate level playing field for imports.	Increased support programme for EV manufacturing. Level playing field for the import of EVs.	Comply with target to avoid penalties.
OEMs (importers)	Negotiate targets with government. Negotiate level playing field for imports.	Level playing field for the import of EVs.	Comply with target to avoid penalties.
Middle- to high-income households	None	Improved EV offer Lower cost of EVs.	No direct cos.t Indirectly, increased support to automotive manufacturing industry would divert government resources from other priorities.
Low-income households	None	Reduced price of public transportation (buses and minibuses) if cost savings are passed through to customers.	No direct cost. Indirectly, increased support to automotive manufacturing industry would divert government resources from other priorities.
Government	Negotiate targets with industry. Negotiate renewed partnership and support programme Require strong institutional capacity.	Allow to send strong signal to the market through ambitious targets.	Risks of reduced revenues (due to lower sales) if targets cannot be met. Implementation may require support measures.

Source: Authors

Echoing the costs and benefits highlighted in Table 27, arguments for or against fleet-level targets are split on the ability of the state to design and implement such measures effectively. In addition, fleet-level targets would be more effective in terms of market development than manufacturing transition.

Table 28: Principal arguments for and against fleet-level targets

FOR	AGAINST
- Targets are inexpensive to implement on their own. - They provide policy certainty. - They send a strong signal to the market (through ambitious targets). - They cover both manufacturers and importers. - They lead to systemic implementation across different sectors, with wide-ranging benefits to energy and mining sectors.	- Regulatory measures rely heavily on the capacity of the state to design and implement targets. - Targets at the fleet level run the risk of not delivering benefits at the manufacturing level and spur imports of EVs. - A renewed partnership with industry and additional support mechanisms would be required to be effectively implemented.

Source: Authors

4.4.3. Fostering local demand for EVs

Another avenue to foster local EV manufacturing is to push an increase in local (and regional) demand. As discussed, such a strategy would be more effective for public transport vehicles than for passenger cars. As a result, fostering local demand for EVs is only seen as a core measure in the case of buses and MBTs. In the short to medium term, until demand for EV becomes sizeable, it is considered a supporting measure in the case of passenger cars.

Section 3 discusses the various options available to foster local demand for electric public transport vehicles. As a reminder, principal interventions are: changing the VAT and/or ad valorem excise duty; promoting the deployment of e-MBTs through the TRP; facilitating access to a preferential interest rate for e-bus and e-MBT finance; and public procurement.

Irrespective of the policy options selected to support the demand for e-buses and e-minibus taxis, this section focuses only on the costs and benefits of using a demand-led approach to drive local manufacturing. For a detailed discussion of the costs and benefits of various options, see Section 3.

Due to the strong interconnection between the domestic demand and the domestic manufacturing of public transport vehicles in South Africa, a demand-led approach could be effective in driving local production. The Cape Town experience furthermore shows, despite the challenges encountered, that such an approach is implementable even with small volumes (11 units in this case).

Such an approach would be coherent with the existing demand-supply dynamics in the sector in South Africa. Any other approach aimed at driving local manufacturing of public transport vehicles would likely be unsuccessful in the absence of key anchor clients.

In addition, it provides the opportunity to ensure that local EV manufacturing develops in line with local demand requirements and specificities. Given that the local industry already supplies domestic requirements, a demand-led approach would build on existing strengths and knowledge. In the case of public procurement (which would account for the vast majority of demand), local content requirements would furthermore maximise the development of local capabilities through the supply chain. If structured around large fleet orders (such as the BRTs, the Gautrain buses or the TRP), economies of scale would also lead to cost reduction per unit.

Risks associated with a demand-led approach in the public transport segment are limited but not inexistent. As exemplified with the City of Cape Town experience, adequate design (including selecting the appropriate technology) and implementation of the procurement processes is required to ensure that vehicles meet local conditions and requirements.

Such a demand-led approach, however, requires local buyers to show leadership and adopt a proactive attitude for the rollout of e-mobility in the country's public transport system. As of March 2020, only the City of Cape Town has shown active leadership in this respect.[37]

Table 29 details the implementation requirements as well as the costs and benefits for various stakeholders. Implementation requirements are relatively high as this approach requires all stakeholders to agree on a common platform. It also puts the onus on government, notably municipalities, to drive demand through procurement processes and a reform of the TRP. Over time, society-wide benefits are expected to materially outweigh short-term costs linked to implementation. A gradual approach in terms of rollout would also help mitigate any shortcomings.

Table 29: Socio-economic implications of using a demand-led approach to support EV manufacturing of public transport vehicles

STAKEHOLDERS	IMPLEMENTATION REQUIREMENTS	EXPECTED BENEFITS	EXPECTED COSTS
OEMs (manufacturers)	Negotiation around technical requirements, including local content, and pricing.	Demand certainty Economies of scale.	Development of new models for the local market. Development of leading edge in e-mobility technologies.
OEMs (importers)	None	None	Reduced likelihood of servicing the local market.
Public transport sector	Negotiation around technical requirements, including local content, and pricing.	Positions the sector as a leader in the field. Cost saving over the lifetime of vehicles.	Risk associated with new technologies/models. Higher upfront cost of procurement.
Middle- to high-income households	None	Access to more affordable and healthier public transport.	None
Low-income households	None	Access to more affordable and healthier public transport	None
National government	Design and implement public procurement. Negotiation around the TRP incentive. Negotiation around technical requirements, including local content, and pricing.	Maintained / increased localisation in the bus / minibus taxi industry. Lower cost of public transport in the long run.	Financial cost of TRP Risk associated with new technologies/models. Higher upfront cost of procurement. Support to infrastructure development.
Municipalities	Design and implement public procurement.	Healthier air quality. Lower cost of public transport in the long run.	Higher upfront cost Experimentation with new technologies. Infrastructure development.

Source: Authors

In line with the cost-benefit analysis above, key arguments highlight the coherence and long-term relevance of this proposal. While it is not without risks, a demand-led strategy around public transport EV manufacturing shows many strengths.

[37] Others have piloted alternative technologies. The City of Johannesburg in collaboration with the taxi industry has experimented with the rollout of gas-based minibus taxis. The City of Tshwane has also rolled out gas-based buses in its BRT system.

Table 30: Principal arguments for and against enhancing support to EV manufacturers

FOR	AGAINST
- It is coherent with the current supply-demand dynamics in this market segment and appears as the only viable option to drive local manufacturing. - Local manufacturers already manufacture for the domestic market and understand the local context and requirement. - It would build on a robust, existing manufacturing industry. - It would drive the transition of the local manufacturing industry to e-mobility and set it as a strong contender in these market segments - It would ensure that the rollout of EVs in the public transport system uses locally manufactured vehicles (rather than imported vehicles).	- As with all new technologies, pioneers carry a higher investment risk than followers. - A demand-led approach relies on the ability to design and implement adequate public procurement.

Source: Authors

4.4.4. Complementary interventions

In addition to the principal interventions discussed above, a series of complementary measures could be implemented to support one or / and more primary options. Additional measures essentially pertain to the development of new EV manufacturing capabilities by local entrepreneurs (although they could also be used to support a value proposition for global markets not yet manufacturing in South Africa). They encompass support measures ranging from small business development support, to infrastructure provision, to development finance. All such interventions would be economy-wide and none would be automotive specific. As such, it is difficult to understand their implementation requirements, costs and benefits from an EV-specific lens.

4.5. Policy implications

In conclusion, the development of local EV manufacturing in South Africa hinges on implementing one or more of three key strategies:

- Enhancing the APDP to set a favourable environment for EV manufacturing investment by OEMs;
- Implementing fleet-level targets to trigger market changes; and
- Stimulating demand for EVs, most notably public transport vehicles in the short term.

Importantly, these three avenues are not mutually exclusive. In contrast, they would reinforce each other. They, however, differ in their structure. Using the APDP has the advantage of leveraging an existing, tried-and-tested mechanism but requires government to carry the costs of incentivising OEMs' investment. An approach driven by the APDP would furthermore focus mainly on passenger cars. Fleet-level targets are virtually cost-less to government and put the onus on OEMs to introduce EVs into the market. Such a new regulatory measure would likely be politically controversial and is not guaranteed to trigger local EV manufacturing (targets could be met through imports). Adopting a demand-led approach would be impactful for public transport vehicles only, where the link between local supply and demand is strong. It does require local stakeholders (essentially, the state as well as the MBT industry) to carry some of the risks associated with the rollout of new vehicles. In the case of passenger cars, such a strategy would be viable only in the long term once demand reaches critical levels.

In sum, developing the manufacturing of e-buses and e-minibuses emerges as the primary port of call in the South African case. It would build on an existing manufacturing industry, be consistent with the current structure of the market (in which local supply and local production are linked) and leverage the close-knit nature of the sector. It also has the added advantage of supporting an inclusive rollout of EVs in the country through public transportation.

This would, however, require a strong partnership between various spheres of government (particularly municipalities and the dti), the private bus and MBT industry, and OEMs in order to: a) design vehicles to meet local requirements and specifications; b) organise the rollout of EVs (and associated infrastructure) into the public and private fleets of buses and MBTs; and c) initiate the local manufacturing of vehicles. Municipalities would be instrumental in designing local specifications and procuring buses for BRTs and other municipal fleets. National government could also drive some of the demand and would primarily shape, through the dti and the Department of Transport (DoT), local content targets as well as the support for e-minibuses through the TRP. The private sector, most notably the MBT industry, would be a crucial stakeholder to design vehicles fit for purpose.

Developing the local manufacturing of electric passenger cars could occur in parallel but is likely to require a longer timeframe. While shifting production to EVs is a requirement in the long term, globally, absolute demand for ICE vehicles is also not forecast to decrease in the short term, limiting the incentive to shift production early.

As already noted, EV manufacturing remains heavily driven by local demand as well as the home location of OEMs. As far as South African demand for EVs remains marginal, little impetus exists to develop local manufacturing. This is particularly evident for entry- and mid-level models, which require higher volumes. Moreover, local manufacturing does not, in the short term, generate benefits in terms of domestic market demand for EVs, essentially due to the price premium associated with such vehicles, and is unlikely to spur strong demand. In addition, measures to support domestic EV adoption and local EV manufacturing may, in some cases, not be fully aligned. Indeed, measures which would support market development may not lead to EV manufacturing (such as fleet-level targets) or could even have negative impacts on local manufacturing (in the case of preferential tariff reductions).

The development of local passenger EVs appears tied to a strong growth in the local demand of EVs and/or material incentives and support towards EV production. Given this timeframe, an opportunity exists to develop a specific EV support package as part of the APDP. It would help build capacity and expertise as well as ensure that the policy framework is in place when EV manufacturing is ready to take off in South Africa.

5. HOW CAN THE MANUFACTURING OF EV COMPONENTS BE SUPPORTED IN SOUTH AFRICA?

Embracing technological change in South Africa's components industry requires crucial stakeholders, such as the government, industry bodies and OEMs, to improve the support offered to locally-based component suppliers, to co-create and collaborate to further the local manufacturing of EV components. Investment in domestic R&D and manufacturing capabilities in the components industry would have to be prioritised to strengthen the value chain through improving market conditions for new and existing component suppliers, and develop a supportive policy framework aimed at improving the competitiveness of the industry relative to its emerging market competitors. This would require developing strong linkages along the value chain for component manufactures and OEMs, while also advancing the competitive position of the local automotive industry.

5.1. Problem statement

The local components industry plays a crucial role in South Africa's automotive industry. The industry is a large employment multiplier and employs directly about 80 000 workers[38] (Lamprecht, 2020). But the components industry in South Africa is heavily linked to the ICE value chain. Without change, the shift to EVs would, over time, result in fewer workers employed in component manufacturing and assembly as OEMs buy more electric powertrains and batteries, and lower their demand for ICE component parts. Looking ahead, OEMs would either continue to work with the same suppliers if they evolve and innovate or find new suppliers specialised in manufacturing EV components — or a combination of both. The long-term sustainability of component suppliers therefore relies on their ability to cope with ongoing investment and cost pressures combined with the threat of technological substitution of their current product offerings.

Most locally based OEMs source their products externally rather than employing the services of local manufacturers (Monaco et al, 2019). This raises particular concerns regarding localisation. Current local content levels are very low (below 40%) relative to Thailand and Turkey, where local content levels are substantially higher (Barnes et al, 2018). Accordingly, a 60% local content target is outlined in the South African Automotive Masterplan for 2035, in line with South Africa's emerging market competitors. This would call on component suppliers to play a pivotal role to ensure an understanding of standards and requirements suitable for OEMs and the resources needed to support them (Barnes et al, 2018).

Import expansion of EV components could threaten the viability of local manufacturers, not only by eroding their domestic market share, but also by limiting their capacity to take advantage of new export opportunities. However, currently, the domestic market limitations impede the ability for the components industry to achieve sufficient economies of scale, and the industry also lacks sufficient R&D investment needed to enable localisation growth and competitiveness. A radical shift in developing value-add through new product specifications and offerings is vital for the survival of local component manufacturers.

As the success of the local components industry is heavily dependent on the strategies of OEMs, locally manufactured EV components in South Africa would require OEMs and Tier 1 suppliers to commit to long-term relationships with existing lower-tier suppliers, and increase localisation to help better

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[38] Workers in the components industry include part-time and temporary workers.

develop the value chain. Increasing localisation tends to be closely linked with the challenge of promoting inclusive transformation of the industry among lower-tier suppliers, however, progress has been slow.

Joint-ventures and wholly-foreign-owned Tier 1 suppliers are better integrated into global value chains (GVCs). Most Tier 1 suppliers have had success in keeping up with changing skills and capabilities. Lower-tier suppliers servicing both the EV and ICE markets are likely to escape the unfolding technological disruption and remain unaffected, however, they would still need to build new competitive platforms and technological competences. Locally based lower-tier suppliers have made significant gains in productivity, quality and operational-competitiveness, but unfortunately still struggle to close the gap on emerging market competitors, and could be hit hard by these technological shifts. Furthermore, the relatively small domestic industry is constrained by a slowdown in economic growth, increasing costs, including production and logistics, and insufficient economies of scale. This means that South Africa experiences cost disadvantages in respect of component manufacturing and exports.

Manufacturing EV components locally requires a strong local supplier base to effectively provide competitive components to its customers. This section focuses on contextualising South Africa’s components industry, while also looking at existing opportunities for new EV component manufacturing, particularly Membrane Electrode Assembly (MEA) component manufacturing for fuel-cell electric vehicles (FCEVs), and the manufacturing and assembly for LIBs, a key component necessary to make local assembly of BEVs and PHEVs viable, and how South Africa can ensure support for local manufacturing.

5.2. Context

5.2.1. The value chains – electric vs combustion

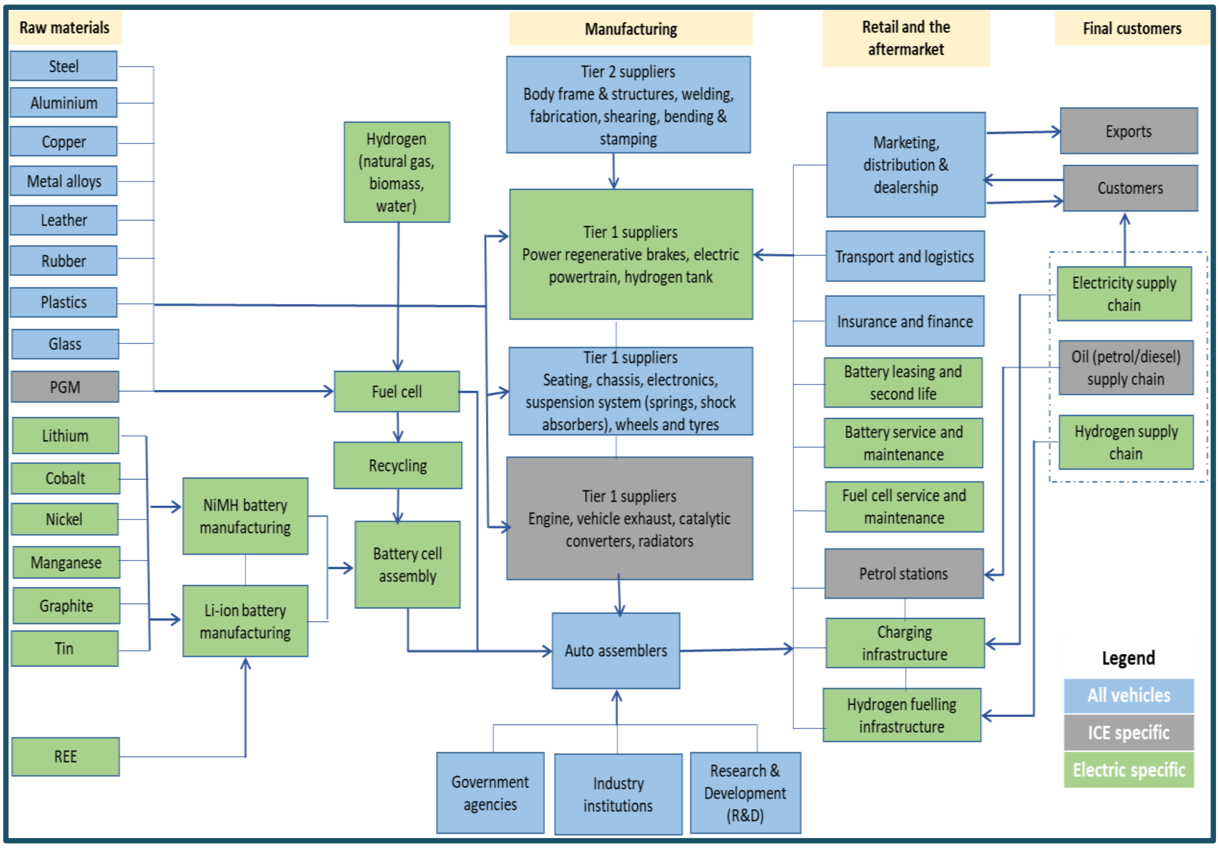
The value chain in Figure 38 shows a comparison of the automotive value chains based on ICE and electric drivetrains. EVs have several unique components, namely the battery and electric powertrain, but they also have many similar components common in an ICE vehicle. With the growing EV demand worldwide, the production of electric motors, batteries, wiring harnesses and inverters is set to get a boost, while the impact on the demand for steering systems, shock absorbers and seats, supplied by both Tier 1 and 2 suppliers, would likely remain unaffected. However, because engine parts, radiators and catalytic converters are replaced in BEVs and FCEVs, these ICE-specific components should experience the most negative impact by the uptake of EVs.

The most striking difference between full EVs (BEV and FCEV) and ICE vehicles, However, is their fuel source. PHEVs and HEVs are powered by a combination of gasoline, diesel, or even biofuels and a battery, while BEVs run solely on fully rechargeable batteries, and FCEVs use compressed hydrogen gas as fuel to generate electric power using a fuel cell stack (Alternative Fuels Data Centre, 2018).

Component manufacturers use steel, aluminium, copper, plastics and other precious metals to produce traditional ICE components, however, in the case of EVs, due to their lightweight design, aluminium is expected to contribute more to production than steel, especially in heavy passenger vehicles (Aluminium Insider, 2019). EV batteries are made with REE, such as neodymium, praseodymium and samarium. These are essential metals used in the application of permanent magnets in EVs.

Overall, significant changes are expected in component manufacturers' portfolios with existing powertrain-related suppliers scheduled to lose market share, while new opportunities would emerge in EV parts, such as battery, electric powertrains and fuel cells. The advent of large-scale EV production is expected to change the tiered nature of suppliers in the value chain as existing suppliers are required to upscale on their technological capacity while new entrants emerge. Electrification and the rollout of EVs will disrupt the normal flow of components and materials within the value chain. In addition, BEVs and FCEVs are zero-emission vehicles with simpler component parts requiring fewer replacement parts and lower maintenance costs than vehicles with an ICE (including HEV and PHEV). However, because EVs include a large portion of HEVs and PHEVs, this means the ICE value chain will remain relevant for the foreseeable future. The nature of EV production could present an opportunity for new entrants and for existing firms to create highly innovative and competitive products within the e-mobility ecosystem. Although EVs do not yet have fully developed global value chain linkages, their production has a number of advantages that may contribute to the development of a more strengthened GVC system.

Figure 38: The automotive value chain: EV and ICE vehicles



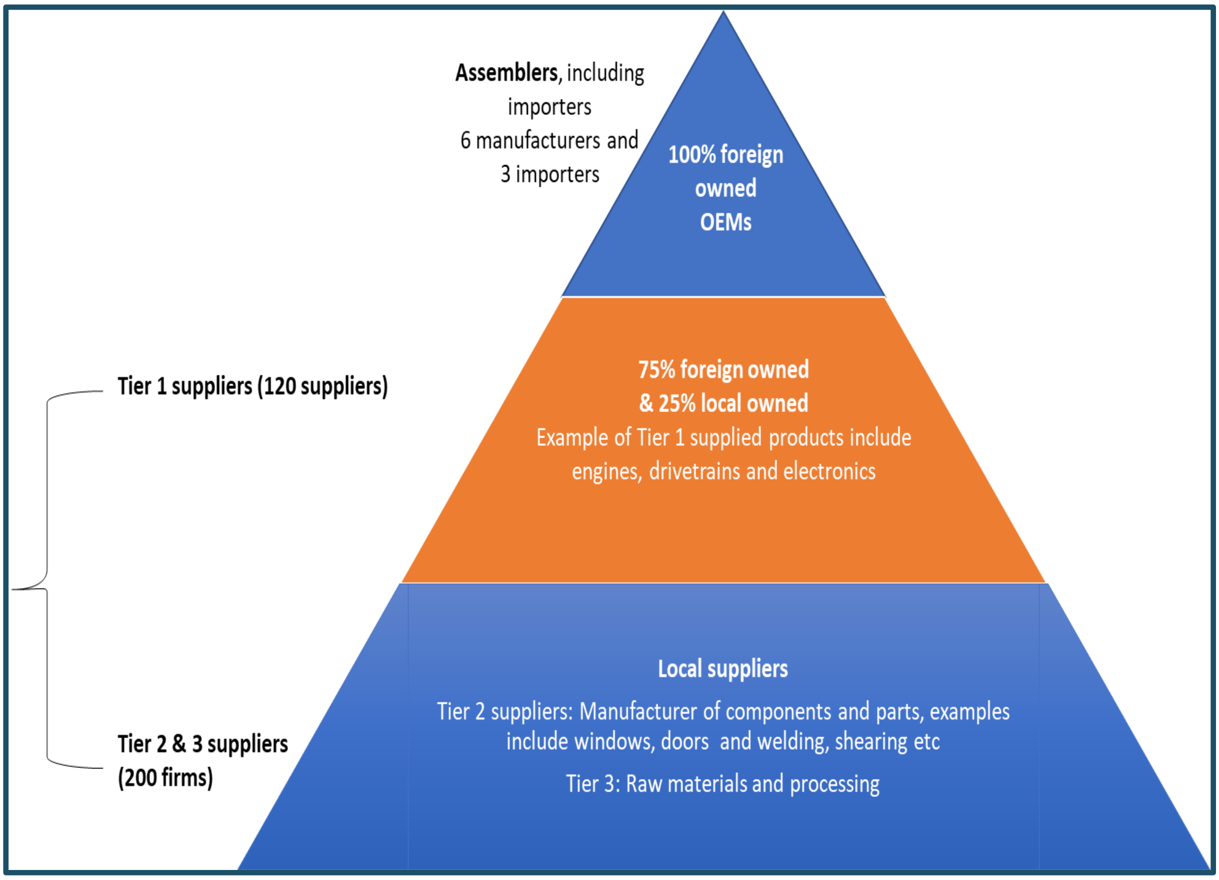
Source: Authors

5.2.2. The components industry

Based on the AIEC manual (2020), there are approximately 120 Tier 1 suppliers and over 200 Tier 2 and Tier 3 suppliers in South Africa. Figure 39 shows the manufacturing value chain structure in the local automotive industry. Tier 1 suppliers are integrated globally. Lamprecht (2020) states that 75% of Tier 1 component suppliers based in South Africa are foreign-owned with these firms contributing to about 80% of the components industry's total domestic and export sales. Many Tier 2 and Tier 3 suppliers are not predominantly automotive focused; however, the automotive industry does account for a portion of their base (Monaco et al, 2019; Comrie et al, 2013). In addition to this, Tier 2 and Tier 3 suppliers operate in a regional or local environment. Tier 2 suppliers are typically South African owned suppliers classified as a Small, Medium and Micro Enterprise (SMMEs). They provide materials and component parts to Tier 1 suppliers, however, sometimes they also supply to OEMs. The mining industry remains influential in the South African automotive value chain. Tier 3 suppliers, i.e. mining companies, have strong forward linkages with the automotive industry, supplying mineral products necessary for the manufacturing of vehicles, components (such as PGMs for catalytic converters) and accessories.

As previously highlighted, South Africa lacks a well-developed and competitive Tier 2 supplier base specialising in high value-add in automotive parts and components. The local industry consists of few Tier 2 suppliers, mainly a result of weak infrastructure, limited R&D and innovation capacity by suppliers, as well as inadequate financial and managerial capabilities to expand and compete on a global scale.

Figure 39: Structure of the South African automotive value chain



Source: Authors

The South African components industry is supported by the APDP policy framework (see Box 8 and Box 10) The priority for the local components industry lies in deepening local content and strengthening value chain linkages to move the industry forward and improve the industry's manufacturing competitiveness levels.

Box 10: Summary of the policy support for the components industry

Local content on vehicles manufactured in South Africa is below 40%, with the contraction most evident among Tier 2 and 3 suppliers (Barnes et al, 2018). Furthermore, the low and decreasing local content levels remains distressing for the local automotive industry. This has, in turn, led to deteriorating employment in the components industry. The South African Automotive Masterplan for 2035 and the APDP both emphasise that the importance of improving, particularly for the local automotive industry, as localisation efforts drive employment and skills development.

With regard to increasing local content and the competitiveness of the components industry, Black et al, (2018) notes the Motor Industry Development Programme (MIDP) reduced support for the local component industry by removing local content requirements and reducing import duties for components, leaving the industry exposed to international competition. This forced many local firms to shut down. The APDP in its first iteration failed to take this into account, hence local content levels have remained unimpressive. The second phase of the APDP, from 2021, attempts to address some of these concerns.

As previously highlighted in Box 8, under the current APDP, component manufacturers are supported through the framework's four key pillars:

1. Customs duties on imported components stand at 20%;
2. The VAA is a rebate mechanism for OEMs based on sale value of CBU vehicles. Rather than focusing on local value addition, OEMs were able to earn greater rebates by exporting high value CBUs comprising predominantly of imported components – increasing volume production negated the importance of value addition and local sourcing (Black et al, 2018). The replacement of the VAA in 2021, with a VALA based solely on local value, is expected to drive greater localisation, compelling OEMs and Tier 1 suppliers to source locally (Deloitte, 2018). Such efforts are expected to benefit the growth of the local components industry.
3. The PI benefit is to increase to 12.5% for components in 2021 from the current 10%. The objective of the PI is to increase localisation and economic activity of OEMs and component suppliers in the value chain, but this has not materialised, particularly for components.
4. The AIS, a cash grant for qualifying capital investment, starting at 25% for component manufacturers. The AIS promotes investment, value-add and R&D for qualifying component manufactures and tooling companies. The expansion in investment in the components industry has been modest despite the APDP policy offering significant investment incentives in the form of the AIS. Under the AIS, the achievement of increased R&D and value-add beyond metal pressings, harnesses and plastic moulded products did not happen.

Overall, there is currently no policy support specific for EV component manufacturing available in South Africa. However, the second phase of the APDP (from 2021 to 2035) could introduce a range of policy instruments for deepening capabilities in EV product specialisation for components and promoting the local manufacturing of EV components using the PI, VALA and AIS.

5.2.3. Component imports and exports

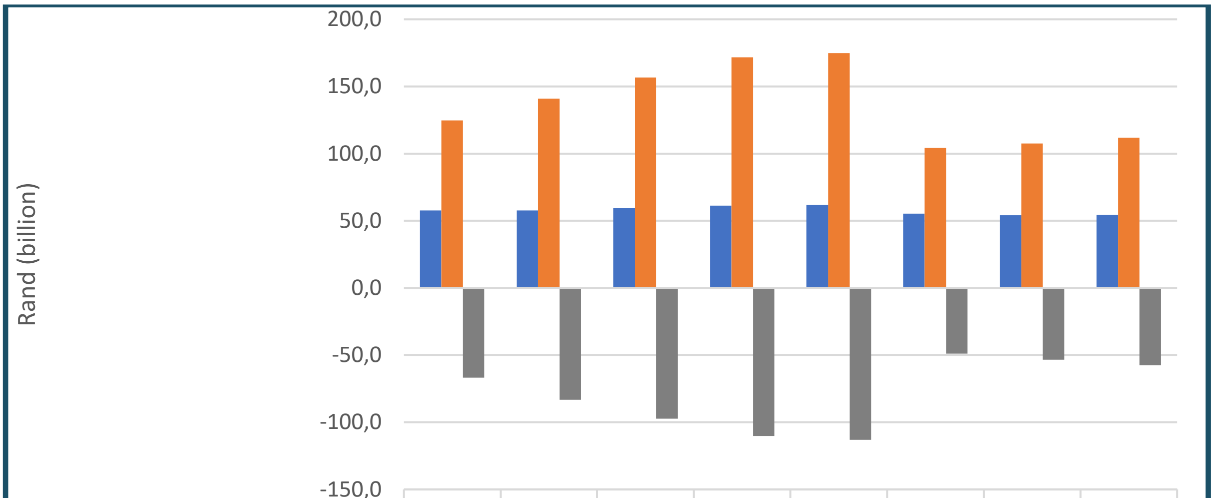
The components industry's trade performance is mixed. Following the implementation of the MIDP and later the APDP, the industry rapidly expanded its exports and competitiveness, while imports also surged. Recent years have seen a decrease of exports in real terms.

The total value of component exports, in real terms, shifted from R57.8 billion in 2012 to R59.3 billion in 2014 and R54.2 billion in 2019 (see Figure 40). In 2019, the components industry accounted for 30.2% of the total value of exports in the automotive industry. In turn, components valued at R111.7 billion were imported into the country in 2019, resulting in a components trade deficit of R57.5 billion. The rising level of imports and sustained trade deficit in the components industry results from high-value and technologically sophisticated imports of components into South Africa (Lamprecht, 2020).

Component manufacturing has resulted in job creation, increased government revenue and the stimulation of product expansion in raw materials, including steel, leather and plastics.

Over the past years, a slowdown in economic growth, falling domestic demand, labour unrest, high infrastructure and logistics costs and changes in policy have exposed the vulnerability of the domestic industry. Unfortunately, this has hindered the industry's ability to compete resulting in declining growth.

Figure 40: Components exports and imports (in ZAR billions, in real 2019 terms)



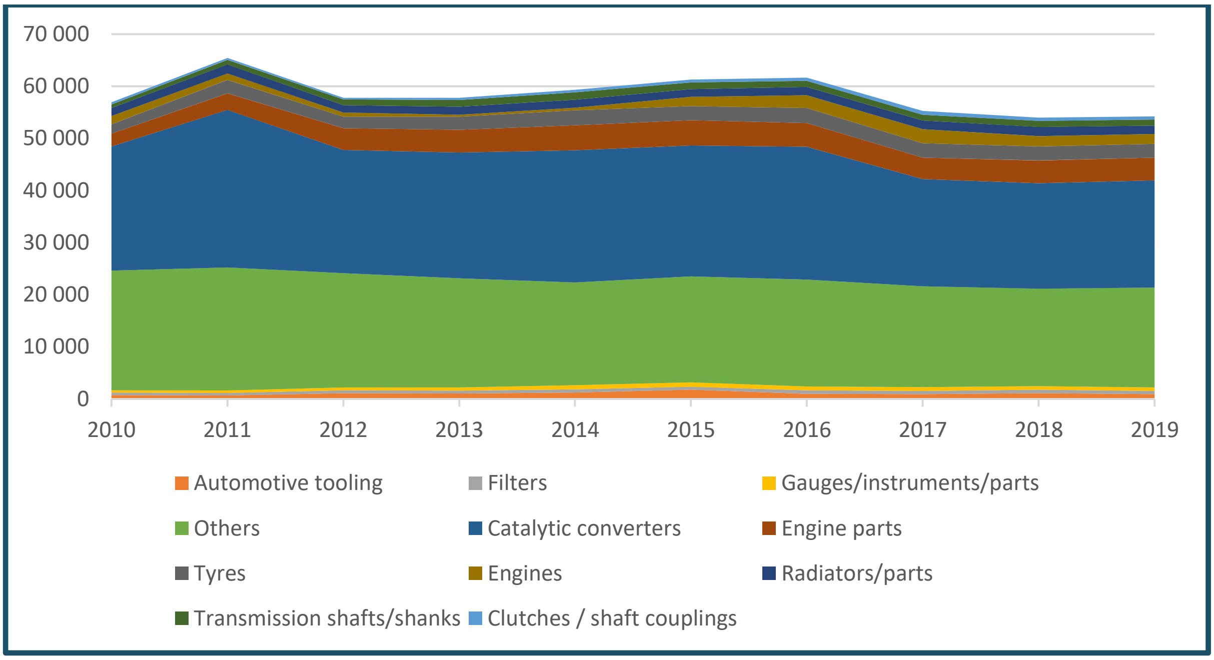
	2012	2013	2014	2015	2016	2017	2018	2019
Total value of component exports	57,8	57,8	59,3	61,3	61,7	55,2	54,0	54,2
Total value of component imports	124,6	141,0	156,8	171,6	174,9	104,2	107,5	111,7
Trade balance	-66,8	-83,2	-97,4	-110,3	-113,2	-48,9	-53,5	-57,5

Source: Authors, based on AIEC data

Top South African component exports in 2019 included catalytic converters, engine parts, tyres and radiator parts. Catalytic converters dominate South Africa's component exports. Engines, transmission shafts/shanks, and clutches are among components showing increasing value in their exports between the 2010 and 2019 period.

The growth of exports is, however, limited to a small group of products and declining in real terms, as shown in Figure 41.

Figure 41: South Africa's top automotive component exports in 2019 (in ZAR millions, in real 2019 terms)



Source: Authors, based on AIEC data

South Africa's top component exports are ICE-specific and largely exported to European markets, with the exception of engines, which go mostly to India. These markets are set to enhance the delivery of electric mobility as a result of tightening GHG emission standards and the addition of new product specifications to the existing range of requirements (see Table 31). With nearly all major European OEMs and large Tier 1 suppliers looking to expand their output of EVs and components, the adoption of EVs across Europe is set to greatly impact on South Africa's component exports – particularly catalytic converters, engine parts and radiators and parts. This raises concerns about the long-term sustainability of component exports, and could leave South African ICE-component suppliers scrambling for new market opportunities in demand for ICE-based components.

Proximity to markets and infrastructure influence logistic costs and competitiveness. But, for South Africa, the industry is at a logistical disadvantage because of high transport costs and the country's geographic distance to its major markets. If local manufacturing of EV components does not take off, then the alternative would simply be to import components required by OEMs in local EV production. The domestic market would yet again be flooded with imports, consequently undermining local capabilities and production.

Table 31: South Africa's main export markets for components

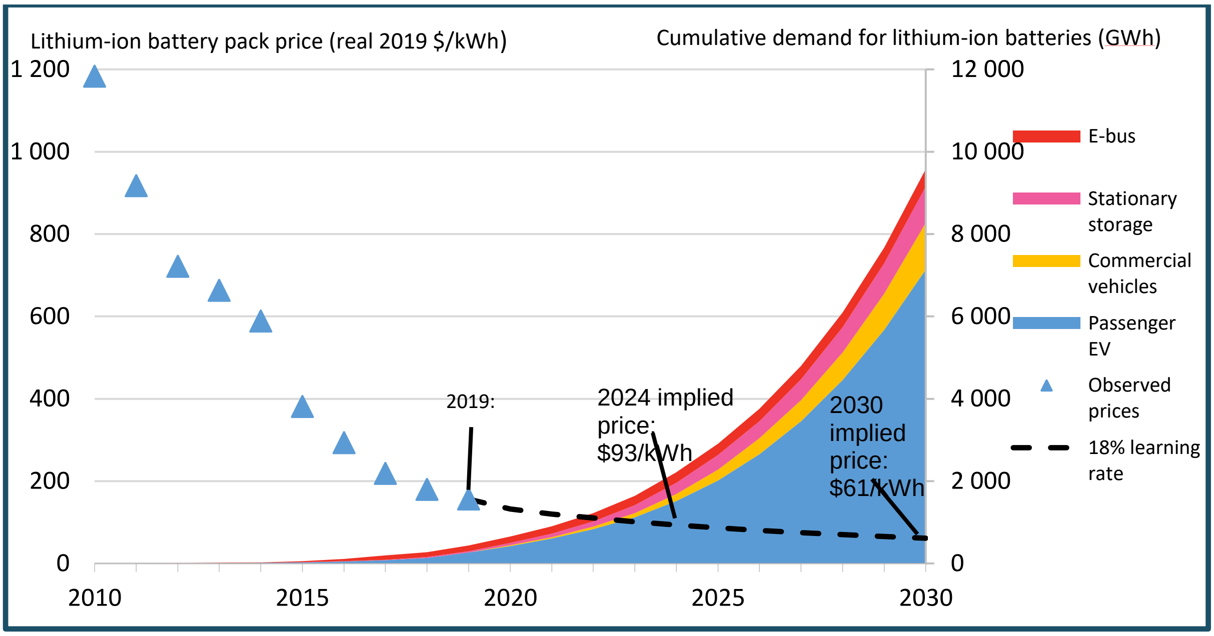
COMPONENT	EXPORT (IN R BILLION)	MAIN IMPORTER	SECOND IMPORTER	THIRD IMPORTER
Catalytic converters	19.2	Germany (42%)	US (12%)	Czech Republic (10%)
Engine parts	4.2	Germany (26%)	US (24%)	Thailand (16%)
Tyres	2.6	Belgium (16%)	Namibia (12%)	Botswana (8%)
Engines	1.9	India (59%)	Zambia (10%)	Mozambique (6%)
Radiators and parts	1.7	Germany (34%)	Spain (12%)	US (12%)

Source: Authors, based on AIEC data

5.2.4. Battery production

Currently, batteries make up between 40% and 50% of the total cost of an EV.[39] Economies of scale and improvements in battery technologies have seen battery prices fall by more than 70% since 2010 (see Figure 42). A battery cell represents most of a LIB pack cost. Battery cells typically account for 70% of the total value of the battery pack, and cell costs are roughly composed of 50% raw materials and 50% manufacturing (BNEF, 2019). Other major cost components for LIB cells are material (supply and logistics), labour, energy, depreciation, R&D and other general and administrative expenses.

Figure 42: Cost structure of a 100kWh NMC (622) BEV pack



Source: BNEF, 2020.

LIB manufacturers and OEMs around the world are investing in "giga-factories" with huge capacities anticipating growth in LIB demand for application in EVs, e-buses and e-trucks. LIB prices are forecasted to decline to US$131/kWh by 2020 and below US$100/kWh by 2025 (Figure 42). The electrification of commercial vehicles and stationary storage is expected to become increasingly attractive by 2030. The forecast in demand is due mostly to the rapid expansion of EVs, from about 2% of global market share in 2018, to 25-35% by 2030 (Bloomberg, 2020).

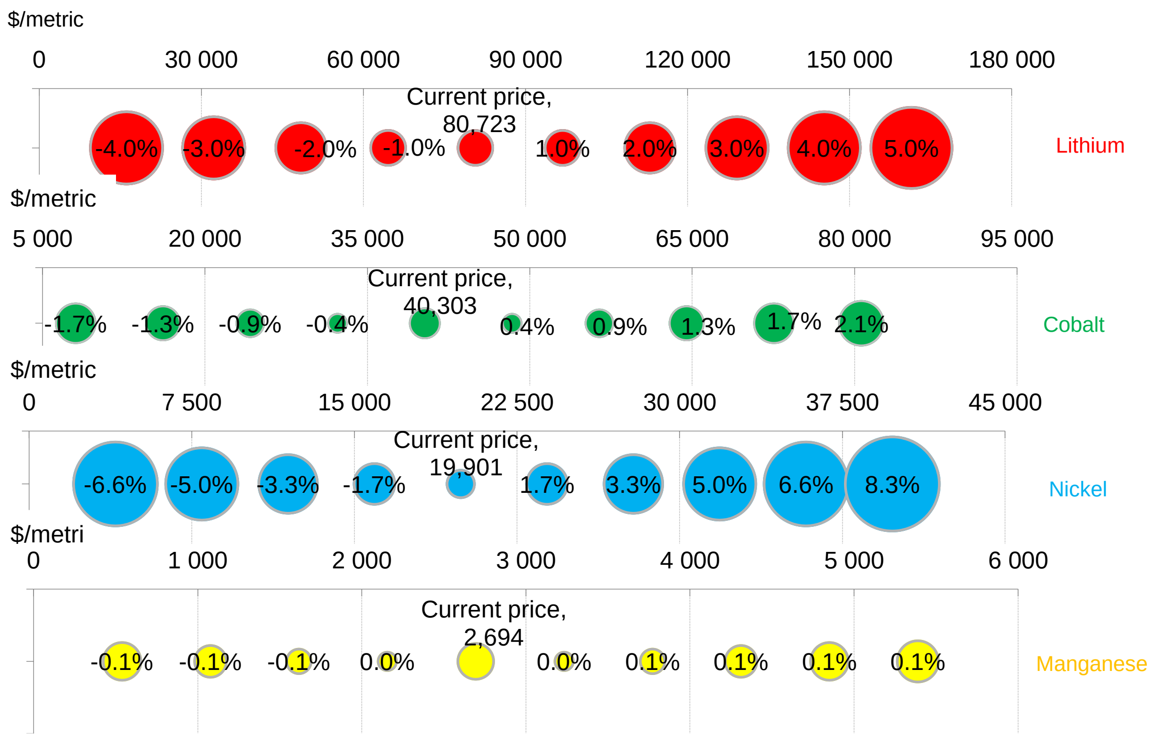
Importantly, LIB costs depend much less on raw material costs than on the production volume of the batteries, hence steadily improving economies of scale for LIB production will lead to expected cost reductions. Continued cost declines for LIB pack prices will also be achieved through reduced manufacturing capital expenditures, new pack designs and changing supply chains. Low battery prices remain the most critical goal to lowering the high cost of EVs.

Figure 43 shows the sensitivity of a LIB battery (NMC) to lithium, nickel, cobalt and manganese prices. The sensitivity of the LIB price to commodity prices is shown to be quite low. For example, a 50%

[39] Based on the increasing demand from the automotive industry, there are a number of different chemistries used in LIBs by various manufacturers. Lithium Iron, Phosphate (LFP), Lithium Nickel Cobalt Aluminium Oxide (NCA), and Nickel Manganese Cobalt Oxide (NMC) are the three leading cathode chemistry types. Of the three, NMC is the most prevalent and the fastest growing chemistry used in EVs. This is due to its high specific energy and low internal resistance.

increase in lithium prices would increase the price of a LIB battery pack by less than 5%. Manganese price sensitivity is by far the lowest compared to other raw material inputs, and at a price of US$2 694 per metric ton, any increase in the price of manganese would have a negligible impact on the battery pack. While for nickel, doubling its prices would result in an increase of over 8% in the overall price of the battery pack. Despite this low-price sensitivity, forecasted increases in the demand and prices of LIB materials would favour African mining and beneficiation prospects. This would provide strong underpinning to consider strengthening regional value chains in the mining industry.

Figure 43: NMC (811) battery pack price sensitivity



Source: BNEF, 2020.

China is a dominant player in manufacturing LIBs, with a 75% global share of production capacity in 2019 (Bloomberg, 2020). BNEF (2019) forecasts that, by 2023, China's manufacturing capacity would be 804 GWh (65%). Other countries are catching up. According to BNEF's projections, by 2023, Europe and Middle East and Africa (EMEA) regions would account for almost 228 GWh of lithium-ion cell manufacturing capacity per year, compared to 345 GWh by the Asia-Pacific region (excluding China).

While LIBs are currently imported, South Africa has committed to manufacturing LIBs. Efforts are being made in South Africa to further promote the manufacturing of LIBs and create prerequisites for charging infrastructure and recycling. Centres and facilities for battery development and manufacturing for EV and storage applications are underway in South Africa, with local and foreign investment in LIBs and competing battery technologies, such as redox-flow batteries.

Although Asian LIB producers have a cost advantage resulting from economies of scale and expertise developed over the last decades in LIB manufacturing for storage and EV applications, this has not deterred investors and the government from providing investment support to the industry. As part of the Energy Storage Research, Development and Innovation (RDI) Programme, the Department of Science and Innovation (DSI) has supported the establishment of two pilot facilities aimed at facilitating the local production of LIBs. A precursor development pilot facility, located in Nelspruit and managed by the University of Limpopo, is focused on producing value added manganese-based precursors like lithium manganese dioxide (LMO) and NMC, which are critical components of the LIB cathode. The second pilot facility at the University of the Western Cape (UWC) in Cape Town focuses on producing LIB cells. The competitiveness of the LIB industry in South Africa and the associated benefits for growth and jobs critically depends on the ability of the industry to serve local and export markets with battery cells and battery packs.

The CSIR, Zellow and uYilo have all played a key role in protecting LIB technology innovations and developing testing standards at various stages in the battery value chain. According to reports by GreenCape (2020) and Who Owns Whom (2019), the CSIR is responsible for the protection of the cathode material using South African intellectual property (IP) laws, while Zellow is in charge of developing local lithium-ion cell manufacturing competency. Furthermore, the uYilo e-mobility programme hosts a nationally accredited battery testing laboratory to execute testing in accordance with international standards for lithium-ion cells.

In addition to these contributions, as of March 2020, three companies, namely Metair Investments, Megamillion Energy Company and Bushveld Minerals, have invested in partnerships to manufacture LIBs and redox-flow batteries locally largely for storage applications. These initiatives highlight the key role of long-term partnerships between universities, industry and government in advancing new technologies in energy storage solutions and vehicle manufacturing.

Local automotive specialist, distributor and retailer of energy solutions and automotive components, Metair Investments, launched a programme to produce LIBs across its operations in South Africa, Romania and Turkey. In 2019, Metair began its production for LIBs in its plant in Turkey. In Romania, the company acquired a 35% holding in Primemotors through its wholly-owned subsidiary, Rombat, in an effort to accelerate its production of LIBs for the growing European market, as the global production of EVs accelerates (Metair, 2019). Metair is partnering with UWC to produce cells for LIBs (Metair, 2019). Metair's agreement with UWC should lead to the company investing R3 million over three years to pilot a prototype lithium production project.

According to GreenCape (2019) and Metair (2019), the company's facility houses the only pilot scale lithium-ion cell assembly facility in Africa. The production would focus on mining cap lamp cells, 12 V lithium-ion automotive batteries, 48 V lithium-ion batteries for energy storage applications and solar panel recharge technology, using the efficient chemistry mixes based on widely available local minerals, such as manganese and nickel (Metair, 2019). Metair believes that sustained R&D initiatives to support local production with locally available commodities will drive down the cost for LIBs. However, as highlighted, production scale is a key factor in reducing battery prices (Venter, 2019b).

Megamillion Energy Company, in partnership with battery technology experts from China and the Nelson Mandela University (NMU), plans to be Africa's first large-scale producer of LIBs, primarily for the energy storage market and EVs (Venter, 2020b). Megamillion aims to develop Africa's first LIB production pilot plant in the Coega Special Economic Zone (SEZ) located in East London, with an initial investment of US$35 million from various sources, including a mix of local and global private equity investors (Venter, 2020b). The plant's annual LIB production is estimated at 32 GWh cells by 2028. Venter (2020b) reports that a sample of LIBs have successfully been produced and have undergone tests at NMU.

Bushveld Energy is one of the leading vanadium producers globally. The company is focused on developing and growing vanadium for the global energy storage market and in advancing battery technology (Bushveld, 2018). Bushveld Energy mined between 2 800 and 2 900 tonnes of vanadium from Brits and Mokopane in 2019 – on average South Africa produces 8% of the world's vanadium feedstock. Vanadium is a key input in the vanadium redox flow battery (VRFB) – an alternative battery technology to LIBs. VRFBs recharge EVs by an electrolyte exchange consisting primarily of water and chemical additive acids, such as sulphuric acid or hydrochloric acid. Despite its uncertainty, and limited share in battery markets at present, the demand for VRFBs is expected to increase to over 18 000 MWh by 2027 (Liedtke, 2018). Although Bushveld currently produces batteries for energy storage, the VRFB technology is suitable for EVs too. However, the rate of commercialisation of flow batteries is still held back by the high capital costs associated with the sourcing and extraction of vanadium (Kear et al*.,* 2011). In 2019, Bushveld Energy received its first delivery of VRFBs from UniEnergy Technologies in South Africa.[40] This has significantly assisted in building the company's capability to develop and deliver energy storage solutions across Africa.

On the end-of-life front, South Africa currently does not have a process for recycling LIBs. Recyclable batteries are shipped from South Africa to OEMs' home countries for recycling (Knights and Saloojee, 2015). This highlights the opportunity to increase and expand the battery recycling efforts in South Africa to recycle LIBs. As of January 2020, the e-Waste Association of South Africa (eWASA) is initiating a background study on the waste management of LIBs in South Africa (to be completed by June 2020). It is the ambition of eWASA to inform the establishment of a pilot recycling plant by 2021. Implementation would be enabled by the extended producer responsibility strategy, which is driving waste management in the country. The collection of LIBs would be managed by eWASA against a specific levy on the battery (on the same model as lead-acid batteries) and the recycling would be handled by a separate, independent company.

5.2.5. Fuel cells

There are various types of fuel cells which are generally classified on the basis of the electrolyte used in the cell, including solid oxide (SOFC), molten carbonate (MCFC), phosphoric acid (PAFC), proton exchange membrane (PEMFC), and alkaline (AFC). At the heart of the PEMFC is MEA), which includes the membrane, the catalyst layers, and gas diffusion layers (GDLs) (US Department of Energy, 2019). The PEMFC has emerged as the best technology used for FCEVs. According to IPM (2020), only the PEMFC and PAFC are particularly relevant to the South African mining value chains as they are the only types of cells directly making use of PGM-containing catalysts.

FCEVs are considered complementary to BEVs and key to expanding the range of zero-emission transportation options available (IDC, 2018). A fuel cell device in a FCEV consists of a stack, which is composed of a number of individual cells stacked to achieve higher power and voltage (DMR, 2013). Fuel cell technology is similar to battery technology insofar as they both generate electricity from an electrochemical reaction and both fuel cells and batteries convert chemical energy into electrical energy (and also, as a by-product of this process, into heat energy). However, a battery stores energy within it and once this is depleted the battery must be recharged by using an external supply of electricity. A fuel cell, in contrast, uses an external supply of chemical energy and can run indefinitely, as long as it is supplied with a source of hydrogen and oxygen (DMR, 2013). The power output from a single cell is relatively low, but a stack arrangement makes fuel cells a versatile technology, allowing

[40] VRFBs are being manufactured by Bushveld Energy's US-based technology partner, UniEnergy Technologies. The trial will take 18 months, after which the system will be redeployed locally to a commercial site (James, 2018).

them to power FCEVs and a broader range of other applications (including stationery storage) (DMR, 2013; IDC, 2018). FCEVs are very effective for long-distance travel and applications in which minimal downtime is required, such as trucks, long-distance buses, or industrial vehicles. As such, the future of mobility is likely to see BEVs and FCEVs play a complementary rather than a contradictory role.

The South African government's efforts along with the mining companies to develop a viable fuel cell manufacturing industry has seen a few local projects emerging in the fuel cell value chain. HySA, CHEM Corporation and local company IPM are examples of emerging key players in developing manufacturing capabilities in the fuel cell value chain.

The HySA Programme, an RDI initiative funded by government and implemented through the DSI with Centres of Competence located at universities and science councils, has made significant progress in developing IP on hydrogen and fuel cell technologies. Through a spin-off company, HyPlat and Bambili Energy Group (Bambili), MEAs developed through HySA have been validated and integrated into commercial products in collaboration with global OEMs, Element One and Horizon. Plans are underway for local manufacturing of fuel cell systems containing the locally developed MEAs.

In its attempt to boost PGM beneficiation in South Africa and contribute to the global fuel cell economy, IPM began developing its fuel cell manufacturing project in 2016 with support from the dti[41] (Engineering News, 2019). Their first plant, sourced from Germany, will be located at the OR Tambo SEZ in Johannesburg. IPM has started construction of its facility at the SEZ and expects to commission operations in 2021. As a component supplier, IPM will manufacture and assemble high-quality fuel cell components including the MEA and PGM catalysts for local and global fuel cell automotive supply chains, the stationary fuel cell industry, for electrolysers that produce hydrogen for transportation fuel, and for energy storage. In addition, the project will create new jobs in the new fuel cell component manufacturing value chain and will also include MEA recycling operations (to recover the PGMs) within a closed loop business model (IPM, 2020; Engineering News, 2019). IPM has also developed the blueprint for Africa's first integrated hydrogen refuelling station that will be capable of refuelling fuel-cell electric buses, FCEVs and, via fuel cells, recharge BEVs (without impacting the Eskom grid) (IPM, 2020).

CHEM Corporation, a leading Taiwanese manufacturer and distributor of electric solutions, is expected to build a fuel cell manufacturing plant in in KwaZulu-Natal, through its subsidiary, CHEM Energy South Africa (Engineering News, 2019). Telecommunications network provider Vodacom has used CHEM's fuel cell solutions for its South African network since 2011. CHEM's latest fuel cell product provides greater reliability than batteries or diesel generators at a lower cost and with lower emissions (Engineering News, 2019). This move is supported by the dti's commitment to working with CHEM to realise the full potential of fuel cell production in South Africa.

Although government has strong support measures in place for fuel cell manufacturing through various incentives by the dti, including the Black Industrialist Scheme, some of the most stringent challenges facing (small) players involved in PGM beneficiation are the lack of financial support, difficulties in accessing incentives from traditional funding schemes, and the lack of support for local value added initiatives by the PGMs industry.

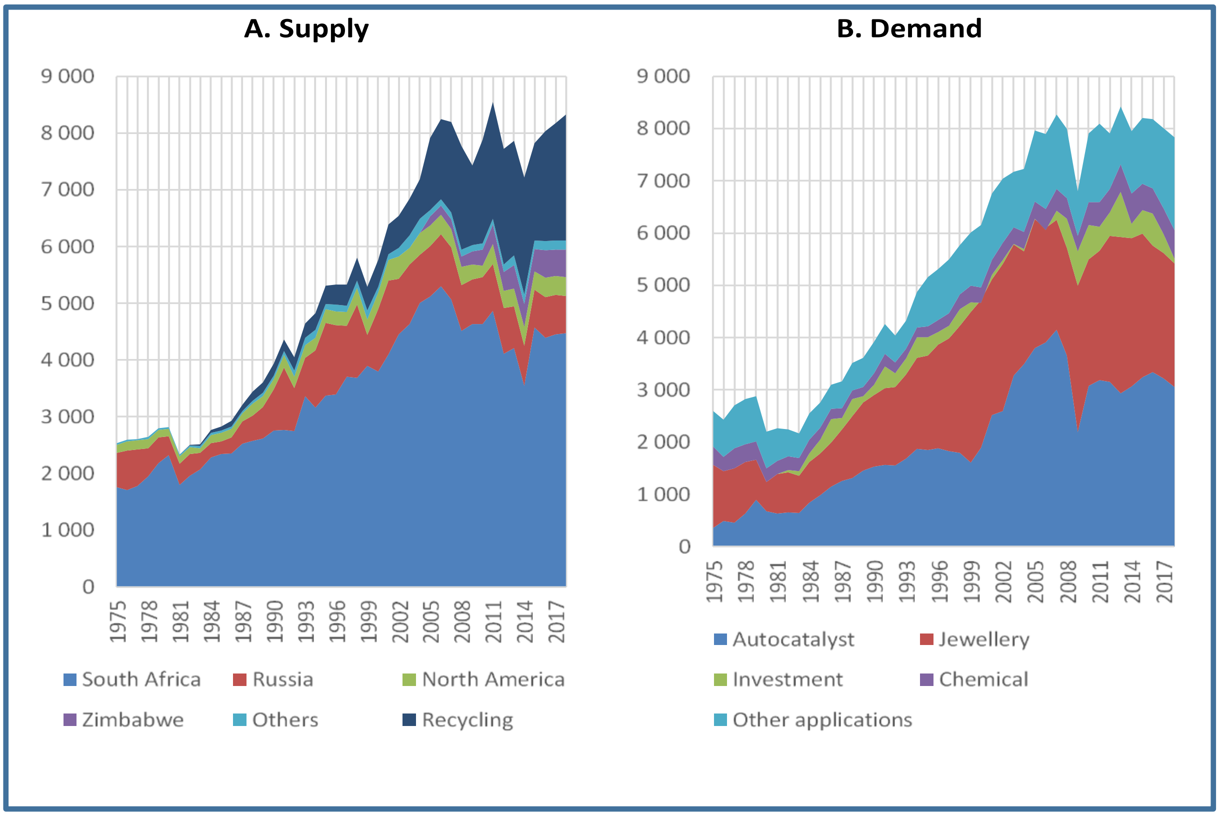
[41] According to Desai (2019), the dti contributed R15 million to fund part of IPM's feasibility study.

5.2.6. Minerals for EV-specific applications

Platinum Group Metals

South Africa is a leading supplier of PGMs. South Africa has the highest PGM reserves at 63 000 t (91%) (DMR, 2013; USGS, 2016). South Africa produces about 75% of global platinum, along with 35% of the world's palladium and over 80% of rhodium. In 2017/2018, South Africa's share of global platinum production reached 69%. The demand for PGMs is largely dominated by auto catalysts (39%), followed by jewellery which represents a further 31% of demand, while industrial applications account for 22% of demand, and the rest (8%) is made up of platinum coins, bars and ingots used for investment purposes (IDC, 2018).

Figure 44: Platinum supply and demand from 1975 to 2018 (000 troy ounces)



Source: Authors, based on data from Johnson Matthey. Market Data Tables and PGM Market Reports. downloaded from http://www.platinum.matthey.com in May 2019.

As shown in Figure 44, auto catalyst production remains the largest consumer of PGMs. The electrification of mobility is expected to have a negative impact on catalytic converters for use in the automotive industry.

The rise of EVs, particularly BEVs, which do not have an exhaust (therefore no catalytic converter) is expected to have a negative impact on PGM prices and demand (Els, 2016). FCEVs also do not use catalytic converters but rely on fuel cells, which require PGMs. Because PHEVs and HEVs burn petrol and diesel, their engines need catalytic converters. However, the converter is used less frequently and therefore requires smaller amounts to process pollutants than in a traditional ICE vehicle (Els, 2016).

At present, future demand seems to hinge on the development of fuel cells, both in stationary and vehicle markets. Future demand remains, however, uncertain and will depend on the rollout of fuel cells as well as the amount of PGMs required to produce them. For instance, according to Desai (2019), FCEVs currently use around 30-60 grams of platinum, compared to a catalytic converter in a diesel passenger vehicle which uses three to seven grams. However, over time, the Toyota Mirai FCEV is expected to cut platinum by two-thirds to around 10 grams per vehicle in its next version, down from 30 grams in the current model (Desai, 2019). In any case, a small percentage of FCEVs on the road could have a positive impact on the demand for platinum. Forecasts from one industrial company expect platinum demand from FCEVs to reach one million ounces by 2030 (about 13% of total platinum demand in 2018), driven by the production of 1.85 million FCEVs per annum.

The South African government and locally based PGM producers are eager to develop new demand streams for PGMs through encouraging beneficiation activities and the development of fuel cell components to help boost demand for PGMs in the domestic market. DMR (2013) reports that South Africa intends to supply 25% of the fuel cell market by 2020. Anglo American Platinum launched the PGM Development Fund in 2019 with an initial endowment of R100 million. In efforts to find alternative demand streams, Anglo American plans to significantly ramp up the establishment of two venture capital funds of US$100 million each, co-funded equally by Anglo American Platinum and the Public Investment Corporation (PIC). The DSI, in collaboration with research councils (such as Mintek and the CSIR) and local universities (UWC, UCT and North West University (NWU)), has also actively supported R&D for the PGMs value chain, through the Advanced Materials Initiative (which includes a Precious Materials Development Network) and the HySA RDI programme aimed notably at developing fuel cell technologies identifying pathways to commercialisation.

To date, the DSI has spent just under R1.2 billion towards the HySA Programme, which has led to an IP portfolio of 20 registered patents, 120 students graduating at MSc and PhD level and over 300 peer reviewed publications. In addition to the IP on catalyst and MEAs, technologies for hydrogen storage and compression have been developed and piloted in stationary fuel cell deployments and through niche mobile applications such as fuel cell powered forklift, range extension in scooters and related refuelling infrastructure. While further support is required for technology development and deployment at scale, these technologies and capabilities provide a foundation on which a local EV industry and a hydrogen economy could be built.

Manganese

South Africa is the world's largest producer of manganese, accounting for about 33.5% of global production, and contains more than 70% of the world's manganese reserves (Figure 45). Manganese is a crucial element used in steel production. Only 6% of manganese production ends up in non-steel production and around 90% of the manganese consumed globally is used to produce manganese ferroalloys, consisting of various grades of ferro- and silico-manganese (Steenkamp and Basson, 2016.

There are four manganese producers in South Africa: Metalloys – the largest producer of manganese, Assmang, Transalloys, and Mogale Alloys (Steenkamp and Basson, 2016). According to the HeraldLive (2019), for every million tons of manganese exported, 500 jobs are created from the mine to the port. The growth of this industry could potentially see new opportunities for jobs in the country's mining sector.

Although South Africa is well-endowed with manganese, 95% of this is exported for beneficiation in China, India, Japan and Malaysia, the top four importers of South African manganese (Steenkamp and Basson, 2016; HeraldLive, 2019; ITC Trade Map, 2019). China, India and the Ukraine are leading global producers of ferromanganese, as shown in Figure 46. Ferromanganese is imported back into South Africa, however at a much higher price.

The opportunity for beneficiation of manganese in South Africa is moderately low, mostly due to high electricity prices and low productivity of labour, among other factors (Steenkamp and Basson, 2016). Rising electricity prices have led to a decline in South Africa's foundry capacity, including iron and steel foundries (see Box 11). According to the Energy Intensive Users Group (2016), up until 2001, 50% of South Africa's manganese was processed locally, but by 2014, this figure fell to only 16%. More than 40 furnaces that produced ferroalloys in the manganese industry were shut down, mainly due to the high cost of electricity in South Africa. The processing and refining of manganese would need to be supported by affordable electricity, as refining manganese to produce ferromanganese requires high electricity consumption. In addition, because manganese is considerably cheaper to mine than lithium, cobalt and nickel, this limits the potential benefit that favourable manganese prices would attribute to the overall competitiveness of LIB packs. Mineral beneficiation is likely to continue taking place outside the country until solutions are available to secure reliable and affordable electricity supply in South Africa.

Figure 45: Global production of manganese ore (in thousand metric tons of manganese content)

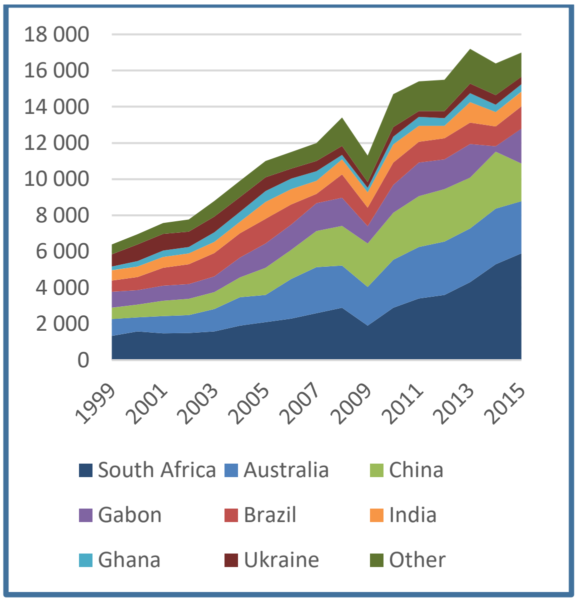
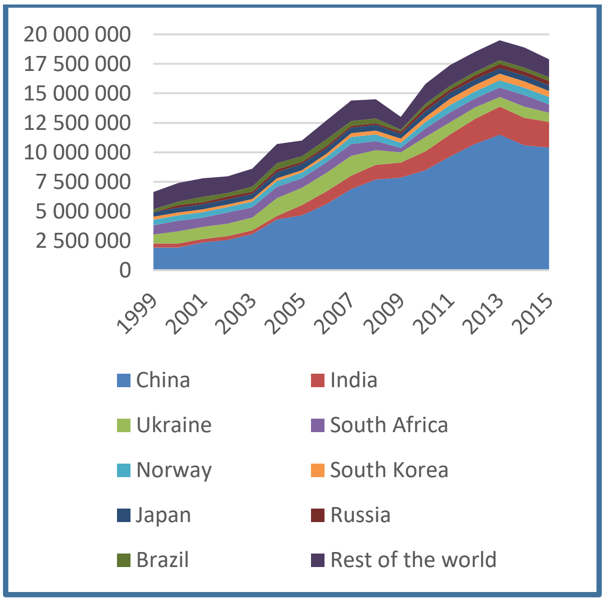


Figure 46: Global production of ferro-and silico-manganese (in metric tons, gross weight)



Source: Authors, based on data from the US Geological Survey (USGS) Minerals Yearbook, Series on manganese, downloaded in January 2020 at https://www.usgs.gov.

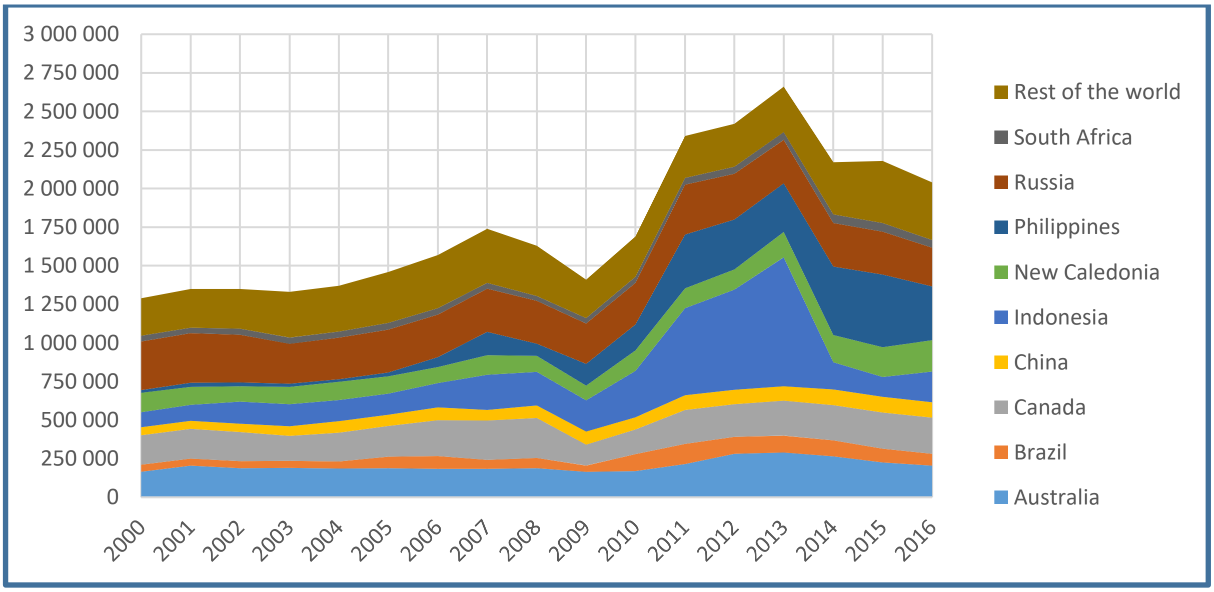
Nickel ore

As EV sales climb, research and consulting firm Roskill forecasts nickel demand from the battery sector to rise to 258 000 tonnes or nearly 10% of the total demand in 2022 (Desai, 2019). Desai (2019) predicts that OEMs manufacturing EVs will be driving demand for nickel by around 16 times to 1.8 million tonnes in the next years fuelled by meeting large EV markets, and other global markets where demand for nickel is expected to grow. Strong EV production in China, India and other emerging markets should continue to fuel demand for nickel from 2018 to 2022.

In 2016, South Africa produced about 49 000 tonnes of nickel. It was the ninth largest producer, accounting for only 2% of global production (see Figure 47). In 2016, the largest nickel producer was the Philippines producing around 347 500 tonnes of nickel, followed by Russia which produced about 252 500 tonnes. The world's largest nickel reserves are in Indonesia, Australia and Brazil.

South Africa has several nickel-producing mines, with one of the largest being the Nkomati mine, in Mpumalanga with an estimated 409 million tonnes of reserves. Two new nickel mining projects led by mining company Uru Metals are underway in Zebediela, Limpopo, and Burgersfort in Mpumalanga (Uru Metals, 2019). According to Moolman (2018), BMI Research 2019 estimates that the Zebediela mine has 1.5 billion tonnes of inferred and indicated resources and will be able to produce 20 000 tonnes of nickel a year. The growth of the South African nickel mining industry through new projects follows the projected growth of the international nickel market (Moolman, 2018).

Figure 47: Global production of nickel ore (in metric tons, contained nickel)



Source: Authors, based on data from the US Geological Survey Minerals Yearbook, Series on nickel, downloaded in January 2020 at https://www.usgs.gov.

Rare earth elements

REE are used in many high technology applications. REE magnets are used in various products, including electric motors, wind turbines and miniature speakers in smart phones. Large electric motors in EV batteries use up to 200g of neodymium and 30g of dysprosium per motor. Over time, the market for permanent neodymium magnets (neodymium-iron-boron) has been growing at a rate between 5% and 10% a year, mainly as a result of the growth in traditional consumer electronics and the automotive industry, but growth is also expected from technologies such as wind turbines and NEVs (Steenkampskraal, 2019).

According to the Steenkampskraal report (2019), the total market for REE in 1960 was 5 000 tons, however, by 2017, the market had grown to about 133 000 tons and there are forecasts that the market will grow to over 200 000 tons by 2020. The annual global production of neodymium is 7 000 MT, and total reserves are estimated at 8 000 000 MT, mainly found in China and Australia. China has dominated the production of REE for a number of years. Approximately 85% of the world's neodymium is mined in China. In 2018, China's domestic output was 120 000 MT. South Africa, Brazil and the US previously dominated the market of REE; however, their operations are no longer cost effective leading to the closure of their REE mines (Financial Times, 2019). One key challenge for REE mining and processing is funding (Gorrill, 2019). REE mining also carries specific risks of environmental damage linked to the radioactive thorium that is produced as a by-product (Financial Times, 2019).

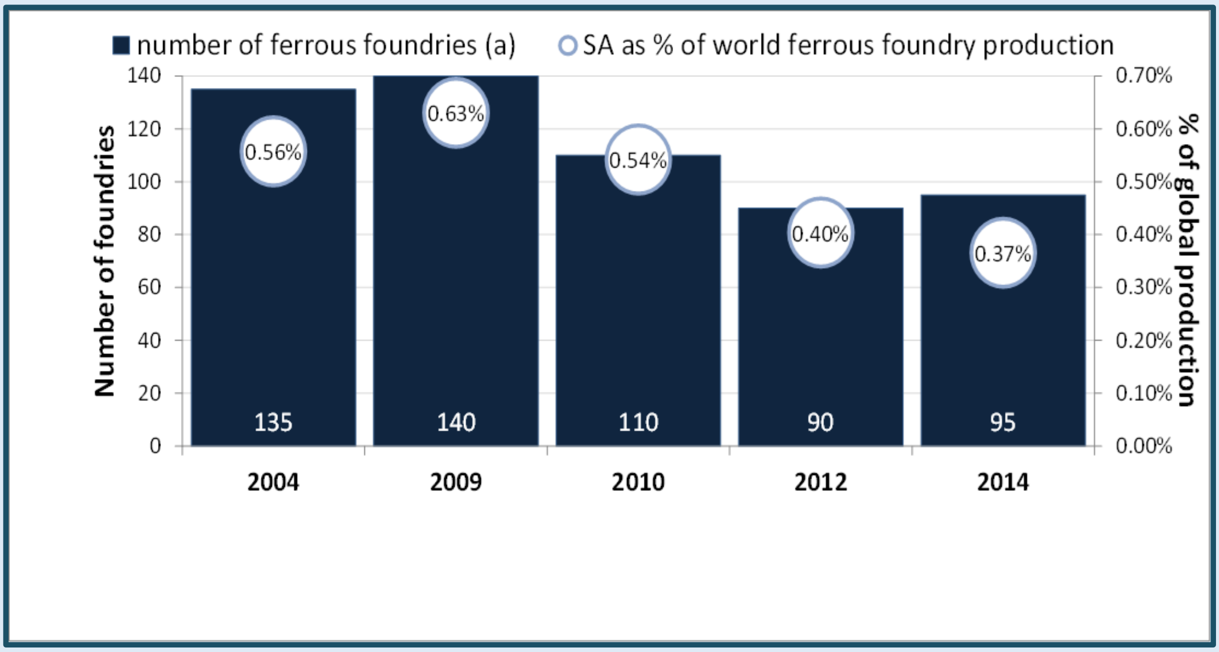
South Africa is not among the top ten producers of REE, but the country plans to reopen its REE Steenkampskraal mine in the Western Cape, which according to Kruger (2019) has one of the world's highest concentration of REE. More than half the economic value of the Steenkampskraal mine is in neodymium, praseodymium and dysprosium. Steenkampskraal plans to produce 2 700 MT of REE a year once funding of US$50 million has been secured, with further plans to expand the mine. The total quantity of neodymium in the mine is 15 600 MT.

Box 11: Foundry capacity in South Africa

Foundries are key to the machinery and equipment industry value chain. From Figure 48, the local foundries industry has however been shrinking in the last ten years. Between 2004 and 2014, 40 of South Africa's foundries were closed, resulting in direct job losses in the foundry industry. This also impacted on jobs and production in downstream machinery firms. In 2014, there were just less than 100 ferrous foundries operating in the country.

Electricity is a key cost structure in operating foundries. According to Slater (2016), cheap electricity was one of South Africa's key cost advantages against other foreign manufacturing countries, however, that has now become one of the industry's major cost driver. Foundries were among the hardest hit by increasing electricity costs. Unfortunately, this resulted in downstream firms importing foundry component inputs and fully assembled products such as pumps and valves, while others stopped production (Slater, 2016). South African foundries also have a strong skills deficit compared to competitors in other emerging economies, leaving them at a disadvantage.

Figure 48: Number of foundries in South Africa and their share in global foundry production (2008 to 2014)



Source: Authors, based on American Foundry Association, Census of Global Casting Production for relevant years. Downloaded from http://www.afsinc.org/ in May 2016.
Note: (a) Figures derive from a survey of enterprises undertaken annually for the international study by the South African Association of Foundrymen.

LIB minerals in the region

Being the largest economy in the sub-region, South Africa exerts influence on the development of regional minerals' value chains. An opportunity arises for South Africa and its neighbouring mineralrich countries to deepen and broaden collaboration to foster regional linkages and significant investment toward LIB production capabilities and refining capacity. The African Continental Free Trade Area (AfCFTA) could play a key role in enabling African countries to build regional value chains; however, there are constraints mainly centred on skills, industrial finance and infrastructure.

Cobalt

Globally, the demand for cobalt from LIBs tripled in the last five years, and is projected to double again by 2020 (Frankel, 2016). Cobalt prices increased from US$25 000 a tonne to US$90 000 a tonne in two years, making cobalt the most expensive material in the battery (Financial Times, 2019). The output of cobalt is largely dependent on copper production. As more copper is processed, more cobalt is collected as a by-product (Forbes, 2018. In 2016, total production for cobalt reached 126 000 tonnes, with the largest global supply (55%) sourced from the DRC. Concerns about mining conditions,[42] including the high cost of cobalt, are forcing battery producers to move toward battery chemistries that rely on magnesium, sodium or lithium-sulphur as these have the potential to compete with LIBs on energy density and cost, with the added benefit of reduced cobalt requirement in their application (Darton Commodities, 2016).

Zambia, as one of Africa's leading cobalt producer, could act as an alternative supplier.[43] However, Zambia's production capacity has decreased in the last few years, from 7 800 tonnes in 2008 to 5 000 tonnes in 2016 (Din, 2017). Cobalt production has not kept pace with rates of copper production in Zambia (Din, 2017). The greatest challenge Zambia faces in growing its cobalt production is the massive capital investment required to set up cobalt processing plants (Din, 2017). The second challenge for the country is sourcing enough clean power to produce cobalt in a way that is green and environmentally friendly.

Lithium

Zimbabwe is expected to become one of the world's largest exporter of lithium. Zimbabwe is ranked fifth among top lithium producing countries (1 600 tons), with proven reserves of 10.8 million tons of lithium ore (African Mining Market, 2019). Zimbabwe's Arcadia Mining is expected to reach an annual production of 2.5 million tons of lithium ore after its mine is deployed. According to S&P Global (2019), Zimbabwe aims to supply 10% of the world's lithium by 2025. Currently, Zimbabwe has an agreement with a South African mining company whose lithium mining project is expected to create US$1.4 billion over eight years.

Graphite

South Africa does not produce natural graphite. South Africa currently imports all its graphite ore. Mozambique has one of the largest deposits of high-quality graphite in the world. Mozambique is estimated to account for 20% to 40% of total global reserves of graphite (The Africa Report, 2019). According to US Geological Survey (2016), the graphite deposit is owned by Syrah Resources Ltd, an Australian company, which has estimated resources of 1.1 billion tons, thereby containing more natural graphite than all other identified global deposits combined. In the region, Tanzania and

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[42] The DRC's cobalt mining and trade has been the target of criticism linked to environmental pollution, ecosystem destruction and human rights abuses including the use of child labour (Lena, Frankel and Sadof, 2018). Concerns about ethical procurement of raw material, supply chain transparency and geopolitical tensions in the DRC are identified risks to the global supply chain of cobalt.

[43] Recycling could be another way to reduce the burden on mining cobalt in the Congo.

Madagascar could also become significant key players in graphite. Both countries are said to have some of the world's largest untapped deposits of graphite (E&MJ, 2019).

Rare earth elements

To supplement South Africa's capacity in REE production, Burundi and Malawi have large-scale deposits of REE available. Among global REE producers, Burundi is ranked in ninth place producing 1 000 MT of REE in 2018, up from no production in 2017 (Argus, 2019). The Burundian mine is one of the highest-grade REE projects in the world, yet the country lacks the infrastructure and experience to support mining operations (Argus, 2019). The key advantage in Burundi, unlike South Africa, is that there are no radioactive minerals, such as thorium or uranium in the deposit, making the operation less environmentally damaging. In Malawi, there are reported reserves of 2.5 MT of REE (Tubei, 2019).

5.3. The universe of possible solutions

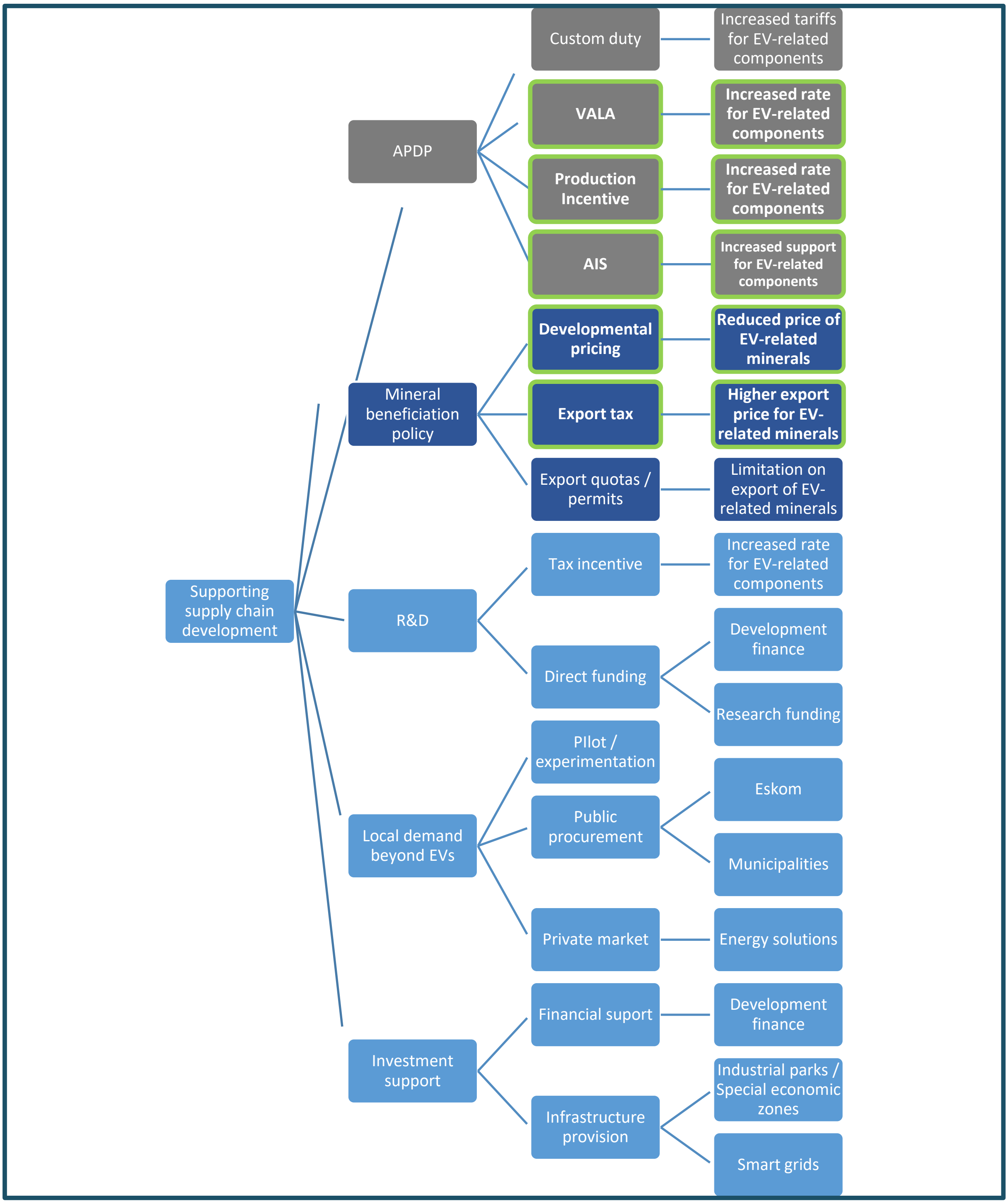
Locally manufacturing EV components and improving the competitiveness of the local industry requires government commitment, working in partnership with component firms, OEMs, mining companies and other relevant stakeholders. Challenges confronting the components industry extend beyond limited R&D, low value-addition in lower-tier suppliers, and low local content levels. Because of this, available options need to be part of a wider strategic plan that is focused on improving growth and creating a competitive components industry.

As shown in Figure 49, the available options take into account various policy tools that can be used to support the supply chain development of EV components in South Africa. To advance the manufacturing components of EVs in South Africa, two main options are available:

1. Using a top-down approach through the APDP pillars, i.e. modifying VALA to include the support of local sourcing for EV components, adjusting the AIS targets to include EV powertrains, LIBs, fuel cells and telematics, and increasing the PI for EV-specific components; and,
2. Using a bottom-up approach to promote value-addition and beneficiation through a mineral beneficiation policy.

An array of complementary intervention could also reinforce the implementation of a top-down and/or bottom-up approach. They range from increased R&D and investment support to stimulating a broader local market (i.e. beyond EVs) for components.

Figure 49: Possible options to support the local manufacturing of EV components



Source: Authors

Note: primary interventions are circled in green and highlighted in bold text

5.3.1. Top-down approach through the APDP

As already discussed in Section 4.3.1, the main avenue to support the automotive value chain is through the existing APDP. As detailed in Table 24, in line with the multi-pronged nature of the APDP, enhanced support for EVs could take different forms.

The revised APDP (from 2021) is expected to increase the local sourcing of components by OEMs in line with the SAAM, notably due to the shift from VAA to VALA. The AIS also targets increased localisation of core technologies, including powertrains, drivetrains and telematics investments by component firms (Engineering News, 2019).

However, the APDP does not make specific provisions for the EV value chain. As far as component manufacturing is concerned, increased EV-specific support could include:

- Rising tariff protection for EV-specific components, such as batteries and electric drivetrains, to protect local manufacturers;
- Increasing the allowance rate of the VALA for EVs, *de facto* providing increased duty credits to EV manufacturers as well as including electric buses in the mechanisms;[44]
- Increasing the PI rate for EV-specific component through a dedicated list of products and/or an amended list of qualifying beneficiated raw materials; and
- Additional support (i.e. higher rate) through the AIS for EV-related investments, such as electric powertrains, wiring harnesses, inverters and telematics.

In practice, due to the high import dependency, increased tariff protection would likely be resisted by stakeholders, leaving the three incentive pillars available for intervention.

Similar to India and Thailand, import duty for EV components could be increased to promote local manufacturing. The Indian government is set to increase customs duty on CBUs of EVs to 40% from the existing 25%, while imports of SKD of EVs will attract 30% customs duty as opposed to 15% applicable currently (Ghosh, 2020). The call to increase import duty would mainly be set to benefit component suppliers in the EV-segment; however, in the South African context, there are two major obstacles to following a similar path to India and Thailand. First, although increasing duties would provide greater protection to the components industry, any change in import duty for components would be subject to high levels of contestation and dispute. And, any increase in duty would have to be tied to a strategy to ramp up local production to produce required EV components and increase localisation. Second, the SADC-EU EPA between the EU and the six countries of the SADC EPA Group[45] which includes South Africa as a member state, contains a preventative clause that prohibits any increase in tariffs, the use of import duties and quantitative restrictions toward the EU. Thus, these drawbacks prevent any form amendment to the APDP to increase import duties to benefit EV-related components.

An increased allowance rate for EVs in the calculation of the VALA would indirectly support the deepening of the EV-related value chain in South Africa. It would incentivise OEMs (which are the final

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[44] MBTs are already included in the APDP.

[45] The SADC-EU EPA Group comprises of Botswana, Lesotho, Mozambique, Namibia, South Africa and eSwatini. Angola has an option to join the agreement in future.

recipient of the benefit) to engage in EV-related manufacturing using local producers to receive higher benefits.

The PI encourages component suppliers and OEMs to source components and parts locally, at a 12.5% duty credit (compared to 10% until the end of 2020). The PI could be increased for EV-related components and raw materials. This could be achieved by increasing duty credits for EV-specific components to a higher rebate with the aim to encourage existing ICE-suppliers to innovate and develop components to meet EV-specifications.

Both the VALA and the PI remain key to promoting local value-add and sourcing of automotive components. The increased support for EV components could boost the production of EV components and make these the component of choice for Tier 1 suppliers and OEMs wanting to offset import duties.

The AIS could also be harnessed to support EV-specific investment. This would be targeted at investments in powertrains, telematics and other EV-specific components. Supporting new technologies in the automotive industry means revising the AIS to include the support of investment, whether R&D, value-add or production, in LIBs and other technologies, such as fuel cells and VRFBs. The offer, however, of a cash incentive through the AIS may not be influential enough to motivate firms to invest in R&D and innovation activities.

In the previous automotive policy framework, the MIDP, a top-down approach was applied, based on a strategy to generate high-value component exports with high-value local raw material input of PGMs. This made catalytic converters, which are platinum-based products, the component of choice for local OEMs wanting to offset import duties. The result was a flow of investment into PGMs (Bronkhorst et al, 2013). Catalytic converters, however, never grew beyond 12%-15% of global market share, irrespective of how remunerative and easy it was to earn credits. The strategy generated a high value of incentives for relatively modest economic activity and was very costly. High-value incentives were provided on a basis that was disproportionate to low employment and other economic benefits, which led to the government reducing the valuation of PGM content on a mid-term revision of the MIDP (Bronkhorst et al, 2013). Following the introduction of the APDP, the incentive scheme changed from a scheme based on export value to production value-add, giving manufacturers less support for exports under the APDP. If a similar approach were to be adopted for PGMs in fuel cell manufacturing using manganese and nickel for LIBs, the strategy would need to consider providing support for expansion into global markets to ensure competitiveness to satisfy the duty pool offsetting levels, while also taking into account advancing the beneficiation of other key EV-related minerals.

5.3.2. Bottom-up approach through a mineral beneficiation policy

A second available option, outside of the APDP, would be to implement a bottom-up approach. It would aim to support value-adding mineral beneficiation and processing by granting preferential access to local and regional mineral resources. For instance, South Africa could, through a mineral beneficiation policy, support the development of value chains around PGMs (for fuel cells), manganese and nickel (for batteries), REE (for drivetrains) and other EV-related minerals. In addition, as one of the SAAM pillars, regional integration in the minerals sector could unlock intra-Africa trade and develop regional value chains for LIBs.

The rationale behind a bottom-up approach in the components industry is that restricting exports of minerals would help foster downstream processing through lower input prices (Tralac, 2017; Fung and Korinek, 2013). However, securing preferential supply of EV-related materials is not a sufficient condition to ensure competitive beneficiation operations on a globally competitive scale. Besides raw materials, the viability of smelting, refining and processing activities depends on a range of factors, such as energy supply and pricing. This could take the form of a developmental pricing policy, export taxes or export quotas. South Africa could implement such measures on available EV-related minerals like PGMs, manganese, nickel and REE materials to secure high-grade core material at low prices for the local production of batteries, fuel cells and other EV-specific components.

The aim of export restrictions (taxes and quotas) on raw materials is to develop processing and value-add activities in downstream and upstream industries. Export restrictions can act as an indirect subsidy to the production costs of manufacturing industries (Tralac, 2017). Imposing export taxes or/and quotas raises the price of raw material for foreign markets, while reducing the relative price for domestic downstream producers, thereby creating an indirect subsidy in their production process. More of the raw material supply would become available for local manufacturers, at below world market prices (Fung and Korinek, 2014). Although they do not generate revenues, export quotas would also achieve similar objectives, but quantitative export restrictions, including export quotas and export bans, are generally prohibited under World Trade Organization (WTO) regulations and the SADC-EU EPA. Jiang (2018) notes that although these restrictions are prohibited, WTO members may appeal to the five major General Agreement on Tariffs and Trade (GATT) exceptions.[46] It is argued that the imposition of export restrictions should be on a temporary basis as a second-best option. Rather, governments should replace export restrictions with alternative regulations and policy instruments that are more effective in achieving the same goals (Jiang, 2018).

The average export tax on unprocessed and semi-processed raw materials usually ranges from 3% to 9.45% (Korinek, 2015). This OECD report by Korinek noted that, if the relative price of steel for local firms was reduced by 10% as a result of an export tax on iron ore exports, this would reduce the price of local steel by between 0.6% and 1.3%, and so would have minimal impact on the cost-competitiveness of South African steel. Because manganese and iron ore are inexpensive to mine, one can assume that these results would be similar for manganese ore.

According to Fung and Korinek (2014), mineral prices are not, on their own, influential in the competitiveness of a country's industrial sector. Local industrial producers receive little to no advantage from their presence in the host country because they still have to pay global prices further inflated by the transport costs for imports of additional products they are unable to source locally (Fung and Korinek, 2014). However, the developmental pricing intervention could be thought of as a move away from global prices to one that offers an advantageous price to local producers. This is expected to have a positive impact on the beneficiation of raw materials, and subsequently manufacturing. The then-Department of Mineral Resources (DMR), now Department of Mineral

[46] The five major GATT exceptions are Article XI:2(a), Article XX(b), XX(g), XX(i) and XX(j). Article XI:2(a) allows countries to impose export restrictions "temporarily" to prevent or provide relief for "critical shortages" of foodstuffs or other essential products; Article XX(b) permits WTO members to adopt export or import restrictions that are "necessary to protect human, animal or plant life or health"; Article XX(g) permits WTO members to adopt WTO-inconsistent measures relating to "the conservation of exhaustible natural resources"; Article XX(i) permits the use of export restrictions that have been implemented in an effort to keep the domestic price of certain raw materials below the world price as "part of a governmental stabilization plan" aimed at ensuring the availability of essential quantities of raw materials for domestic industries; Article XX(j) permits WTO members to impose export restrictions on certain products in the event of 'local short supply' provided that all members are able to obtain an "equitable share" of these products (Jiang, 2018).

Resources and Energy (DMRE), formulated strategies for beneficiation of minerals through the amendment of the Mineral and Petroleum Resources Development Act No 28 of 2002 (MRPDA), which includes the introduction of developmental pricing – a price regulation implemented to achieve the securing supply for mineral and petroleum products. Developmental pricing is effectively a set cost plus pricing regulation based on facilitating the attractiveness for investment in the minerals value chains in South Africa and on upgrading industry activities to higher value addition or/and beneficiation (Gova, 2017).

The desired outcome of the pricing is to reduce input costs and ensure competitive local pricing for downstream industries in the components value chain (Gova, 2017). In addition, beneficiation can stimulate labour-absorbing downstream industries through increased access to minerals. The success of such a local beneficiation policy would require an investigation into the capacity of foundries to ensure that they can absorb the increase in capacity; however, this remains a challenge for the South African industry (see Box 11). According to Gova (2017), the MRPDA does not specify the pricing methodology which would be enforced under developmental pricing conditions. Therefore, for a developmental pricing to be effective as a policy instrument, the DMRE would need to determine the price at which earmarked materials should be made available under developmental pricing, and also the possible impact this might have on investment returns in the mining industry.

Tier 3 firms supplying raw materials are an integral part to localisation in the automotive industry – securing their supply at an affordable rate is a key determinant of cost and production levels in upstream manufacturing. However, low input costs are neither a sufficient condition for processing and value-add to take place, nor are they the only factor that determines whether processed products are sufficient to attract new investment. Development of downstream activities requires significant investment in supporting infrastructure. The supply of electricity that is both cheap and reliable appears to have reached its limits in South Africa and cannot support the smelting and processing of manganese.

Indeed, such a bottom-up approach could only be used to enhance already viable activities. The success in developing a local fuel cell manufacturing industry in South Africa lies in mineral beneficiation strategies, as well as advanced manufacturing, which requires investment in infrastructure in mining and smelting activities. Using local platinum reserves for local beneficiation in the fuel cell manufacturing may facilitate the increase in fuel cell exports, thereby growing a stronger fuel cell industry for the country. That said, mineral beneficiation activities in South Africa have become decreasingly viable because of fast-rising electricity prices. For example, while South Africa's production of manganese ore has expanded significantly (Figure 45), most refining and processing of manganese ore takes place outside of the country (Figure 46). Many refining, processing and smelter facilities in South Africa have either shut down or are struggling to survive as a result of high electricity prices (among other factors).

To successfully support local beneficiation, government policy, including the SAAM, would need to continue supporting the development of local/regional capabilities and well-priced inputs (from raw materials to energy).

At the regional/continental level, although additional trade costs, such as border inefficiencies and poor infrastructure, may result in significantly negative trade effects (Moremong, 2019), the AfCFTA could also ease the process of manufacturers importing raw materials from other African countries. In addition, because many countries on the continent may not have the governance structures, capital or resources required to develop strong regional value chains, the building of partnerships for a regional beneficiation infrastructure for the development of battery value chains is crucial (SAIIA, 2019). Moreover, geopolitical issues and human rights abuses in the mining of raw materials in some African countries impacts on the availability and accessibility of these resources. As such, there is a need for regional LIB value chains and for the automotive industry to support the responsible, ethical and sustainable sourcing of minerals and recycling processes.

Another consideration in supporting regional LIB value chains is the cumulation of local content with respect to rules of origin. As raised in Section 4, cumulation generally refers to rules of origin – the restrictions in trade agreements that define how much value a country must add to a product or component for it to be said to have originated in that specific country. Cumulation of rules of origin allows for the value added by any other country to count as local value add. Under the SADC-EU EPA, component manufacturers in either a SADC EPA state or the EU can use originating materials in the other countries as if they originated in their own country to grant preferential originating status on goods traded between them. This enables the facilitation of better intra-regional trade and integration by the EPA. The cumulation of local content could work in a similar way as it does for rules of origin in that a good would be said to be "local" irrespective of whether it was produced in South Africa for example, or in a regional partner subject to the agreement (Wood, 2017).

5.3.3. Complementary measures

In addition to the main policy options discussed above, several complementary options that could be implemented to support the main options are discussed below.

Investment in R&D is one of the main determinants for advancing new technologies, an aspect critically important in the automotive industry. The local industry would benefit from additional support to encourage domestic investment in R&D, largely targeted at lower-tier suppliers. The DSI's R&D tax incentive serves as an alternative support to the AIS cash grant for component suppliers, particularly for existing lower tier suppliers struggling to increase R&D expenditure and for new entrants in EV-related manufacturing. This would be used to incentivise the adoption of new emerging technologies, and encourage innovation and product development specific to EVs, adding to the existing range of requirements by OEMs. Without research funding and strong R&D capabilities, adapting to changing technologies would be impossible for local suppliers. Furthermore, the incentive should encourage R&D partnerships and collaboration between industry and universities. Not only does this promote and improve knowledge transfer, but it also allows companies to spread costs and risks implied by undertaking new R&D, and to internalise any spill-over effects associated with the creation of new knowledge (Aristei et al*,* 2016).

Government and other local funding organisations need to provide financing and investment support for companies, both small and large, and industries championing and advancing new technologies in the automotive industry (for example LIB production, fuel cell manufacturing and the manufacturing of charging infrastructure). The uptake of production in the local battery and fuel cell industries depends primarily on these industries' ability to secure demand through long-term supplier contracts by OEMs, government incentives and a procurement policy strategy (driven by Eskom and municipalities). This would enable suppliers to scale-up and better position themselves to supply components beyond the automotive industry.

Following a similar intervention by the Thai government, South Africa could add key EV components to a list of products exempt from the corporate income tax (CIT) for a number of years. For Thai component manufacturers, these include EV batteries, telematics, battery management services, EV charging infrastructure and EV powertrains (Smart International Energy, 2018. In addition, investment by manufacturers in these items would result in additional privileges, as well as a 50% cut on CIT (Smart International Energy, 2018). A reduced CIT could lead to improvements in companies advancing technologies and encouraging investment in the local industry.

More broadly, government, using the industry's enhanced capabilities, mineral beneficiation policies and the APDP (through the PI and AIS), could actively promote the development of a sourcing hub in South Africa. This would rely on attracting both local vehicle assemblers and vehicle importers to use South Africa as a sourcing hub for EV-related components supplying wiring harnesses, LIBs, fuel cells and possibly headlights, taillights and inverters to regional and global automotive markets.

Indeed, South Africa has emerged as a major sourcing destination for catalytic converters, engines and related parts and radiators, but remains marginal with EVs. The core idea would be for South Africa to become a key supplier (in full or parts) of batteries, fuel cells and inverters, wiring harnesses[47] and other EV-related components.

The local capacity in the country could be harnessed accordingly. For instance, in June 2020, Metair Investments secured a key contract to supply automotive components to new Ford vehicles manufactured in South Africa. Metair's Hesto Harnesses will be the largest beneficiary, supplying a wide range of wire harnesses to Ford. Other subsidiaries, including Unitrade, Automould and Lumotech, will provide a variety of wires, plastic and chrome-plated parts, as well as headlights and taillights (all EV-related components) (Cokayne, 2020). Although Ford has not yet provided details on its expansion plans in South Africa, these developments aim to increase localisation and local market growth whilst participating in GVCs.

This would require leveraging excise duties and possibly a tax incentive linked to localisation to support the growth of local industrial capacity in EV-related component production. An effective export hub would also require strengthened regional value chains. Although African automotive markets are small, they are relatively well-established and their robust growth could offer South African component suppliers an opportunity to increase their export competitiveness, economies of scale and reduce their dependence on the local vehicles industry.

5.4. Exploring the socio-economic costs and benefits of key options

5.4.1. Modifying the APDP in support for local sourcing and value-add of EV components

The APDP framework is the main avenue through which the automotive value chain in South Africa is supported. This mechanism could be used to further support the manufacturing of EV-specific components, through a mix of changes to customs duties, the VALA, the PI and the AIS.

The implications of key choices are discussed in Section 4.4.1. Some of the key implications to consider for this option are that, in the case of local manufacturers (OEMs), additional and significant investment is required to increase the support toward the local production of EVs in South Africa. The expected drawbacks are that, in the long run, increased EV support may be conditioned to reduced support for ICE vehicle manufacturing. Compared to local manufacturers, importers are not directly affected by a change in the APDP; however indirectly, importers would be penalised compared to local manufacturers. Government would have to negotiate additional benefits for EV manufacturing with

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[47] The increased integration of electronic devices and infotainment systems in vehicles should positively affect demand for automotive wiring harnesses.

relevant stakeholders, while also setting aside additional financial resources. This would result in the increased long-term sustainability of the local automotive industry.

In the short run, volumes of locally produced EV components would be low, generating diseconomies of scale. Increased support through the APDP would help mitigate the impact of high production costs. Importantly, due to the amount of uncertainty surrounding EV development in South Africa, expectations linked to changes to the APDP relating to EV-components should be managed. Former Minister of Trade and Industry, Rob Davies, described local content targets as "ambitious" for component suppliers and OEMs, and there are concerns on whether companies can achieve these targets.

Caution should also be raised on mandatory local content requirements in the short term. While localisation requirements can be powerful tools, they can also serve as a disincentive for large suppliers and OEMs. Importantly, the use of mandatory local content requirements is not permitted under the Trade-Related Investment Measures (TRIMS) Agreement and by the 1947 GATT Article III. Also, mandatory targets could deter new investment in the automotive industry, particularly if a supply base for EVs does not exist. For example, Tesla had expressed that it wanted to set up local manufacturing in India. However, because of the country's local content requirements at 30% for components, including EV components, Tesla considered delaying its investment. The Indian government took a decision to remove local content requirements for Tesla, granting the OEM a temporary relief on import restrictions for components (Kapur, 2018). In addition, unrealistic requirements could prevent firms from sourcing inputs from lowest-cost suppliers available and lead to higher prices for domestically sourced components. Higher costs are nevertheless economically justified in the short term if domestic firms acquire the industrial capabilities to manufacture high value-add components.

Table 32 details the implications of adjusting the APDP support of EV components. The implications of adjusting the APDP to support EV related components would require both local manufacturers (OEMs) and suppliers to invest in EV manufacturing domestically. The expected benefits of increased investment for local manufacturers are the increased availability of local, competitive EV components and reduced logistics cost, allowing firms to generate savings. For component suppliers, especially lower tiered suppliers, the expected benefits are increased likelihood of long-term contracts with local manufacturers and support for the development of new products and competencies, important for strengthening the automotive value chain. However, one of the biggest costs for lower tier suppliers is that this option could result in higher production costs in the short run as new products are developed. Tier 3 suppliers are also set to benefit from the increase in local demand for EV-related raw materials.

Table 32: Implications of adjusting the APDP to include increased support for EV-related components

STAKEHOLDERS	IMPLEMENTATION REQUIREMENTS	EXPECTED BENEFITS	EXPECTED COSTS
OEMs (manufacturers)	Negotiation of additional benefit for EV manufacturing Investment in EV manufacturing domestically.	Increased support for local EV manufacturing Increased price differential between locally manufactured and imported vehicles. Higher availability of local, competitive EV components.	None in the short to medium term. In the long run, increased EV support may be conditioned to reduced support for ICE vehicle manufacturing. Higher cost of EV-related imports in case of tariff protection.

		Reduced logistic costs.	Higher cost of input in the short term if associated with unrealistic local content requirements.
OEMs (importers)	None	None	No direct cost. Indirectly, importers would be penalised compared to local manufacturers. Higher cost of EV import in case of tariff protection.
Tier 1 suppliers (manufacturers)	Negotiation of additional benefit for EV manufacturing Investment in EV manufacturing domestically.	Increased support for local EV manufacturing. Increased price differential between locally manufactured and imported components. Increased likelihood of long-term contracts with OEMs. Support for the development of new products and competencies.	None in the short to medium term. In the long run, increased EV support may be conditioned to reduced support for ICE vehicle manufacturing.
Tier 1 suppliers (importers)	None	None	No direct cost Indirectly, importers would be penalised compared to local manufacturers.
Tier 2 suppliers	Negotiation of additional benefit for EV manufacturing Investment in EV manufacturing domestically.	Increased support for local EV manufacturing Increased price differential between locally manufactured and imported components. Increased likelihood of long-term contracts with buyers. Support for the development of new products and competencies.	Higher production cost in the short term as new products are developed. In the long run, increased EV support may be conditioned to reduced support for ICE vehicle manufacturing.
Tier 3 suppliers	Negotiation on list of supported raw materials and possible quid pro quo	Increase local demand for raw materials.	None
Middle- to high-income households	None	Reduced price of EV produced domestically (compared to imported EVs) if costs savings are passed through.	No direct cost Increased price differential between imported and locally made vehicles if costs savings are passed through Indirectly, increased support to automotive manufacturing industry would divert government resources from

			other priorities (opportunity cost).
Low-income households	None	Reduced price of public transportation if cost savings are passed through to vehicle manufacturing and to customers.	No direct cost. Indirectly, increased support to automotive manufacturing industry would divert government resources from other priorities (opportunity cost).
Government	Negotiation of additional benefit for EV manufacturing. Additional financial resources. Monitoring and evaluation.	Increased long-term sustainability of the local automotive industry. Increased levels of local content and value-add.	Increased financial requirements associated with the APDP (possibly cost neutral if support for ICE is reduced accordingly). Increased support could artificially support inefficient firms.

Source: Authors

From the above table, changing the APDP to include EV components presents greater benefits than costs for the competiveness and long-term sustainability of the automotive industry. Table 26 lists the main arguments for and against the above option. Key arguments for modifying the APDP is that it gives local suppliers an opportunity to expand their product range and support local manufacturers in EV production; however, concerns remain as the industry struggles with diseconomies of scale and high production costs.

Table 33: Principal arguments for and against modifying the APDP in favour of greater support for EV components

FOR	AGAINST
- Using the VALA and PI leverages the existing APDP programme, limiting implementation requirements. - Opportunity for the local suppliers to expand their product range and meet required specifications for local and international markets. - Additional investment in capabilities, product development and infrastructure support are required to boost supply base for value-add EV components in the local industry.	- The automotive industry continues to struggle to secure local content to support the ICE market and, because of this, targets for EV components might also not be realised. - The challenge of diseconomies of scale is likely to be exacerbated if firms were to produce EV components – as low volumes would reinforce the industry's high cost structure and lack of competitiveness.

Source: Authors

5.4.2. Mineral beneficiation policy for EV-related materials

Table 34 details the implications of a mineral beneficiation policy for EV-related raw material. The implications of a mineral beneficiation policy strategy for EV related minerals – either in the form of an export tax/quota or developmental pricing – would have the largest impact on Tier 2 and Tier 3 suppliers, while Tier 1 importers and households are expected to benefit from this strategy through reduced public transportation prices, that is if cost savings are passed through to vehicle manufacturing and to customers. There would be increased local demand for EV-related mineral products from Tier 3 suppliers, as well as the increased opportunity for local beneficiation by downstream component manufacturers. Tier 3 suppliers would, however, suffer from a loss of revenue from forgoing export parity prices. Tier 1 and Tier 2 suppliers would benefit from lower relative pricing of local raw materials compared to foreign competitors (resulting from developmental pricing and/or preferential access to local raw materials).

Table 34: Implications for a mineral beneficiation policy for EV-related materials

STAKEHOLDERS	IMPLEMENTATION REQUIREMENTS	EXPECTED BENEFITS	EXPECTED COSTS
OEMs	None	Higher availability of local, competitive EV components Reduced logistic costs.	Higher cost of EV-related imports.
Tier 1 (manufacturers)	Negotiation of mineral beneficiation policy.	Preferential access to local raw materials. Relatively lower price of local raw materials and other material inputs compared to foreign competitors.	Higher cost of EV-related imports.
Tier 1 (importers)	None	None	No direct cost. Indirectly, importers would be penalised compared to local manufacturers.
Tier 2 suppliers	Negotiation of mineral beneficiation policy.	Preferential access to local raw materials Relatively. lower price of local raw materials compared to foreign competitors.	None
Tier 3 suppliers	Negotiation of mineral beneficiation policy.	Stronger local demand for minerals Increased opportunity for local beneficiation.	Loss of revenue from forgoing export parity pricing.
Middle- to high-income households	None	Reduced price of EV produced domestically (compared to imported EVs) if costs savings are passed through.	No direct cost. Increased price differential between imported and locally made vehicles if costs savings are passed through. Indirectly, increased support to automotive manufacturing industry would divert government resources from other priorities (opportunity cost).
Low-income households	None	Reduced price of public transportation if cost savings are passed through to	No direct cost. Indirectly, increased support to automotive manufacturing industry would divert government resources from other priorities (opportunity cost).

		vehicle manufacturing and to customers.	
Government	Negotiation of mineral beneficiation policy.	Increased revenue from export tax only.	Risk of trade dispute if export restrictions are pursued. Risk of path dependency and difficult in removing the scheme in the long run.
Mining value chain	None	Mineral industries, metal smelting, refining and processing are set to benefit when more and cheaper raw materials become available locally.	No direct cost. Indirectly, these industries will require additional investment to support infrastructure and new technology.

Source: Authors

Given the cost and benefit analysis outlined above, key arguments for a beneficiation strategy highlight the importance of promoting local beneficiation and encouraging value-add activities in local minerals industries. Although this strategy has lagged, it has long been championed by the government as one of the major drivers for advancing industrialisation through developing mining value chains. Electricity remains, nevertheless, a huge challenge for mineral beneficiation in the country.

Table 35: Principal arguments for and against a mineral beneficiation policy for EV-related raw materials

FOR	AGAINST
- Export restrictions and developmental pricing could promote local and regional beneficiation and encourage value-add for locally sourced EV-related components. - Lower input prices for raw materials could attract new investment into the LIB manufacturing. - The policy, if a success, could create increased capacity for the smelting and processing of locally sourced raw materials.	- South Africa and developing countries' previous attempts at using export restrictions has been unsuccessful, therefore the success of this policy is uncertain and meeting intended developmental goals is not definite. - Without a cheap reliable supply of electricity and supporting infrastructure, a beneficiation policy is unlikely to result in significant gains.

Source: Authors

5.5. Policy implications

In conclusion, strengthening the components industry in the EVs value chain would require an amendment of the APDP policy framework with greater support for EVs and new technologies, and possibly support from a mineral beneficiation policy in the form of export restrictions and developmental pricing.

For VALA requirements to be effective, local components should be competitive in price, quality and Just-in-Time. This can happen only with improved infrastructure support for suppliers, increased investment and firms securing economies of scale. It remains important for government to caution against a flood of imports, so local sourcing and value-add for EV components should be accompanied by increased production and competitiveness by component suppliers and the local manufacturing of

EVs. Real contributions to increasing investment and upgrading technological and production capacities remain important to achieve VALA and PI targets for EV components.

The refining and beneficiation of minerals could promote the competitiveness of the South African mining sector while ensuring value-adding activities in manufacturing. Export restrictions or developmental pricing could be used to secure PGMs, manganese and nickel supply for local LIB and fuel cell production at local prices, in a bid to develop the local industry. However, for export restrictions, Jiang (2018) and other research suggests that these restrictions should only be used as a second-best option because they often do not achieve their desired objectives. Favourable terms for sourcing raw material brought about by export control measures do not directly get production to respond when existing capacity is limited. Similarly, the advantage of cheap local supply of the raw material can be offset by other major constraints on the operation and growth of the processing industries and their export performance.

Breaking into the LIB and fuel cell markets will be challenging for South Africa. However, with demand rapidly growing, the availability of raw materials locally and in the region, and the impending need for low-cost alternatives for manufacturers, opportunities do exist for South Africa and other emerging economies. If South Africa is to take full advantage of manufacturing EV-specific components, it must attract substantial interest and investment from the private sector and government agencies. Furthermore, locally based OEMs with plans to locally manufacture or import EVs would benefit from the availability of LIBs and fuel cells on the local market. The successful development of an EV component industry requires commitment and active involvement of all stakeholders along local and regional value chains.

For policy instruments to work effectively in support of EV components, world-class manufacturing capabilities need to be deepened within component supply chains, and new investment by OEMs and large suppliers is needed to ensure that suppliers are able to secure local demand for EV components. Importantly though, the long-term objective of increasing local content and value-add for EV components cannot be instantly brought to reality without addressing wider and deeper structural challenges faced by the local industry. Indeed, the key pillars of the APDP framework should not be seen as a panacea for every challenge in the domestic industry.

The development of the EV-related components industry and raw materials is heavily dependent on the growth of demand for EVs and support for production. Looking ahead, the industry faces many challenges, in its current state producing solely for the ICE market. Similar to EV OEMs, supporting the production of EV components sends the right signal to suppliers and manufacturers, both local and foreign, that South Africa is encouraging production and deepening its capabilities in EV components and technologies in the automotive space. The success of policy interventions in supporting the South African automotive industry will ultimately depend on the extent to which these policies can influence competitiveness and facilitate the integration of the local industry into the global value chain.

6. CONCLUSIONS

As highlighted throughout this report, the development of e-mobility is a multi-faceted endeavour. Even considering solely the passenger market (i.e. passenger cars, buses and MBTs), crafting a policy framework aimed at fostering the sector requires the consideration of multiple angles. Four key questions were considered, covering both market development and industrial development.

On the market development front, the first question related to how the offer of passenger EVs could be supported. This is critical to ensure that a) EVs are available on the local market, and b) customers are enticed to buy them. The second question dealt with the rollout of EVs in South Africa's public transportation system. Public transport enables society-wide benefits by bringing the technology to all, particularly low-income households.

On the industrial development front, the first question considered how to promote the manufacturing of EVs (cars, buses and minibuses) in the country. A transition of the local manufacturing industry is fundamental to its long-term sustainability. The second (and last) question investigated the ability of South Africa to support the automotive value chain, particularly component manufacturing, by leveraging the country's (and region's) mineral resources, such as PGMs, manganese, nickel and REE.

For each of these questions, many options exist to support the industry. Only a few are, however, sensible in the short term, particularly considering the interdependencies between the various aspects. One option, on its own, is unlikely to deliver the kind of transition that would deliver the intended benefits. Importantly, options are not mutually exclusive and should be pursued in parallel. In addition, various secondary options have been discussed and collectively (as part of a package of options), these could contribute to an enabling environment that would support the primary options.

Promoting an equitable rollout of EVs in the country hinges on simultaneously tackling the private and public passenger transport markets, where the high upfront cost of EVs represents the biggest barrier. A reduction in the VAT and/or ad valorem excise duty on EVs would be an effective avenue to support the market. A partnership between DFIs and local banks to provide low interest rate to EVs buyers would also go a long way in improving the cost competitiveness of EVs. For passenger cars, addressing the tariff anomaly (on BEV originating from the EU) would assist with levelling the playing field. On the public transport side, demand should be supported by proactive procurement by municipalities and a reform of the TRP. Fleet-level targets would also help getting tractions for both markets. In all cases, strong partnerships are needed, as well an iterative approach to ensure appropriateness within the South African context.

On the industrial development side, an addendum to the APDP, aimed at enhancing support for EV manufacturing would be the primary avenue to send a positive signal to industry. Crafted adequately, this could support both EV manufacturing as well as the development of component manufacturing, leveraging South Africa's mineral resources. Increased local demand would also support domestic manufacturing. This is particularly evident with electric buses and minibuses. In addition, consideration should be given to a mineral beneficiation policy (such as an export tax) to support manufacturing of EV-specific components, such as batteries, electric drivetrains and fuel cells.

Overall, strong signals are required to kickstart the development of EVs in South Africa. In light of the nascent nature of the sector, a trial-and-error approach, leveraging pilots as well as phased mechanisms, would be the most sensible approach in the short term. This would enable government and relevant stakeholders to tailor support packages in line with market responses as well as address any drawbacks or shortcomings. It is also recommended that public policy does not actively discriminate between technologies. BEVs, hybrids and FCEVs all have a role to play in the transition to e-mobility and the multiplicity of options offers the opportunity to pair technologies with specific usages and functions.

Beyond this report, many other areas remain to be explored in further detail, both for enhancing co-benefits and minimising disruptions and drawbacks. First, a comprehensive approach should consider the rollout of e-mobility across all segments, including two- and three-wheelers, light commercial vehicles and trucks. Second, the interplay of EVs with their broader environment, particularly the energy sector, should be given more attention. The direct relationship between e-mobility and the electric and hydrogen value chains needs to be further unpacked to adequately plan their development. The impact of e-mobility on spatial development and municipalities should also be paid more attention, especially as MaaS increasingly develops. Third, a deeper understanding of short-term impacts (both positive and negative) on the economy and society should be gained. This is crucial to ensure a just transition to e-mobility, minimising job losses (in the liquid fuel value chain for instance), maximising employment creation in new economic activities (such as green hydrogen), and guaranteeing a progressive rollout of EVs to all.

Importantly, further work should not hinder progress. The time to act is now. EV sales are growing exponentially, but apart from a few exceptions, they are still marginal globally. This offers South Africa a window to position its economy and society appropriately. In the long run, rolling out EVs brings multiple co-benefits, from lower transport costs, to reduced dependency on imported fossil fuels, to improved air quality. It is also the only avenue to maintain the long-term sustainability of the local manufacturing industry. In the process, some dynamics will have to be managed to minimise disruptions, particularly in the electricity and liquid fuel value chains. The progressive nature of the transition should, however, enable the country to do this without major complications. In turn, missing the curve would have dramatic consequences on the country.

EVs represent the only platform to a modern, sustainable transport system in the country and globally. Coupled with the transition to renewable energy technologies (from solar and wind energy to green hydrogen), increased connectivity and changes to spatial development, they also are the road to smart cities, inclusive development and a sustainable economy.

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ANNEXURES

Annex A: Comparing Vehicle Technologies using the Levelised Cost of Transport Model

This study leveraged and built on the LCOT model developed by Sustainable Energy Africa (SEA) (Change Pathways, 2018). The model was used to:

- Compare a range of private passenger BEVs available, or expected to be available in 2020, to ICE vehicle alternatives (see Section 0); and
- Compare BEV bus and minibus taxi (MBT) to ICE alternatives (see Section 3).

The model compared a range of vehicles and technologies, as shown in Table 36.

Table 36: Technologies and vehicles included in the LCOT

	BEV	ICE
Private Passenger[48]	• BMW i3 eDrive • Jaguar I-Pace EV400 AWD s - HSE • Audi e-tron* • Nissan Leaf Gen 2*	• BMW 3 series 320i - 330d • Jaguar E-Pace • Audi Q8 (55 TFSI - 45 TDI) • Nissan Micra Visa - Tekna Plus
Public Passenger	• Battery Electric Vehicle Minibus Taxi (MBT) • Battery Electric Vehicle Passenger Commuter Bus (Bus)	• Internal Combustion Engine Minibus Taxi (MBT) (Petrol) • Passenger Commuter Bus (Bus) (Diesel)

Source: Authors

**Forthcoming: costs based on reported estimates*

The LCOT approach establishes the cost of supplying the transport service over the life of the vehicle and is expressed in units of Rands per passenger.km (R/pkm) and is calculated as follows:

$$\text{Levelised Cost of Transport} = \frac{\sum_{t=1}^{n} \frac{I_t+M_t+F_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}}$$

....Equation 1

Where:

I_t = Investment expenditures in the year t

M_t = Operations and maintenance expenditures in the year t

F_t = Fuel expenditures in the year t

E_t = passenger.km delivered in the year t

r = Discount rate

n = Life of the vehicle

[48] The Mercedes-Benz EQC was not included in the analysis due to a lack of available information on the expected vehicle price in South Africa.

A number of parameters have been included in determining the expenditures I, M and F as follows:

- Investment Cost
- Interest Rate on Finance
- Discount Rate
- Economic Life
- Technical Life
- Fixed Costs (licensing, insurance, etc.)
- Maintenance Costs (these are modelled to escalate with mileage)
- Fuel Costs
- Real Fuel Cost Escalation

The approach is therefore similar to a TCO approach that has been used to compare emerging vehicle technologies (see Section 0). In this case, however, all costs are discounted as is the transport/energy service delivered (passenger.km – p.km) in the same way that electricity power plants are typically compared with one another.

Key assumptions and parameters used in LCOT modelling are summarised in Table 37 (Fuel cost assumptions), Table 38 (public transport) and Table 39 (passenger cars).

Table 37: Fuel and electricity assumptions

		High (+30%)	Low (Apr 2020)	
Diesel (R/litre)	Public	R 16.56	R 12.74	Wholesale: inland
	Private	R 16.56	R 12.74	Wholesale: inland
Petrol (R/litre)	Public	R 15.40	R 11.84	Retail: inland
	Private	R 15.40	R 11.84	Retail: inland
		High	Low	
Electricity (R/kWh)	Public	R 2.07	R 0.78	95% at depot charging (Eskom Megaflex- High: R1.87; Low: R0.56 /kWh), 5% public fast charging (Grid Cars – Standard R5/kWh)
	Private	R 2.90	R 1.16	95% at home charging (City of Cape Town – High: R2.78/kWh (domestic); Low: R0.95 /kWh (commercial), 5% public fast charging (Grid Cars – Standard R5/kWh)

Source: Authors

Table 38: Public vehicle assumptions

Vehicles	ICE MBT	BEV MBT	ICE Bus	BEV Bus
Fuel	Petrol	Electricity	Diesel	Electricity
Investment Cost:	R 437 000	R 648 246	R 3 151 400	R 8 000 000
Nominal Interest Rate:	0.25	0.25	0.12	0.12
Inflation	0.05	0.05	0	0
Repayment Period	5	5	8	8
Deposit	0	0	0	0
Base Maintenance (c/km)	66	43	250	195
Licensing (R/annum)	R 450	R 450	R 1 000	R 1 000
Parking (R/annum)	R -	R -	R -	R -
Insurance (R/annum)	R 6 000	R 6 000	R 50 000	R 50 000
Occupancy:	12	12	25	25
Real Discount Rate:	0.2	0.2	0.15	0.15
Technical Life:	12	12	20	20
Fuel Economy	7.5	17.5	36	93.24
Units	(l/100km)	kWh/100km	(l/100km)	kWh/100km
Real Fuel Price Increase	0.01	0.01	0.01	0.01
Charging Losses	0	0.15	0	0.15

Source: Authors

Table 39: Private vehicle assumptions

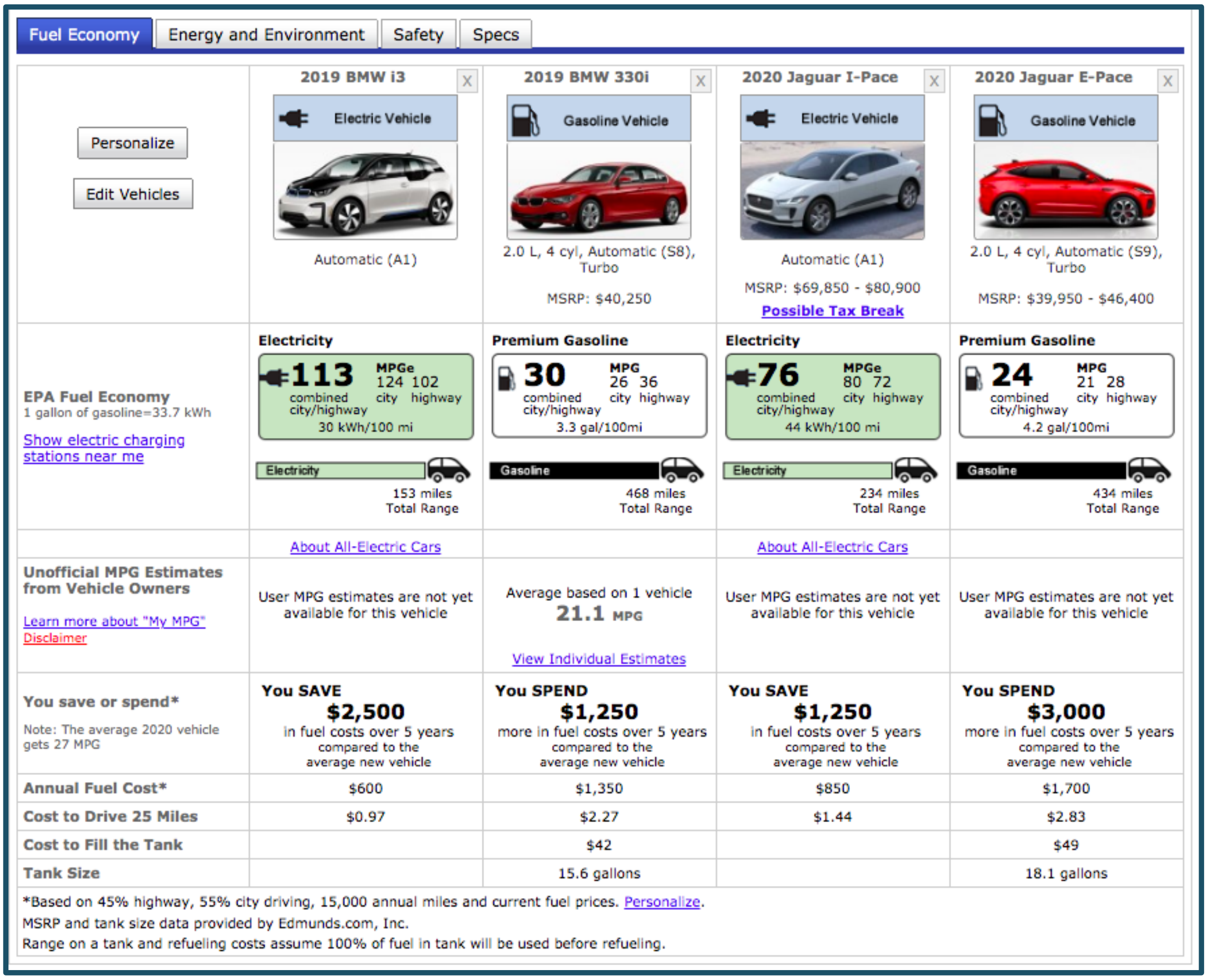
Vehicles	Audi Q8 (55 TFSI - 45 TDI)	Audi e-tron	Jaguar E-Pace	Jaguar I-Pace EV400 AWD s - HSE	BMW 3 series 320i - 330d	BMW i3 eDrive	Nissan Micra Visa - Tekna Plus	Nissan Leaf Gen 2
Fuel	Diesel	Electricity	Diesel	Electricity	Petrol	Electricity	Petrol	Electricity
Tech	SUV	SUV	SUV	SUV	Car	Car	Car	Car
Investment Cost:	R 1 423 000	R 1 600 000	R 816 289	R 1 785 750	R 721 131	R 734 300	R 307 300	R 492 038
Nominal Interest Rate:	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Inflation	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Repayment Period	5	5	5	5	5	5	5	5
Deposit	0	0	0	0	0	0	0	0
Base Maintenance (c/km)	222	144	127	83	112	112	48	48
Licensing (R/annum)	R1 092	R 1 092	R 1 092	R 1 092	R 912	R 912	R 396	R 396
Parking (R/annum)	R-	R-	R-	R-	R-	R-	R-	R-
Insurance (R/annum)	R 14 400	R 14 400	R 14 400	R 14 400	R 14 400	R 14 400	R 8 400	R 8 400

Occupancy:	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Real Discount Rate:	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Technical Life:	12	12	12	12	12	12	12	12
Fuel Economy	7.5	17.5	7.5	22	7.5	13.1	7.5	13.1
Units	(l/100km)	kWh/100 km	(MJ/km)	kWh/100 km	(l/100km)	kWh/100 km	(l/100km)	kWh/100 km
Real Fuel Price Increase	0.01	0.02	0.01	0.02	0.01	0.02	0.01	0.02
Charging Losses	0	0.15	0	0.15	0	0.15	0	0.15

Source: Authors

Annex B: Vehicle efficiency comparison

Figure 50: Comparison of fuel economy of BMW and Jaguar BEV to ICE vehicles



Source: US EPA (https://www.fueleconomy.gov)