THE ELECTRIC VEHICLE ECOSYSTEM AND ASSOCIATED VALUE CHAINS

The role the City of Cape Town can play in the Electric Vehicle Ecosystem

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Acknowledgements

We thank Wilberforce W. Chege for the time and effort that he has put into compiling this report.

Cape Town, South Africa

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List of abbreviations and acronyms

AASA	Automobile Association of South Africa
AC	Alternating current
AEM	Automotive Export Manual
AfCFTA	African Continental Free Trade Area
AIS	Automotive Investment Scheme
Al	Aluminium
APDP	Automotive Production and Development Programme
ARA	Automotive Remanufacturers' Association
AU	African Union
AV	Autonomous vehicles
BEV	Battery electric vehicle
BFP	Basic fuel price
BMS	Battery management system
BnB	Bed and Breakfast
BRT	Bus Rapid Transit System
C	Carbon
CaF_2	Calcium Fluoride
CBT	Carbon Tax
CCA	Customs controlled area
CCS	Combined Charging System
CO_2	Carbon dioxide
CoCT/CCT	City of Cape Town
CPD	Continuous Professional Development
CPO	Charge point operator
CPUT	Cape Peninsula University of Technology
CSIR	Council for Scientific and Industrial Research
CSP	Concentrating Solar Power
Cu	Copper
DC	Direct current
DEFF	Department of Environment, Forestry and Fisheries
DG	Distributed Generation
DMEA	Department of Mineral and Energy Affairs
DMRE	Department of Mineral Resources and Energy
DoE	Department of Energy
DoT	Department of Transport
DRC	Democratic Republic of Congo
DST	Department of Science and Technology
DTI	Department of Trade and Industry
DTIC	Department of Trade, Industry and Competition
E-buses	Electric buses
EC	Eastern Cape
EG	Embedded Generation
E-mobility	Electric mobility
eNaTIS	Electronic national administration traffic information system
EPR	Extended Producer Responsibility
ES	Energy storage
ESG	Environmental, social, and governance
EU	European Union
EV	Electric vehicle
EVSE	Electric Vehicle Charging Service Equipment
FCEV	Fuel Cell Electric Vehicle
FDI	Foreign Direct Investment
GERPISA	Le Réseau International de l'Automobile (International Automobile Network)
GDP	Gross domestic product
GHG	Greenhouse gases
G20	Group of Twenty
GMA	Gautrain Management Agency
GP	Gauteng Province
GTS	Green Transport Strategy
GW	Gigawatts
H_2	Hydrogen
HCV	Heavy commercial vehicles
HEV	Hybrid electric vehicle
HFCEV	Hydrogen Fuel Cell Electric Vehicle
HVAC	Heating, ventilation, and air conditioning
ICA	International Copper Association
ICCU	Integrated Charging Control Unit
ICE	Internal combustion engine
IDC	Industrial Development Corporation
IDZ	Industrial Development Zone
IEA	International Energy Agency
IFC	international Finance Corporation
IGO	Inter-governmental Organisation
IPP	Independent Power Producer
ITAC	International Trade Administration Commission
Km/a	Kilometres per annum
KWh	Kilowatt-hour
KZN	KwaZulu-Natal
LCO	Lithium cobalt oxide
LCV	Light commercial vehicles
LFP	Lithium iron phosphate

Li	Lithium
LIB	Lithium-ion battery
LMO	Lithium Manganese Oxide
LTO	Lithium Titanate
MaaS	Mobility-as-a-Service
MBT	Minibus taxi
MERSETA	Manufacturing, Engineering and Related Services Sector Education and Training Authority
MCV	Medium commercial vehicles
MHEV	Mild hybrid EV
MIR	Market Intelligence Report
MIWA	Motor Industry Workshop Association
Mn	Manganese
NAAMSA	National Association of Automobile Manufacturers of South Africa
NADA	National Automobile Dealers' Association
NCA	Lithium nickel cobalt aluminium oxide
NEC	Nippon Electric Company
NEV	New energy vehicle
NHTS	National Household Transport Survey
NMBLP	Nelson Mandela Bay Logistics Park
NMC	Nickel manganese cobalt oxide
NPI	Nickel pig iron
OCGT	Open Cycle Gas Turbine
OEM	Original equipment manufacturer
OPEC	Organization of the Petroleum Exporting Countries
PAYD	Pay as You Drive
PAYS	Pay as You Save
PGM	Platinum Group Metal
PHEV	Plug-in hybrid electric vehicle
PI	Production incentives
PJ/a	Petajoules per annum
PM	Particulate matter
PPA	Power purchase agreement
PPP	Public Private Partnership
PPPFA	Preferential Procurement Policy Framework Act
PRCC	Production Rebate Credit Certificate
PTRC	Porsche Training and Recruitment Centre
PV	Photovoltaic
RAF	Road Accident Fund
R&D	Research and development
RE	Renewable energy
REE	Rare earth elements
RII	Regulations, Infrastructure, and Innovation
REIPPP	Renewable Energy Independent Power Producer Procurement
RMI	Retail Motor Industry Organisation
RMPPP	Risk Mitigation Power Procurement Programme
SA / ZA	South Africa
SAAM	South African Automotive Masterplan
SABS	South African Bureau of Standards
SADC	Southern African Development Community
SAMBRA	South African Motor Body Repairers Association
SAPRA	South African Petroleum Retailers Association
SAVABA	South African Vehicle and bodybuilders' Association
SEZ	Special Economic Zone
SISR	SADC Industrialisation Strategy and Roadmap
SOV	Single occupancy vehicle
SSA	Sub-Saharan Africa
SSEG	Small scale embedded generation
STRAPSA	Shifting the Transport Paradigm for South Africa
TBC	To be confirmed
TEPA	Tyre, Equipment, Parts Association
Ti	Titanium
TIA	Technology Innovation Agency
UCT	University of Cape Town
UNIDO	United Nations Industrial Development Organization
US/USA	United States of America
USGS	United States Geological Survey
UWC	University of the Western Cape
V2G	Vehicle to Grid
V2H	Vehicle to Home
V2L	Vehicle to Load
V2X	Vehicle-to-everything
VAA	Vehicle assembly allowance
VALA	Volume assembly localisation allowance
VTA	Vehicle Testing Association
WC	Western Cape
XHCV	Extra-heavy Commercial Vehicle

Exchange rate conversion

An exchange rate of 1 USD = R15 was used

1 EXECUTIVE SUMMARY

The South African electric vehicle ecosystem includes a network of organisations – suppliers, distributors, customers, competitors, government agencies, NGOs, IGOs, academia, research, and training institutions – involved through both competition and cooperation. A variety of key players are competing to shape the nascent South African EV market, drawn from both the public and private sectors. The private actors are, however, currently more active, and dominant in the making of the ecosystem and its operation in its current form. The exact dynamics of the industry are still emerging, and the timing of key tipping points remain largely unknown.

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The electric vehicle ecosystem has been segmented into the following categories;

a) Automotive manufacturing

The automotive manufacturing sector is a key player in the country's economic landscape, contributing 6.4% of the gross domestic product (GDP), R201,7 billion in export revenues, and 27.6% of manufacturing output in 2019. Total revenue from this sector was more than R500 billion (US$35.6 billion) in 2019, with the industry employing up to 900 000 people directly and indirectly – including downstream in wholesale, retail trade, and maintenance. Because of South Africa's competitiveness in automotive production, which is mostly due to the relatively low labour costs, the country already has an existing vehicle export market where up to 64% of the vehicles produced locally are exported to the European Union, Japan, Australia, the United States, and 131 other destinations. Several international vehicle original equipment manufacturers (OEMs) operate in the country, serving both the domestic and export markets. These vehicle OEMs are now looking to pivot from primarily manufacturing internal combustion engine vehicles to electric vehicle manufacturing, as they work to future-proof themselves, increase competitiveness, and build resilience.

b) Battery and cell manufacturing and the mining of battery minerals

Batteries are the key component of an EV, making up about 40%-50% of the battery-electric vehicle's value, and the supply of battery minerals remains the largest limiting factor to electric vehicle production globally – primarily copper, nickel, cobalt, and lithium. EVs require significantly more mineral resources, about six times as much as the conventional ICE vehicle, and with the transition to renewables, there would be a significant increase in the demand for minerals. The EV battery market is currently highly geographically concentrated and is dominated by Asian countries and companies, with China, Japan and South Korea providing for up to 97% of the current global LIB demand, however, this dominance is expected to reduce in the coming years as other players invest in this market.

The uptake of EVs and the growth of the distributed generation market are projected to drive battery growth in the coming years, and they have already surpassed portable electronics as the main source of battery demand. However, because of the limited EV uptake in the country presently, the LIB industry has yet to take off. South Africa currently has no local commercial production of battery cells and relies on assembling imported cells. This is likely to continue being the case until significant scale is reached, providing demand and a business case for LIBs. An increase in EV demand and uptake would improve the business case for local battery manufacturing because of the inter-dependency and symbiosis between the two industries.

With circularity in mind, there is a need to investigate ways in which to reduce metal usage in battery chemistries as well as new chemistries and use cases such as second-life use in EVs and micromobility. Extracting the various mineral components of a battery has proven difficult and costly in the past, and recent research is focussing on ways to reuse cathodes and other battery parts mineral usage. Recycling would have the added benefit of reducing the demand for new mines.

c) Charging infrastructure

The EV charging infrastructure market is projected to grow in tandem with the growth in EVs. Locally, the private sector has until now been driving the roll-out of charging infrastructure in the country with limited support from the government, and there are now about 280 publicly accessible charging stations, and 350 connectors since some of the charge points have two connectors. Only 11 of these have the CHAdeMO connector type and are meant to provide charging to the 91 Nissan Leaf EVs, which are the only EVs in South Africa that utilise the CHAdeMO connector standard. The rest are Combined Charging System (CCS) connector type stations. There is however limited geographical coverage of charging stations in the country, with strategic placement on the major inter-city/inter-provincial highways and national roads.

Three business models have emerged in this space:

i. Asset light model
ii. Asset heavy model
iii. Battery swapping as a Service mode

d) Energy supply and the electricity grid

A prime challenge to the EV ecosystem, from the mining of lithium-ion battery minerals to the charging infrastructure value chain, is the availability of electricity. By the end of 2020, South Africa had 51.6 GW of wholesale/public nominal capacity, according to the CSIR. In the same year, load shedding occurred for 859 hours of the year (9.8%) with an upper limit of 1 798 GWh relative to an achieved energy shed of 1 269 GWh – the worst the country has experienced.

With the recent changes in regulations allowing for the procurement of energy from Independent Power Producers (IPPs) and the desire to increase procurement of renewable energy as expressed in the Renewable Energy Independent Power Producer Procurement (REIPPPP) Bid Window 5 programme, several players have emerged in this landscape. The mineral needs however vary among the different clean energy technologies; with the transition to renewables, there would be a significant increase in the demand for minerals.

e) Financing

There are currently no specially tailored EV financing schemes in the South African market, with banks and other financial institutions not yet providing vehicle financing to EVs. All the EV models currently available in the South African market however cost more than R450 000, which is out of reach of most vehicle buyers in the country. Several local banks, including ABSA, Nedbank Group, FirstRand Limited, and First National Bank (FNB) have recently announced new policies to suspend financing of future fossil fuel and carbon-intensive projects to improve their environmental, social, and governance (ESG) credentials. This could be the watershed moment for the financing of e-mobility in the country.

f) Research & Development Network

The EV value chain needs a specialised skills set of personnel available once production comes online for it to invest in new production capacity and supply chains. Due to the chronic skills gap in the country, many of the OEMs and content suppliers are experiencing labour shortages, which is a problem likely to get worse as the country tries to capture some of the jobs that decarbonisation will bring.

The shortage of technical skills remains a major concern. This is an area in which the public sector and academic and training institutes could play a role to develop the necessary training materials and courses and provide funding for the related technical courses such as engineering.

What is evident however is that the adoption of new EV value chains is not only dependent on the engineering and manufacturing side but also on understanding the new needs and demands of the customer.

g) Electric vehicle consumer demand – the end-user

A 2020 national EV perception survey conducted over 12 months on more than 3 000 car buyers found that 1.8% of the respondents have owned an EV, 13% have driven one, and 68% would want to own one in future. Most of the respondents, i.e., 86% would be open to using an EV as their primary vehicle, rather than as a second vehicle.

The unavailability of public and home charging infrastructure (61%), charging times (59.6%), and cost (55%), were cited by the respondents as the biggest barriers to EV ownership in South Africa, which is not surprising considering the cheapest EV available in the country costs over R 450,000, and there are only 280 publicly accessible charging stations in the country.

Opportunity rating matrix

Opportunity	Economic & job creation potential (1-10)	Relevance for CCT (1-10)	Opportunity rating (1-10)
Automotive and component manufacturing and assembly	9	9	9
Battery and cell manufacturing and assembly	6	5	5.5
Mining (of battery minerals)	4	0	2
Charging infrastructure provision	3	4	3.5
Energy provision and electricity supply (renewable energy and grid services)	5	9	7
Innovative financing	2	1	1.5
Research and development	1	2	1.5
Skills development and training	9	9	9
Consumer demand	3	7	5

Summary: Intervention breakdown

Intervention type	Intervention description	Responsible stakeholder
Incentives – Subsidies and support	Incentives and subsidies to reduce the upfront capital cost of purchasing an EV and allow EVs to compete favourably with ICE vehicles. These could include: • customs control providing duty and VAT advantages, i.e., suspension or complete elimination; • access to "Free Ports" and other duty-free areas adjacent to ports of entry where imported goods may be unloaded for value-adding activities, storage, repackaging and processing; • access to "Free Trade Zones" and other duty-free areas offering storage and distribution facilities for value-adding activities for subsequent export; • provision of land and properties for lease, with additional tax reliefs and building allowances; • reduced electricity tariffs for manufacturers; • access to worker recruitment and training services, with additional employment tax incentives; • preferential Corporate Tax rates; • security and other services in enclosed and fenced off areas; • logistical and telecommunication solutions facilitating increased accessibility to the market (major population centres); • access to export markets via ports and international airports; • enhanced access to municipal services; and • investor support and access to incentives available from the national, provincial, and local governments.	National government (DTIC) City of Cape Town – Enterprise & Investment Atlantis Special Development Zone (ASEZ)
Tax incentives and rebates	Import/export credit for EVs and incentivisation for increased levels of localisation (for domestic production).	National Government (DTIC)
Reduced EV charging electricity tariff	Favourable electricity tariffs for off-peak charging.	City of Cape Town – Electricity Generation and Distribution

Intervention type	Intervention description	Responsible stakeholder
Access to electricity	• Initiate, through enabling regulations, a customer-focused response at scale driven by small-scale embedded generation (residential), embedded generation (commercial/agricultural), Embedded Generation (EG) / Distributed Generation (DG) (industrial/mining), and storage. • Address remaining capacity/energy gaps through an accelerated DMRE RMPPP (Risk Mitigation Power Purchase Programme) process to ensure sufficient capacity is available and online when required. • Explore the need to upgrade the electricity grid, particularly in implementing smart grid, grid management, and smart charging to account for the increased electricity demand. • Explore the feasibility of vehicle-to-grid (V2G), vehicle-to-home (V2H), inductive charging, and wireless charging for electric vehicles. • Support the implementation of IRP 2019 as an immediate focus to ensure sufficient lead-time for procurement processes and technology-specific construction lead times. • Invest in a diversified source of new energy supply, i.e., from renewables such as wind and solar. • Promote research and technology innovation at all segments along the value chain for more efficient use of materials, facilitate material substitution, and foster resilience along the supply chains by conducting regular assessments of potential vulnerabilities and the potential collective responses. • Create policy frameworks to promote ESG (environmental, social, and governance) standards and incentivise recycling and strategically targeted R&D into new recycling and second-life usage applications and technologies. • Provide reliable and transparent data and promote knowledge transfer and capacity building to support SMMEs and grow the EV ecosystem.	City of Cape Town – Electricity Generation and Distribution National Government (DMRE) Eskom
Procurement of EVs	Procurement of EVs for future City of Cape Town (CCT) vehicle fleets.	City of Cape Town – Procurement/Supply Chain Management
R&D funding	A readily available pool of local technical and fundamental capacity, through skilled workers. Investment into training, academia, and skills development.	City of Cape Town – Enterprise & Investment
Access to capital	Through concessional funding, private and venture capital, loans, and grants, and non-financial investment promotion, partnerships, and vertical integration. The city's role could include offering credit guarantees for EV loans and working with OEMs, dealerships, and commercial banks to develop innovative vehicle ownership models, such as Mobility-as-a-Service (MaaS), vehicle leasing rather than ownership models, and/or enabling finance terms specifically tailored for EVs. This could also include detaching batteries from the financing of the vehicle; thus, the batteries could be financed separately over a longer time, thereby reducing the monthly cost.	City of Cape Town – Enterprise & Investment

Intervention type	Intervention description	Responsible stakeholder
Standardisation	Components such as connectors, safety systems, and power rating, which are at advanced stages, can be standardised to create standards and technical norms e.g., ensure vehicles can conveniently be connected to the grid to recharge and allow for interoperability. The goal should however be global standards to avoid technological islands, and this standardisation should exclude the technologies that are still innovating and are at a nascent stage of development - to allow the market to evolve freely.	South African Bureau of Standards (SABS)
Charging infrastructure	• Policy interventions such as updating the building codes to require provisions for workplace charging or home charging. • Technology standards to require interoperability in public charging.	City of Cape Town – Sustainable Energy Markets
Advocacy	Support in creating demand for EVs and the scale required to aid in the creation of a vibrant EV industry – i.e., automotive manufacturing, battery and component manufacturing, recycling, etc. Raising awareness of the benefits of EVs and a low-carbon future. The communication process should ideally focus on educating the consumer about electric vehicle ownership and viability compared to their existing ICE vehicle, and not just the environmental benefits.	City of Cape Town – Enterprise & Investment City of Cape Town – Transport

2 INTRODUCTION

The transport sector has been identified as a key contributor to global greenhouse gas (GHG) emissions because of its reliance on fossil fuels. Of global greenhouse gas emissions, 15% can be attributed to the transport sector. There is now a global consensus that the climate targets that have been set, particularly for the automotive sector by 2030, cannot be met without EVs being incorporated into the transport system. Internal combustion engine (ICE) improvements alone are insufficient to achieve these targets.

Electric vehicles globally are projected to experience steady growth, largely due to:

- a favourable confluence of factors, including the national emission reduction commitments stemming from the Paris Agreement on climate change;
- growing concerns about urban air pollution due to increasing motorisation and pollution in cities;
- continued crude oil price volatility;
- a substantial decline in electric vehicle (EV) costs led by falling battery prices; and
- favourable policies leading to greater uptake of electric mobility.

This report aims to increase the understanding of the role that the City of Cape Town (CCT) can play in the electric vehicle space, with guidance on the key 'entry points' where high impact can be achieved. This work is in line with CCT's vision for net-zero carbon emissions by 2050; and will provide support to CCT's transition into a lower carbon mobility future. The analysis in this report has been done by mapping the clusters/categories in the EV ecosystem and identifying the key and relevant actors and stakeholders in the different clusters through direct stakeholder engagement and desktop research. This report will identify the key role-player clusters that allow this industry to function and grow in the future, including the original equipment manufacturers (OEMs), electricity utility and independent power producers (IPPs), EV charging providers, EV owners (private), vehicle and project financiers and developers, EV fleet owners (Mobility as a Service, MaaS), the research and development network, customers, key suppliers, and the respective channels.

A high-level description of the business models currently being implemented is also presented, as well as a case study of a local Cape Town-based company transitioning to an EV fleet, and the benefits accrued to them from this transition. A discussion of where there are 'niches' in the ecosystem and associated value chains for CCT to intervene to drive impact and develop and grow the EV ecosystem and value chain is also presented as recommendations at the tail-end of this report. It is, however, beyond the scope of this project to recommend corrective measures to overcome identified and mapped challenges.

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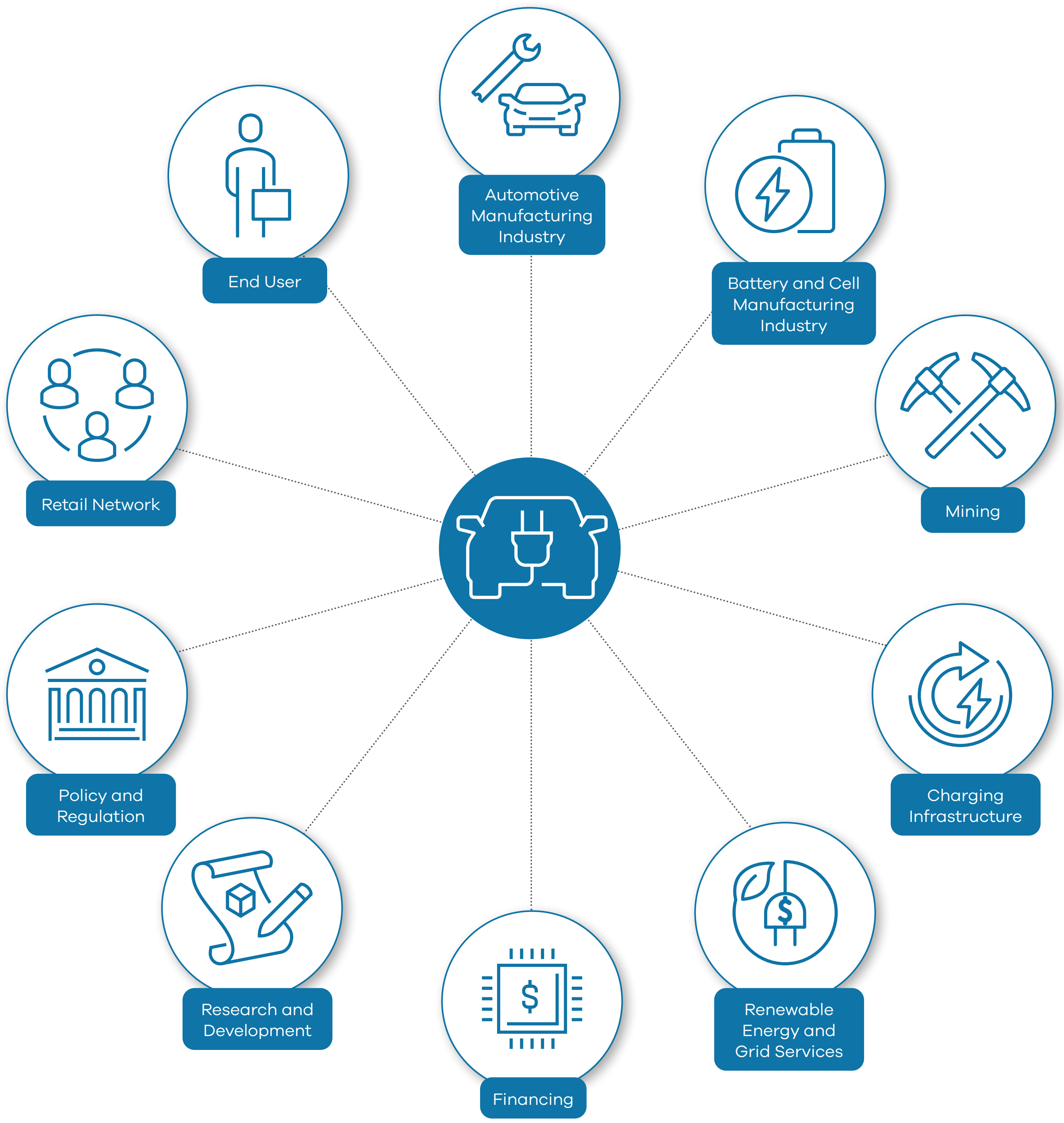
Figure 1: The Electric Vehicles Ecosystem



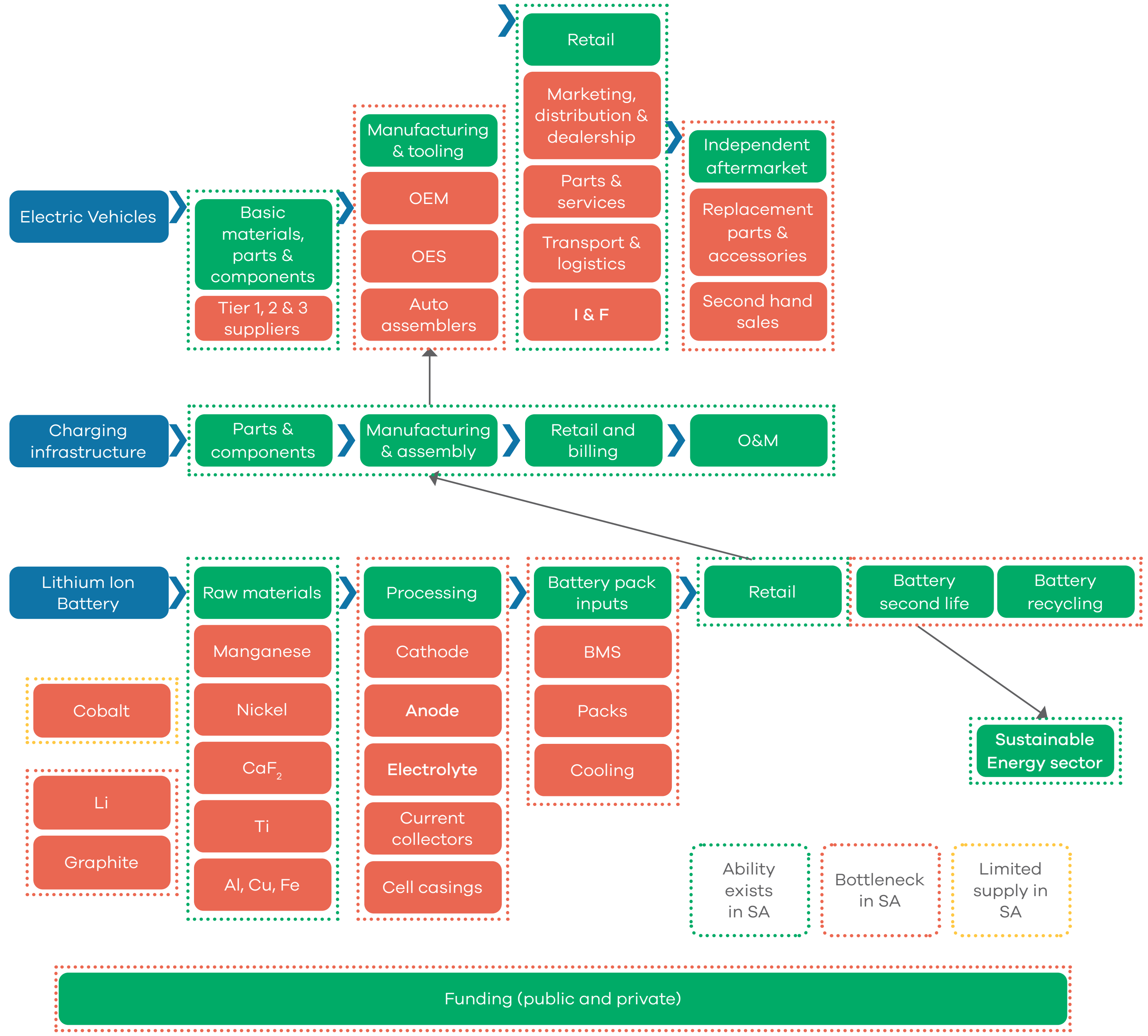
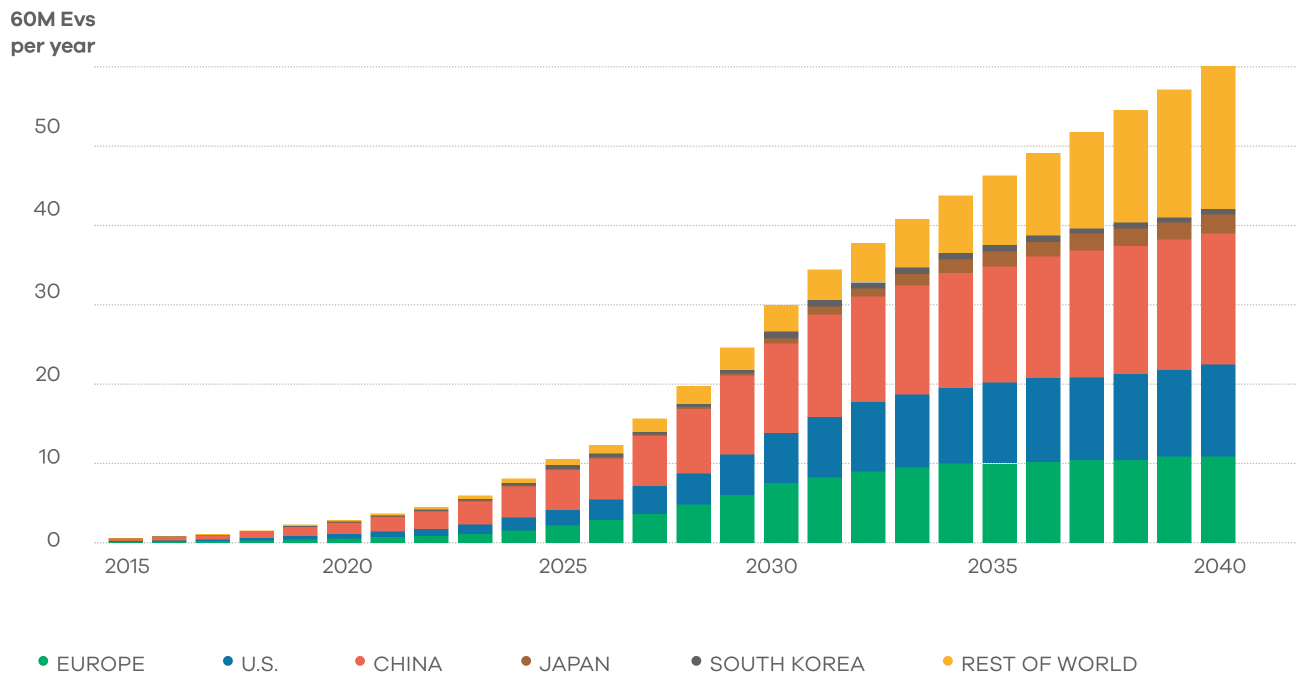


Figure 2 illustrates the global increase in EV sales over the past five years. These figures are projected to increase at a near-exponential rate over the current and next decade.

It is projected that by 2030, 40% of all new car sales in the European Union will be electric, and this is to grow to 80% by 2040 (European Commission, 2020).

Figure 2: Global increase and projections of EV sales

Source: (BloombergNEF)



Locally, most of the automotive original equipment manufacturers (OEMs) are making investments into EVs as they realise the disruption and transition happening in the automotive industry. These companies are engaging in new supply chain partnerships and investing in strategically targeted R&D, skills development, and training as they seek to future-proof their businesses. Some examples of these activities will be outlined later in this report.

The number of EVs sold to date in South Africa as a proportion of overall vehicle sales since 2010 has been small (< 1%) as shown in Table 1.

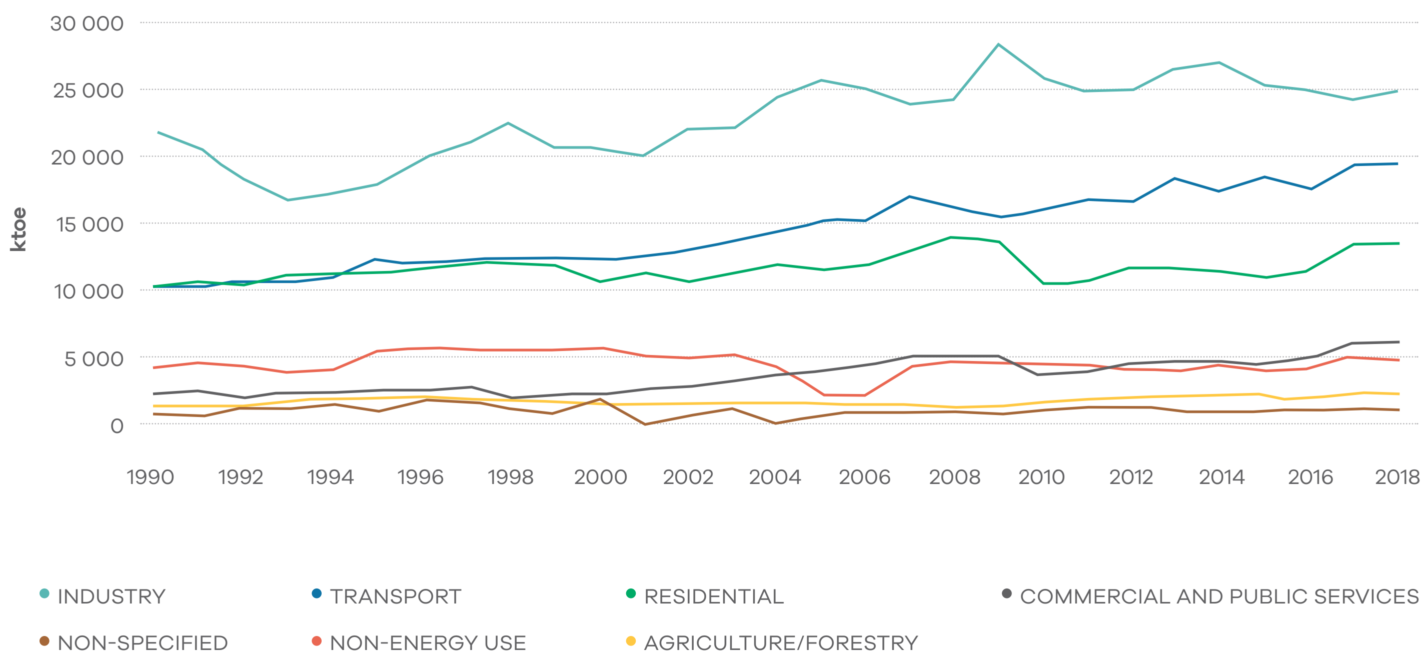
Table 1: Total vehicle sales in South Africa between 2010 and 2019

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
	%	%	%	%	%	%	%	%	%	%
ICE Total	**99.87**	**99.84**	**99.83**	**99.88**	**99.85**	**99.88**	**99.87**	**99.90**	**99.94**	**99.89**
Petrol	85.53	85.78	84.38	82.26	82.04	82.68	82.22	82.10	82.80	84.25
Diesel	14.34	14.06	15.44	17.62	17.81	17.19	17.65	17.80	17.14	15.63
EV Total	**0.13**	**0.16**	**0.17**	**0.12**	**0.15**	**0.12**	**0.13**	**0.10**	**0.06**	**0.11**
PHEV	-	-	-	-	-	0.03	0.05	0.03	0.02	0.02
BEV	-	-	-	0.01	0.00	0.03	0.03	0.02	0.02	0.04
HEV	0.13	0.16	0.17	0.11	0.15	0.06	0.06	0.05	0.02	0.05

The transport sector is also the second-largest source of GHG emissions, at about 10.8%., It is the fastest-growing source of GHG emissions in the country, accounting for 91.2% of the increases over the past decade (NAAMSA, 2020). South Africa contributes about 1.1% of overall global emissions, according to the Department of Transport's Green Transport strategy. Road transport accounts for 91% of direct emissions across the transport sector, primarily from the combustion of fossil fuel and the fuel quality in South Africa that is at a Euro 2 level.

The Department of Transport (DoT) contends that fossil fuels, at 92%, are the largest source of primary energy in South Africa (DoT, 2018); the highest in the Group of Twenty (G20). Emission intensity, on the other hand, is almost double the average of the other G20 countries (DoT, 2018).

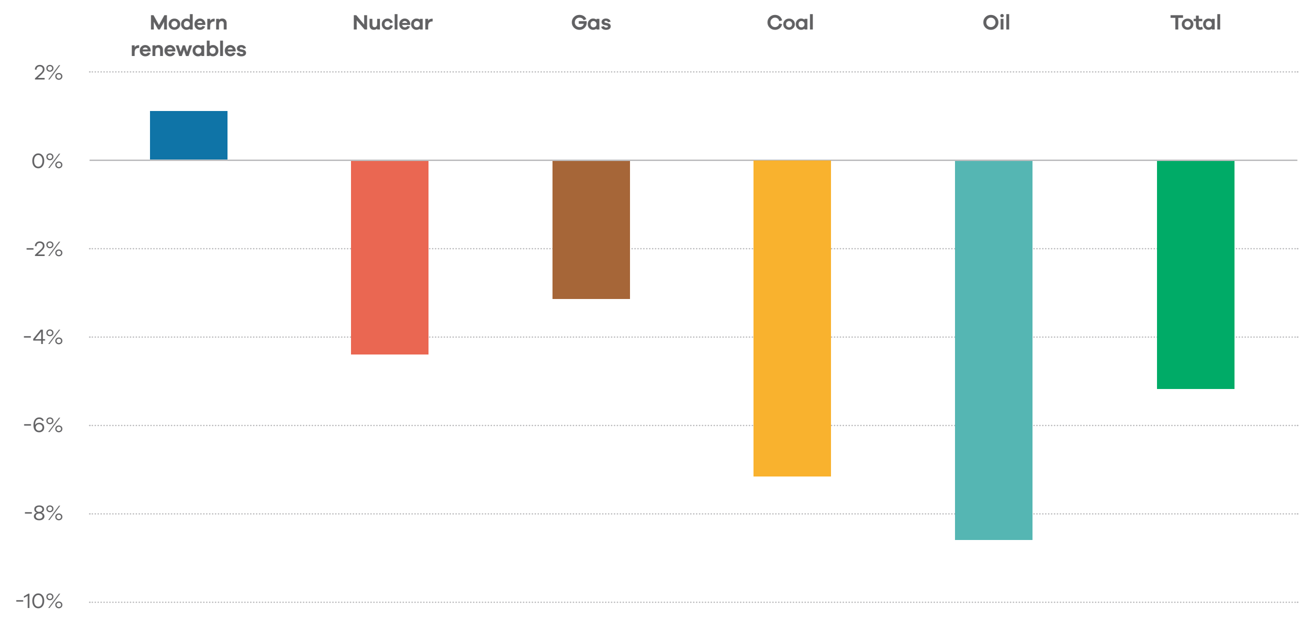
Figure 3: South Africa's total final consumption (TFC) of energy by sector, 1990-2018
Source: (IEA, 2020)



For the City of Cape Town (CCT), the emergence of an EV industry is necessitated by a need to achieve CCT's environmental and climate commitments and targets such as carbon-neutrality by 2050, since the transport sector is the second-largest source of greenhouse gas (GHG) emissions in Cape Town. The climate targets already set for the automotive sector cannot be met without electric vehicles (and other electric automobiles such as electric bikes, electric scooters, and micro-mobility) in the vehicle modal mix as ICE improvements alone are insufficient to make a significant impact.

Accounting for upstream emissions, however, EVs are only as green as the energy source used to power them. Powering EVs using electricity from coal sources is counterproductive. Renewable energy sources like wind and solar are increasingly being seen as more ideal options, in line with the global clean and just energy and urban transition. As illustrated in **Figure 4** below, renewable energy is the only energy source that grew in 2020 (IEA, 2021).

Figure 4: Change in demand of each energy source between 2019 and 2020
Data sourced from the International Energy Agency



3

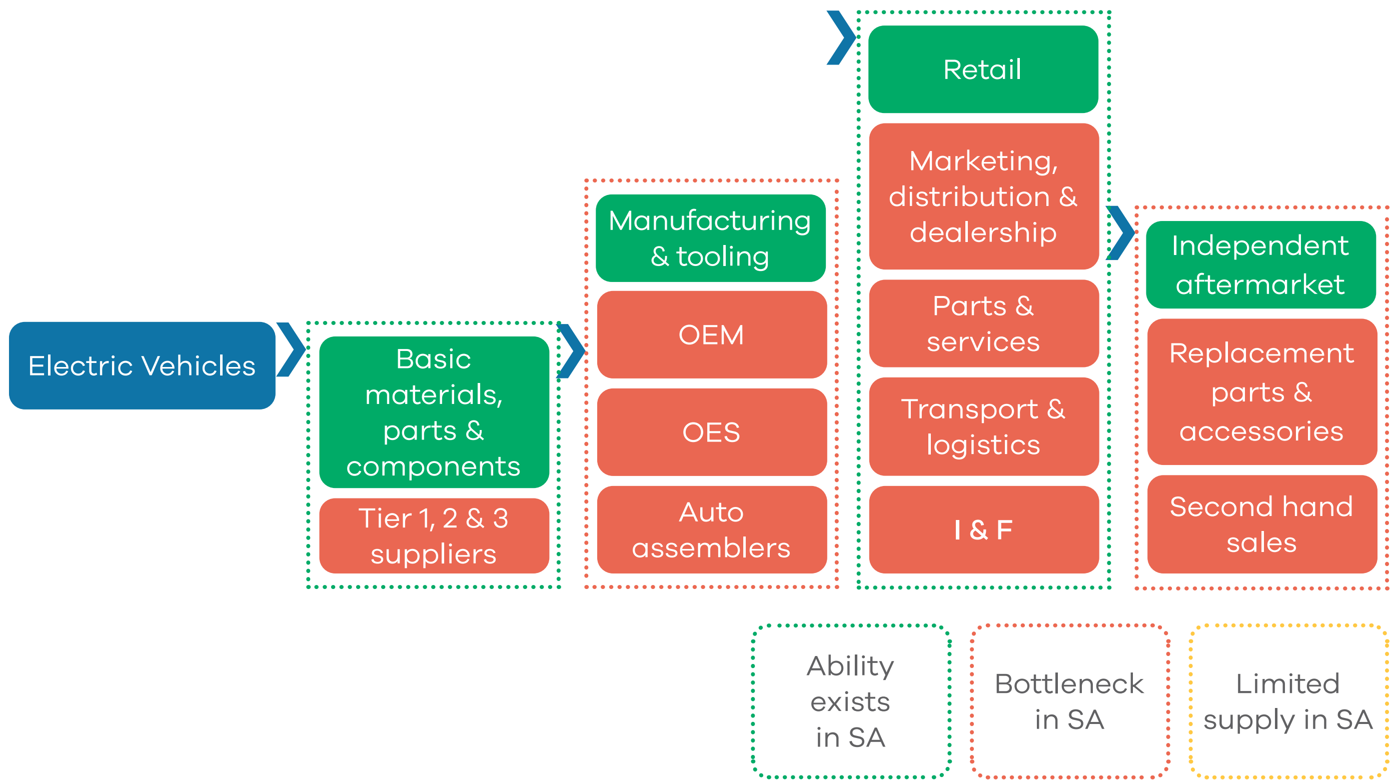
The local automotive manufacturing industry – Localising the EV value chain

3.1.

Automotive manufacturing value chain

The figures below summarise the automotive value chain for electric vehicles, and how the different segments and components fit together to produce a vehicle as the output.

Figure 5: The automotive manufacturing value chain



South Africa has a strong existing world-class automotive industry and a market for the assembly of internal combustion engine (ICE) vehicles. The automotive sector is the largest manufacturing sector in the economy and a priority industry under the Industrial Policy Action Plan, and thus receives strong government support. The country is also classified as a second-tier market and net exporter of vehicles. In fact, more than 600 000 ICE vehicles were manufactured in 2019 (the year preceding the Covid-19 pandemic and disruptions from the lockdowns), predominantly destined for the export market, with the automotive sector gaining R10.8 billion in foreign direct investment (FDI) (Naamsa, 2020). Technically, however, South Africa assembles rather than manufactures vehicles, because some of the components are imported and not made locally. This is a key reason for the low local content in the automotive industry

Figure 6: The electric vehicles manufacturing value chain

	Materials	Component production	Component assembly	System assembly
Electric Vehicle	• Steel • Aluminum • Copper • Glass • Rubber • Special fibers • Plastics • Lead • Titanium • Magnesium	• Catalytic converters • Shock absorbers • Clutches/shaft couplings • Axles & filters • Auto tooling • Brake pads • Engines • Ignition/starters • Gaskets • Gear boxes • Radiators • Tyres & glass	• Vehicle Chassis • Drive train • Tyres • Propulsion system	• Electric Vehicle
Solar PV	• Silicon & glass • Cement & concrete • Iron & steel • Polymers & plastics • Aluminium & alloys • Copper and Alloys • Other metals & minerals (e.g., cadmium)	• Cells • Aluminum Frames • Super-substrate (glass) • Backing sheet • Ethylene Vinyl Acetate (EVA) • Copper wiring • Junction box • Magnetics • Transformers • Circuit boards • Electronics • Enclosures • Steel profiles • Aluminium profiles • Clamps • Nuts & bolts. • Conductors • Insulation • Armour	• Modules • Inverters • Mounting structures & trackers • Cabling	• Solar PV System
Battery Storage (e.g.,lithium-ion)	• Cobalt • Graphite • Lithium • Manganese • Nickel • Titanium • Phosphate • Aluminium • Copper • Iron • Polymers & plastics	• Cathode • Anode • Electrolyte • Separator • Current collectors • Cell casings • Electronics	• Battery pack • Battery manage-ment system • Cooling system • (Inverter)	• Energy Storage System

The automotive manufacturing sector is a key player in the country's economic landscape, contributing 6.4% of the gross domestic product (GDP), R201,7 billion in export revenues, and 27.6% of manufacturing output in 2019. This decreased to R175,7 billion in export revenues and 18,7% of manufacturing output in 2020 because of the Covid-19 pandemic. Total revenue from this sector was more than R500 billion (US$35.6 billion) in 2019, with the industry employing up to 900 000 people directly and indirectly – including downstream in wholesale, retail trade, and maintenance. Exports of automotive products reached a record of R178.8 billion in 2019, shipped to 155 export destinations, up from 149 in 2018 (Cision, 2019). The government, through the South African Automotive Masterplan (SAAM) coming into effect from July 2021, has in recent years sought to further support the growth of this industry by pushing for increasing local content – the percentage of locally produced parts on a vehicle by volume – through enhanced local production of drivetrain components, such as engines and gearboxes.

The first locally produced vehicles were exported in 1995, and as of 2020, 4.7 million vehicles have been exported cumulatively. Table 2 below summarises South Africa's percentage share of global vehicle production in the previous seven years, excluding 2020 when the Covid-19 pandemic halted manufacturing output and exports for several months. The country's market share of global vehicle production peaked in 2019, at 0.69% of total global vehicle production.

Table 2: South Africa's percentage share of global vehicle production (2013-2019)

Year	2013	2014	2015	2016	2017	2018	2019
South African market share of global vehicle production (%)	0.63	0.63	0.68	0.63	0.62	0.64	0.69

3.2.

Local automotive OEMs in South Africa

Several vehicle original equipment manufacturers (OEMs) operate in the country, serving both the domestic and export markets. Table 3 provides a summary of the main vehicle OEMs in the country and importers and distributors of vehicle parts and components.

Table 3: The main vehicle OEMs in South Africa

Original equipment manufacturers (OEMs)	Importers and distributors
BMW South Africa (Pty) Ltd	Audi (VW Group)
Ford Motor Company of Southern Africa (Pty) Ltd	European Automotive Imports South Africa (EAISA) (Pty) Ltd (Maserati)
Mercedes-Benz SA Ltd	FCA South Africa (Pty) Ltd (Fiat Chrysler Automobiles Group)
Volkswagen Group South Africa (Pty) Ltd	Jaguar Land Rover
Nissan South Africa (Pty) Ltd	Mini South Africa
Toyota South Africa Motors (Pty) Ltd	Porsche
Isuzu South Africa (Pty) Ltd	Volvo Car South Africa
	Honda
	Mahindra and Mahindra South Africa (Pty) Ltd
	Mazda Southern Africa (Pty) Ltd
	Mitsubishi Motors South Africa (MMSA)
	Peugeot SA (Pty) Ltd
	Renault South Africa (Pty) Ltd
	Subaru
	Suzuki Auto South Africa
	Hyundai Auto South Africa Pty Ltd (MOTUS Group)
	KIA Motors South Africa (Pty) Ltd
	HAVAL Motors South Africa (Pty) Ltd (HMSA)
	TATA Motors South Africa

Figure 7: The main automotive manufacturing hubs in South Africa

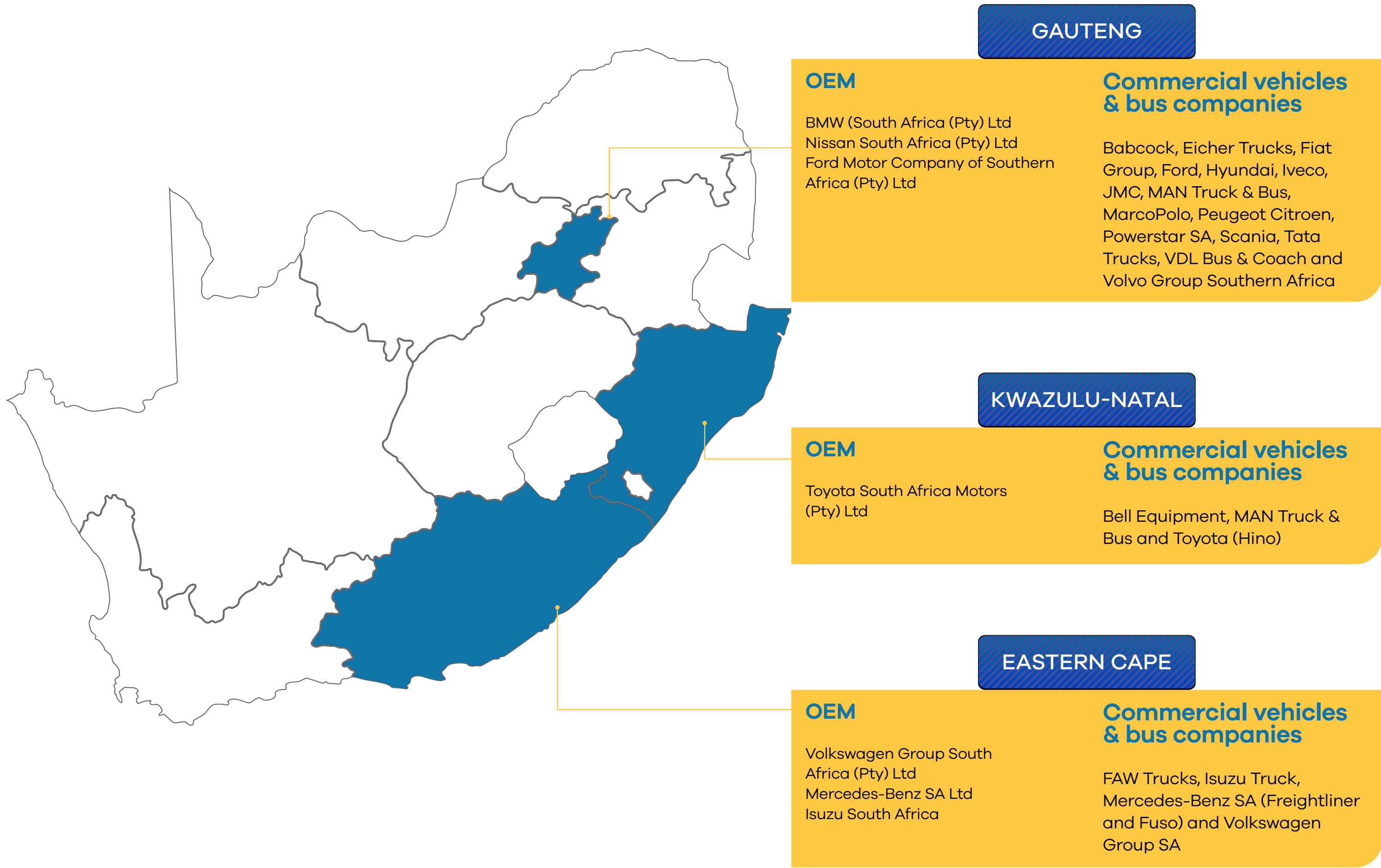


Figure 7 shows that South Africa's main automotive manufacturing hubs are centred on the Eastern Cape (EC), KwaZulu-Natal (KZN), and Gauteng (GP) provinces. The Eastern Cape in particular has been an attractive manufacturing destination for years, despite not having as high commuter patterns as either the Western Cape (WC), KZN, or GP. OEMs yet still set up in the EC because of the incentives provided by the East London and Coega Industrial Development Zones (IDZs), and the Nelson Mandela Bay Logistics Park (NMBLP), which provide infrastructure and services mainly to the automotive manufacturing industry.

The three transport hubs have in common that they all harbour private, public, and industrial transport manufacturing industries, as well as component companies (dealers and suppliers) that support them.

The Coega IDZ provides the following incentives to automotive manufacturers:

- location in a customs-controlled area (CCA) offering duty and VAT suspension;
- shared 24-hour security and other services in an enclosed and fenced off area;
- land and buildings for lease;
- logistical solutions providing easy access to the national freeway connecting all major cities in the Eastern Cape and other SA provinces;
- access to export markets via South Africa's newest deep-water Port of Ngqura, the existing port of Port Elizabeth; and an international airport;
- shared telecommunication networks;
- enhanced access to municipal services;
- investor support and access to incentives available from national, provincial, and local government, as well as linkage with interfacing the Eastern Cape Automotive Industry Forum and the Eastern Cape Tooling Initiative; and
- access to worker recruitment and training services.
(Coega, 2021)

In terms of production volumes, Toyota and Volkswagen produce the most vehicles in the country, holding 24% and 16% of the local production, respectively. The other OEMs each holds less than 10% market share, as illustrated in Table 4.

Table 4: Market share of the top automotive OEMs in South Africa

Source: (NAAMSA, 2020)

Top OEMs in South Africa	Production volumes in 2019 (%)	Location (province)
Toyota SA	24	KwaZulu-Natal
Volkswagen AG	16	Eastern Cape
Ford Motor Co of SA	9	Gauteng / Eastern Cape
Nissan	9	Gauteng
Hyundai SA	6	Gauteng
Renault	5	Gauteng
Mercedes Benz SA	4	Eastern Cape
Isuzu Motors SA	4	Eastern Cape
BMW SA	3	Gauteng
Other	20	–

3.3.

South Africa's vehicle export markets

Because of South Africa's competitiveness in automotive production, which is mostly due to the relatively low labour costs, the country already has an existing vehicle export market where up to 64% of the vehicles produced in South Africa are exported to the European Union, Japan, Australia, the United States, and 131 other destinations. An opportunity that has emerged in recent years is that most of these automotive export markets have announced impending bans on future importation of internal combustion engine (ICE) vehicles from as early as 2025. Table 5 summarises the status of export markets phasing out ICE vehicles in the short to medium term.

Table 5: Countries phasing out fossil fuel vehicles in the coming years.

Country	Start Year	Status	Scope	Details
Austria	2027	Government plan	Non-electric	Newly registered taxis, car shares and hire cars
Belgium	2026	–	Diesel, petrol	New company cars
Canada	2040	Climate plan	Emitting	New vehicle sales
China		Researching a timetable	Diesel, petrol	New car sales
Costa Rica	2050	–	Diesel, petrol	New car sales
Denmark	2030–35	–	Diesel, petrol	New vehicle sales (2030), all vehicle use (2035).
Egypt	2040	–	ICE	New vehicle sales
France	2040	Climate plan	Diesel, petrol	New car sales
Germany	2030	Bundesrat decision	Emitting	New car sales
Iceland	2030	Climate plan	Diesel, petrol	New car sales
India	2030	Government target	Non-electric	All vehicles
Ireland	2030	Government bill, plan dropped from Climate Bill	Diesel, petrol	New car sales
Israel	2030	–	Diesel, petrol	New imported vehicles
Japan	2035	–	Diesel, petrol	New vehicle sales
Netherlands	2030	Coalition agreement	Diesel, petrol	All cars
Norway	2025	Tax and usage incentives	Diesel, petrol	All cars
Singapore	2040	Incentives on electric vehicles	Diesel, petrol	All vehicles
Slovenia	2030	Emission limit of 50 g/km	Diesel, petrol	New car sales
Spain	2040	–	ICE	New vehicle sales
Sri Lanka	2040	–	Diesel, petrol	All vehicles
Sweden	2030	Coalition agreement	Diesel, petrol	New car sales
Taiwan	2040	–	Diesel, petrol	All bus use (2030), all motorcycle sales (2035), all car sales (2040)
United Kingdom	2030, 2035 (plug-in hybrid)	–	Non-electric	New car sales
United States	2030	EV Spree	Emitting, Non-electric	All government vehicles (2030)

This global transition to electric mobility necessitates the country shifting from ICE to EV manufacturing if SA is to retain preferential trade access with some of its major trading partners, and its global competitiveness. The local OEMs have consequently already started to adapt and have gone from barely registering the possibilities of electric vehicles, just a few years ago, to fully embracing them. Every major OEM in the country has an EV strategy, and the shift is accelerating rapidly, as they work to future-proof themselves.

The new **South African Automotive Masterplan** (SAAM) coming into effect from 1 July 2021 up to 2035, replaces the **Automotive Production and Development Programme** (APDP) and addresses some of the policy shortcomings of the latter. Its primary objectives are as follows:

- Growing South Africa's vehicle production to 1% of global production by 2035;
- Improving the automotive industry's competitiveness to be at par with that of global competitors;
- Increasing local content in locally manufactured vehicles from the current 38% to at least 60% (by using local materials in line with local content requirements);
- Doubling the current employment levels in the automotive industry and supply chain.

Local Original Equipment Manufacturers (OEMs) are thereby looking to pivot from primarily manufacturing internal combustion engine vehicles to electric vehicle manufacturing, as they work to future-proof themselves, increase competitiveness, and build resilience. Table 6 and Table 7 below summarises some recent local developments in this regard.

Table 6: Major global OEMs that have announced exits from the ICE market

	2020-2025	2025-2030	2030-2035	2035-2040	2040-2045
Sales Ban	Tesla	Jaguar BAIC	Volvo Ford Fiat Changan Automobile	General Motors PSA	Toyota Hyundai Subaru Honda
50% Target	Nissan	–	Daimler Mobility (Mercedes Benz) BMW	–	–
Stop ICE development	Volkswagen PSA	–	–	–	–

Table 7: Summary of recent EV developments and medium-term plans

Key role player	Recent EV developments and near-future plans
Toyota SA	• Producing their first hybrid vehicle in 2021 at the KZN SEZ (Special Economic Zone) • Toyota SA will produce the all-new hybrid Toyota Corolla Cross SUV- sport utility vehicle later in 2021, which will be sold locally and exported to 43 countries in Africa. This R4.28-billion investment is projected to generate about R2.85 bn in additional component purchases and create 1 500 new jobs – about 500 of these at Toyota's prospection plant in Durban, and 1 000 in the wider supply chain. • As of 2019, 36% of Lexus vehicles sold in South Africa are hybrids. • New full hybrid electric Toyota Prius coming to the South African Market. Toyota has announced its 2021 Prius model for South Africa, which starts at R566,400. The Prius EV will come with a 1.8-litre Hybrid powertrain that combines an electric motor with Toyota's 4-cylinder Atkinson cycle engine for a total system output of 90kW. A dedicated EV mode enables the vehicle to operate under full-electric power. • Sasol and Toyota SA have partnered to develop a hydrogen mobility corridor. The project involves developing infrastructure to support hydrogen fuel cell electric vehicles, as Sasol has partnered with Toyota SA to develop a "proof of concept demonstration" for a green hydrogen mobility ecosystem. The corridor will be tested along the N3 - between Johannesburg and Durban - as it is one of the main freight corridors. • Toyota also has three fuel cell electric vehicles it plans to pilot in South Africa - targeted at the passenger market, the bus and heavy-duty truck market.
BMW SA	• Launching an electric Mini Cooper in Jan 2021. The Mini SE will be the most affordable battery electric vehicle (BEV) in the local market, with pricing starting at R642 000, moving up to R722 000 for the top-spec model. It will be available for sale in South Africa from the first quarter of 2021. • The electric Mini (Mini Cooper SE) Sharing service pilot was launched in Sandton, Johannesburg in early 2021. The pilot will make five Mini Cooper SE electric vehicles available to anyone in need of a vehicle for a day by downloading the Mini Sharing app (available on Android and iOS) and booking some time with one of the five EVs. Costs are set on both a per-hour and per-kilometre basis: R36 per hour and R6 per km of use. • The BMW battery-powered iX crossover – iX Sport Activity Vehicle – has been announced to arrive in the South African market in 2022. The vehicle will have a 100 kWh high-voltage battery allowing for a range of more than 600 km between charges – powered by two electric motors producing a combined output of 370 kW, which is sufficient to accelerate from 0-100 km/h in less than five seconds. The battery could be charged from 10% – 80% in under 40 minutes when plugged into a DC fast charger. When plugged into a normal wall box, it will take less than 11 hours to charge from 0% to 100% capacity. • BMW is working on a new fifth-generation electric drivetrain, due in 2021, that does not require any rare earth metals, and plans to double the energy density of its battery cells for an increased range.
Daimler / Mercedes Benz SA	• Already offers two plug-in hybrid models in South Africa. • Unveiled South African-made C-Class plug-in hybrid electric vehicle. The vehicle will be produced at their facility in East London. • Mercedes EQC to be launched in South Africa in 2021. • Daimler will bring electric trucks to the South African market when the local infrastructure can accommodate the new technology. They anticipate this happening within the next five years.
Volkswagen SA	• Launching an electric VW Golf pilot in Gauteng in late 2020 • Six fully electric vehicles to be tested by motoring and lifestyle media. • The second phase will be expanded to include a fleet of fully electric Volkswagen ID.3 vehicles from 2021. • The third and last phase will see the first fully-electric Volkswagen EVs available for sale to customers in South Africa from 2022. • The newly announced ID.4 electric SUV will also be available for sale in South Africa in 2022.
Shell SA	Launching the first EV charging stations in their retail network in 2020
Gautrain	The Gautrain network will include electric buses powered by micro-grids. The Gautrain Management Agency's (GMA) Urban Mobility Programme is considering buses with a range of 270 km since currently, Gautrain buses run an average of 200 km per day.
Scania SA	Scania South Africa has partnered with the Limpopo Economic Development Agency (LEDA) and the Thulamela municipality to develop the R15-million Scania Thohoyandou auto-workshop. This is in line with Scania's global goal to drive the shift towards a sustainable transport system for business and society.
Nissan SA	The new 40 kWh Nissan Leaf and 62 kWh Nissan Leaf e+ to be launched in 2020/1
Volvo SA	• Volvo launched its first EV in the South African market, the Volvo XC40 P8 Recharge, in May 2021. Just four days after it went on sale in South Africa in mid-May at a price tag of R1,2 million, the initial allocation for the country was sold out. The vehicle has a range of over 400 km and can be charged from 0% to 80% in 40 minutes using a DC fast charger. The twin electric motors deliver 304 kW (408 hp) of power and 660 Nm of torque, allowing it to go from 0-100 km/h in 4.9 seconds. • Volvo South Africa is also rolling out a network of charging stations at its dealerships and will launch four additional models over the next five years. The company plans to produce electric vehicles exclusively only from 2030 (no hybrids either).
Hydrogen fuel cell electric bus pilot in 2020	South Africa's first homegrown hydrogen fuel cell electric bus is to be piloted later in 2020. The bus has been developed by Busmark, several universities, government departments, the Council for Scientific and Industrial Research (CSIR) and Hydrogen South Africa (HySA), which is an initiative of the Department of Science and Technology.

Key role player	Recent EV developments and near-future plans
Hydrogen fuel cell factory	CHEM ENERGY, a subsidiary of Taiwanese conglomerate CHEM Corporation, has opened its $200-million fuel cell production factory in KwaZulu-Natal at the Dube Trade Port Special Economic Zone.
Ford SA	• Building one of the world's largest solar carports in Tshwane (31 000 solar panels = 4 200 parking bays). In 2020, Ford South Africa announced the launch of Project Blue Oval; a renewable energy project which aligns with the company's global target of using 100% locally sourced renewable energy for all its manufacturing plants by 2035 and achieving carbon neutrality by 2050. In its first phase, construction of solar carports for 4,200 vehicles at the Silverton Assembly Plant in Pretoria, will go a long way to seeing the Pretoria property become entirely energy self-sufficient and carbon neutral by 2024 – making it one of the first Ford plants in the world to achieve this status. • Announced it is set to invest $1.05 billion (R15 billion) in South Africa's automotive industry and to locally produce a new Ford Ranger pickup truck starting in 2022, both for domestic sales and exports. The company will also upgrade the Silverton plant in Pretoria, to boost the site's annual vehicle production capacity by 20% to 200 000 units and create about 1 200 direct jobs. • Ford has announced significant greenhouse gas emission targets in its 2021 Integrated Sustainability and Financial Report, as the company aims to achieve carbon neutrality by 2050. The 2035 targets consist of reducing absolute greenhouse gas emissions from company global operations by 76% and from new vehicles sold globally by 50% per kilometre. • Ford doubled its investment in EVs to $22 billion through 2026 as it continues to electrify some of its most popular vehicle models. Ford's strategy in Europe is to go all-in on electrification, with passenger vehicles to be all-electric by 2030. For commercial vehicles, Ford's product range in Europe will be zero-emissions capable, with all-electric or plug-in hybrid offerings, as early as 2024.
KIA SA	KIA SA confirmed that the EV6 might be coming to the South African market. The EV6 is KIA's first venture into EVs on a mainstream, premium level. It offers buyers a choice of multiple fully electric, zero-emission powertrain configurations, including long-range (77.4kWh) and standard-range (58.0kWh) high-voltage battery packs. It provides 800-volt and 400-volt charging capabilities, without the need for additional components or adapters. The car is capable of a high-speed charge from 10 to 80% in just 18 minutes on all variations or a top-up charge of 100km of driving range in less than four and a half minutes. KIA says the vehicle's charging system is more flexible than previous generation battery EVs thanks to an Integrated Charging Control Unit (ICCU). The ICCU enables a new vehicle-to-load (V2L) function, which is capable of discharging energy from the vehicle battery. The V2L function can supply up to 3.6kW of power and can charge another EV if needed. The EV6 can also tow trailers weighing up to 1600kg if it maintains more than 35% battery charge for the duration of your journey.
Jaguar Land Rover	Jaguar Land Rover partnered with the Automobile Association (AA) to prepare for a future of electric mobility in South Africa by training a group of Line Managers on EV-specific roadside assistance and vehicle recovery. Jaguar Land Rover's Training Academy in Pretoria opened its doors to the AA to share its technical expertise on a range of EVs, and while the practical lessons involved Jaguar's all-electric I-PACE, plug-in hybrid Range Rovers and mild-hybrid Land Rovers, most of the procedures taught apply to EV products from any manufacturer. Of specific interest to the group of line managers was the procedure of jump-starting a fully electric vehicle. In an instance where an EV's small 12-volt battery (like those in any car) runs flat due to prolonged standstill, it is possible to boost this small battery for the more powerful high-voltage battery to begin recharging the low-voltage system. Instructions were also given on how to manually override drive selectors and electronic handbrakes to pull an EV onto a flatbed tow truck in neutral.
Electric Mining trucks	Anglo-American, with design assistance from Williams Advanced Engineering, will build the world's largest hydrogen-powered hybrid mining truck in 2020. Test runs are scheduled to take place later in 2020 at Anglo-American's Mogalakwena open-pit platinum mine in Limpopo.

Key role player	Recent EV developments and near-future plans
Construction	The demand for lithium-ion-powered forklifts is increasing locally, owing to companies wanting to reap the benefits of energy efficiency and cost-effectiveness, as well as to prepare for changing legislation regarding emissions.
Uber, Lyft, & Bolt	• Uber wants 100% of their rides to take place in electric vehicles by 2030 in the US, Canada, and Europe, and by 2040 for the rest of the world. Uber commits to becoming a "zero-emission platform" by 2040, with all rides taking place in zero-emission vehicles, on public transport or via micro-mobility, • Lyft also announced it would commit to electrifying 100% of its largest privately-owned fleet by 2030. Bolt announced that all their rides in Europe are now carbon-neutral (through carbon offsetting), and they plan the same for their other markets globally. The company is committed to having climate positive e-scooter operations by the end of 2020.
DHL	Received a fleet of fully electric delivery vehicles for deliveries in and around the major cities in South Africa
Electric micro-mobility – scooters	Several local electric scooter and e-cycle companies have launched in 2020, including Electric Life Rides, Go-Lectric, and Bike & Hike.
Tshwane Automotive Special Economic Zone (TASEZ)	Work has begun on the R3.4 billion Tshwane Automotive Special Economic Zone (TASEZ) – the first automotive city in Africa. When announced in 2019, expressions of interest were received from nine supplier companies. As of August 2020, 12 suppliers have committed to setting up operations within the SEZ with an anticipated investment of over R4.3 billion in the economy. Another 10 have shown a keen interest.
Lithium-ion batteries	• Geological exploration work will soon restart at the Zebediela nickel project on the northern limb of the Bushveld Complex in Limpopo, South Africa. The Bushveld Complex hosts an estimated 11.9 million tons of nickel and ranks third in terms of nickel sulphide content globally. Class 1 nickel is sought after for electric vehicle (EV) lithium-ion batteries, whilst Class 2 nickel is mainly used in nickel pig iron and the steel industry. • Metair will partner with the South African Institute for Advanced Materials Chemistry (SAIAMC), located at the University of the Western Cape (UWC) – it houses the only pilot scale li-ion battery cell assembly facility in Africa – which will see the company invest R3 million over three years to pilot a prototype lithium production project from January 2021. Production will focus on mining cap lamp cells, 12 V li-ion automotive batteries, 48 V lithium-ion batteries for energy storage applications, and solar panel recharge technology. • The Megamillion Energy Company intends to be Africa's first large-scale producer of lithium-ion batteries by launching a pilot Gigafactory in late 2020.
ABSA Bank SA	• Absa announced in October 2020 that they would soon be rolling out a green finance mechanism for electric vehicles (EVs). They intend to provide an all-in-one finance package to consumers that could incorporate a solar PV home installation for charging the EV. The solar PV home installation would increase upfront costs, but the combined green finance deal could still deliver a lower total cost of ownership compared with an ICE vehicle. • In 2020, Absa announced it would not fund any new coal-fired electricity generation projects unless there are extenuating circumstances. The bank is now also part of the United Nations Environment Program for Responsible Banking. Shareholders additionally approved a climate change resolution for the bank to include in its 2021, reporting an assessment of the banks' exposure to climate change risk in its lending portfolios. The company has also been authorised to identify opportunities to finance climate change mitigation.
Nedbank Group	Nedbank Group announced a new energy policy, committed to reducing its exposure to all fossil fuels to zero by 2045 and halt all new thermal coal-mine financing by 2025. The bank would also increase its renewable-energy commitments to R2 billion worth of embedded-generation financing by 2022 and committing R50 billion to South Africa's Renewable Energy Independent Power Producer Procurement Programme (REIPPP). Nedbank would not finance new oil and gas exploration projects from 2021 and not provide new financing for oil production from 2035.

Key role player	Recent EV developments and near-future plans
First National Bank (FNB)	First National Bank (FNB) has cut its carbon footprint by 50% over five years with measures including the use of 3.7 MW capacity solar photovoltaic (PV) panels, currently producing 5.8 MWh/y in its branches.
FirstRand Limited	FirstRand Limited has announced it will publish all its fossil fuel carbon-related assets and lending, to reduce and eventually halt exposure to fossil fuels.
City of Cape Town	The CCT has launched two public EV charging stations with associated carport solar PV systems installed at the Bellville and Somerset West Civic Centre sites. The United Nations Industrial Development Organization (UNIDO) donated these systems as part of its Low-Carbon Transport South Africa (LCT-SA) project. The LCT-SA project aims to promote the uptake of EVs and collect detailed data on charger usage and customer experience, to assess the impact of EV charging on the electricity grid.
General Motors (GM)	GM aims to fully embrace EVs and sell all its new cars, SUVs, and light pickup trucks, with zero exhaust emissions by 2035. The company plans to become carbon neutral by 2040 and will also source 100% renewable energy to power its US sites by 2030, and global sites by 2035.
Electric Safari Vehicles (ESV)	The Mpumalanga-based electric vehicle company, Electric Safari Vehicles (ESV), is converting their nature- and wildlife-viewing vehicles from diesel to electric propulsion. The vehicle conversions have helped the company reduce their emissions and carbon footprint, as well as their maintenance costs since the EVs have better efficiency and provide a smoother and quieter game-viewing experience for their clients and tourists.
MellowVan	MellowVan has conducted several large-scale proof-of-concept projects in South Africa, with retailers such as DHL, Takealot, and Checkers, for their last-mile delivery service. The company's lithium-ion battery cells are imported from Asia, then assembled at their Western Cape plant. The company has also developed its battery management system, and the Industrial Development Corporation (IDC) is one of the major shareholders in the business.

3.4.

Existing local bus manufacturing for domestic and export markets

Electric buses are surpassing the growth of every other EV segment with a compound annual growth of 100% since 2013, compared to 60% for electric passenger cars. Many global cities are already looking at mechanisms to finance electric buses and streamline their procurement. Electric buses are therefore an ideal area on which to focus, particularly for short commutes (i.e., to and from school, work etc.), long-distance commutes, and government and municipal fleets – bus rapid transit (BRT) systems.

South Africa already assembles buses (public transport) for local bus companies as well as for export to the region and further afield. These buses are designated in the country and are subject to ~80% local content requirements by the Department of Trade, Industry and Competition (DTIC) for public procurement.

The assembly of buses further enjoys the benefit of duty-free importation of all driveline components. While this is a flat market in SA, there is scope to revitalise this space. Incorporating e-bus manufacturing for public transportation is a more economically viable way of achieving this revitalisation than private vehicles because, as per the last National Household Travel Survey (NHTS, 2013), the majority of South Africans use public transportation as their primary means of mobility.

Initially, the target market for these e-buses would have to be the export market. This is because the local EV market does not yet provide sufficient demand to attract local manufacturing and assembly exclusively for the domestic market supply, which is yet to take off. The limited demand for EVs in SA is primarily because of the high cost of the vehicles and the limited infrastructure to support these vehicles. The narrow and limited product offerings currently in the market have also not significantly stimulated demand for EVs, and do not seem to be a perfect fit for the market. The country's export markets, however, have a higher demand for EVs, and this is expected to increase significantly over time as they transition to an electric mobility future.

3.5.

Ancillary services, automotive components, and other adjacent markets

The EV automotive industry is also supported by a range of adjacent industries and ancillary services. These include the following;

- Mining industry (vehicle parts and battery minerals)
- Plastics
- Adhesives
- Vehicle Insulation
- Charging connector
- Communication controller
- Traction motors
- Vehicle leasing, dealerships, and the retail network
- Mechanics (maintenance)

Automotive component manufacturers, dealers, and suppliers are mostly centred around Gauteng (200 automotive component companies), Eastern Cape (150 automotive component companies), and KwaZulu-Natal (80 automotive component companies) (TIPS, 2020). Vehicles and components manufactured in the country supply both the domestic and, to a large extent, export markets.

Table 8: Vehicle components manufactured in South Africa in 2018

Source: (Kearby, 2018)

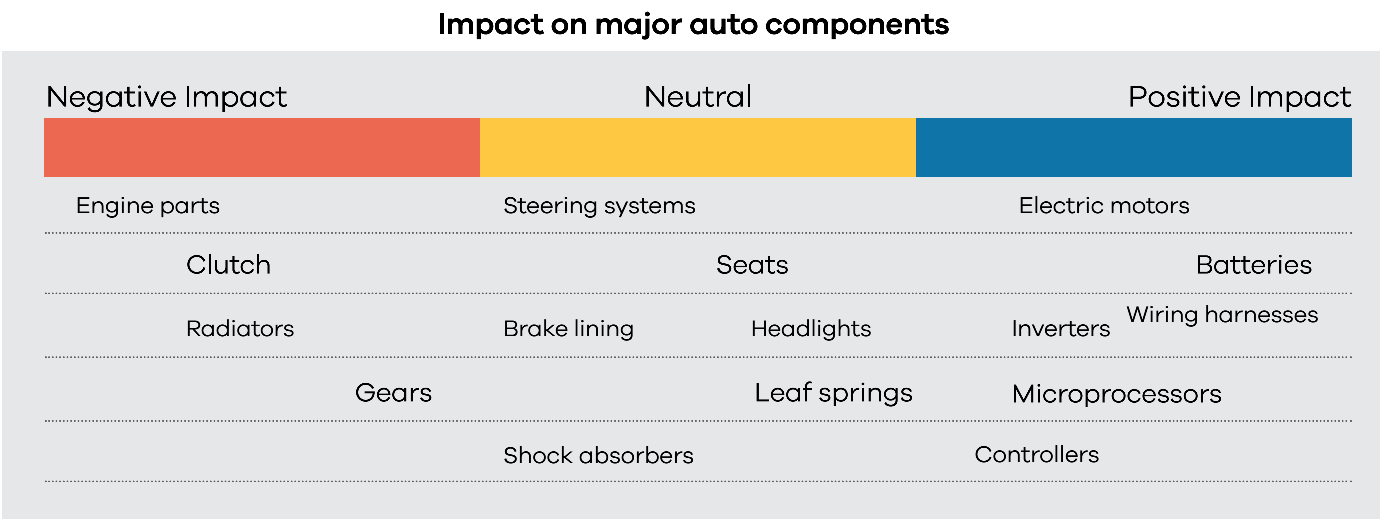
Component	Percentage of total vehicle component sales
Catalytic converters	67.95%
• Of the R19.2 b exported in 2018, the main importers were Germany (42%), USA (12%) and Czechia (10%).	
Engine parts	5.76%
• Of the R4.2 b exported in 2018, the main importers were Germany (26%), USA (24%) and Thailand (16%).	
Radiators & parts	4.642%
• Of the R1.7 b exported in 2018, the main importers were Germany (34%), Spain (12%), and USA (12%).	
Tyres	3.966%
• Of the R2.6 b exported in 2018, the main importers were Belgium (16%), Namibia (12%), and Botswana (8%).	
Shock absorbers	2.181%
Stitched leather seats & parts	2.157%
Automotive glass	2.014%
Clutches/shaft couplings	1.791%
Silencers/exhausts	1.33%
Axles	1.29%
Automotive tooling	1.045%
Filters	1.013%
Road wheels & parts	0.992%
Transmission shafts	0.724%
Body parts/panels	0.672%
Lighting equipment & parts	0.646%
Brake pads	0.479%
Engines	0.312%
Gauges/instruments	0.259%
Ignition/starters	0.194
Gaskets	0.159%
Wiring harnesses	0.108%
Gear boxes	0.094%

Component	Percentage of total vehicle component sales
Springs	0.06%
Steering wheels, columns, & boxes	0.059%
Alarm systems	0.031%
Batteries	0.03%
Air conditioners	0.019%
Seats	0.011%
Jacks	0.007%
Car radios	0.004%
Seat belts	0.003%

Unlike ICE vehicles that have more than 1 000 moving parts, EVs are much simpler with fewer parts and thus require less maintenance. The transition from ICE to EV manufacturing will, however, have an impact on several of these components because EVs have a couple of different components. Dealers and suppliers will also have to adapt to selling EVs and ICE vehicles together but will expect revenues from ICE sales to decrease with time as EV sales increase. Unlike ICE vehicles, EVs will also require less maintenance spend, which will further impact margins for dealers. While this shift occurs, there will likely be a major impact on margins and cash flow. Powertrain suppliers will have to "re-invent" themselves to be relevant in the future.

Table 9 summarises this impact on automotive components. The mineral resource impacts are discussed later in the report.

Table 9: The impact of the transition from ICE to EV manufacturing on major automotive components



The automotive manufacturers and component suppliers, including the potential Plug-in hybrid EVs (PHEVs), Battery EVs (BEVs), Hydrogen Fuel Cell EVs (HFCEVs), and Mild hybrid EV (MHEV) manufacturers, would serve the following vehicle classes:

- Single occupancy vehicles/passenger vehicles (SOVs) – electrification of this segment is already happening locally.
- Light commercial vehicles (LCV) – electrification happening globally but is at very early stages of adoption locally.
- Medium commercial vehicles (MCV) – electrification happening globally but is at very early stages of adoption locally.
- Heavy commercial vehicles (HCV), e.g., trucks – Electrification happening globally, but is at very early stages of adoption locally.
- Extra-heavy commercial vehicles (XHCV), e.g., mining vehicles – Several pilots underway in South Africa.
- Public transport buses (mass transit) – electrification of this segment has had challenges, but pilots are underway, such as Golden Arrow bus services, which has been piloting two e-buses in Cape Town.
- Micro-mobility – e-scooters and e-bikes. Micro-mobility and multi-modality as part of MaaS have increased significantly after the Covid-19 pandemic. Electric micro-mobility such as electric scooters (e-scooters) and e-bikes are witnessing high growth, and this is expected to continue.
- Shared mobility – major shared mobility players Bolt and Uber have announced plans to electrify their fleets in the coming years.
- Hardware component suppliers – e.g., chassis, tyres, and plastic.

Table 10: Breakdown of the size of the vehicle classes in South Africa as of 31 December 2020, excluding non-self-propelled vehicles such as caravans and trailers.

Data sourced from the electronic national administration traffic information system (eNaTIS)

Vehicle class	Total live vehicles in South Africa	Percentage of total live vehicles in the Western Cape (%)
Motor cars and station wagons	7 498 955	65.3
Minibuses	341 853	2.98
Buses, bus trains, and medibuses	64 889	0.57
Motorcycles, quadricycles, and tricycles	339 053	2.96
LDVs, panel vans, and other light vehicles GVM <= 3 500 kg	2 616 359	22.81
Trucks (heavy load vehicles GVM > 3 500 kg)	377 788	3.29
Other self-propelled vehicles	233 613	2.04
Total self-propelled vehicles	**11 472 510**	

Table 11 further narrows this down to the Western Cape province.

Table 11: Breakdown of the size of vehicle classes in the Western Cape as of 31 December 2020, excluding non-self-propelled vehicles such as caravans and trailers.

Data sourced from the electronic national administration traffic information system (eNaTIS)

Vehicle class	Total live vehicles in the Western Cape province	Percentage of total live vehicles in South Africa (%)
Motor cars and station wagons	1 295 351	70.00
Minibuses	37 575	2.03
Buses, bus trains, and medibuses	7 060	0.38
Motorcycles, quadricycles, and tricycles	84 781	4.58
LDVs, panel vans, and other light vehicles GVM <= 3 500 kg	339 661	18.35
Trucks (heavy load vehicles GVM > 3 500 kg)	46 078	2.49
Other self-propelled vehicles	40 059	2.16
Total self-Propelled vehicles	**1 850 565**	

Globally, the trend is expected to initially shift from ICE to EV hybrids as consumers get used to electric vehicles. It should then progressively shift to battery electric vehicles (BEVs) and to some extent hydrogen fuel cell EVs (HFCEVs), depending on the country's capacity and investment into setting up the hydrogen infrastructure – which is significantly more expensive. This will be discussed later in this report.

Local demand is presently a challenge as original equipment manufacturers (OEMs) are reluctant to manufacture EVs if there is no local demand, or even to set up a charging station infrastructure if it will remain unused. The challenge has always been that you need the infrastructure to sell the cars, but you cannot build the infrastructure until you sell the cars – the classic chicken and the egg problem.

Players in the local EV ecosystem and the wider industry are waiting for a market for lithium-ion batteries (LIBs) and EVs to develop before they invest fully in this industry.

As the local EV demand grows, particularly as price parity between EVs and ICE happens in the next few years, and economies of scale are achieved, the cost of electric vehicles will drop significantly. Until then, the available market is the export market. Localisation is crucial for the industry to develop and for OEMs to acquire a stable supply of the required resources and raw materials. While aiming for increased localisation levels in future, the short term requires reliance on the global supply chains, at least until scale is achieved. When the technologies, business models, and support are available, demand would then follow. The policy framework should therefore aim to drive localisation through incentive structures. The projected EV demand, both locally and for the export market, could create the required scale to create a vibrant ecosystem.

3.6.

EV use in construction, retail, and underground mining

A newer emerging industry globally that is starting to demand more attention locally is battery-powered and hydrogen fuel cell EVs and machinery in underground and opencast mining operations, since the mining industry is a key sector of the South African economy. A major cost in mining operations is getting air underground and temperature (thermal) regulation.

Electric mining equipment, however, produces no fine particulate matter (PM2.5) and other tailpipe emissions. It thereby necessitates fewer ventilation requirements, and therefore lower costs, in safeguarding the respiratory health of underground mining personnel. Additionally, EV mining equipment produces less heat because of the higher efficiency of the conversion from electric energy compared to diesel. This saves on ventilation and heat regulation underground.

The electric mining equipment also produces less noise and vibration and requires less maintenance – further saving on mining costs and operational expenditure.

Since EVs produce no tailpipe emissions, they are increasingly being touted as a remedy for use in underground mining.

Anglo-American, one of the largest mining companies in the country, with design assistance from Williams Advanced Engineering, is building the world's largest hydrogen-powered hybrid mining truck locally in South Africa. Test runs are scheduled to take place at Anglo-American's Mogalakwena open-pit platinum mine in Limpopo. Additionally, the demand for lithium-ion-powered forklifts is increasing locally, owing to companies wanting to reap the benefits of energy efficiency, reduced air pollution for public health benefits, and cost-effectiveness, as well as to prepare for changing legislation on emissions.

Mining companies are already exploring the feasibility of a hydrogen valley in the Bushveld geological area, where platinum group metals (PGMs) are mined. This valley would span 835 km from the Mogalakwena mine in Mokopane, Limpopo, to Johannesburg, and then south towards the Durban coast.

4

Battery and cell manufacturing and the mining of battery minerals

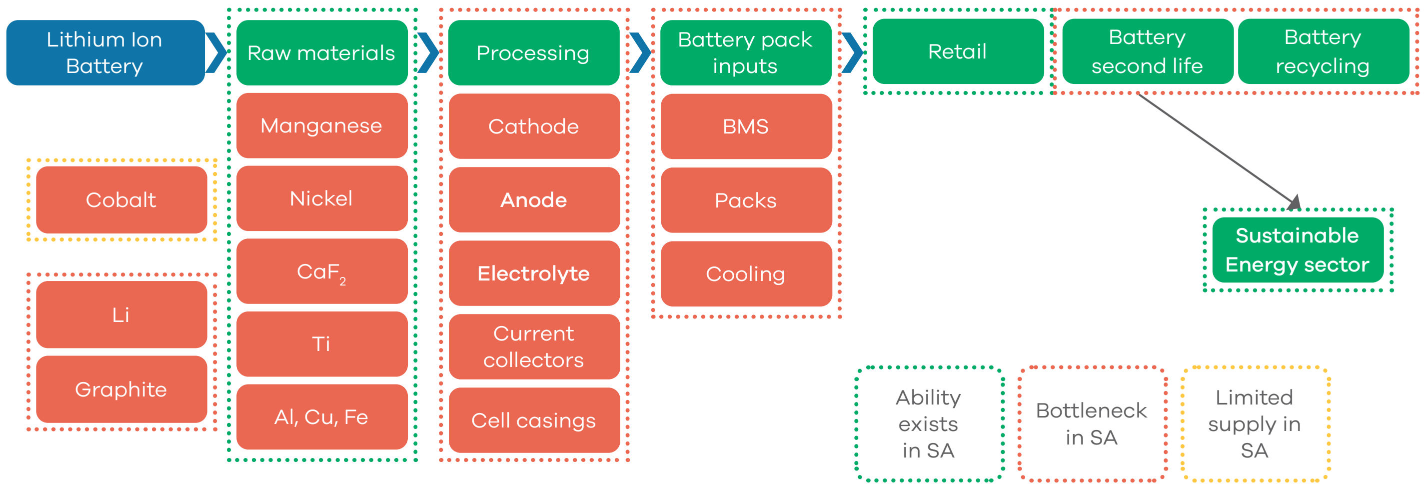
4.1.

Battery energy storage system value chain

Batteries are the key component of an EV, making up about 40%-50% of the battery-electric vehicle's value. The supply of battery minerals remains the largest limiting factor to electric vehicle production globally, with several EV manufacturers, most recently Tesla (USA), having to halt EV production due to disruptions in battery mineral supply.

Consequently, it is crucial to analyse where South Africa could obtain supplies of these critical minerals and identify the potential bottlenecks to enable the development of the EV industry locally. The battery energy storage value chain is summarised in Figure 8 below. Elements of this value chain will be discussed in the subsequent sections.

Figure 8: The Battery Energy Storage System (BESS) value chain



- Battery management system (BMS)
- Cells
- Component-level modelling, design & testing
- Warranty/guarantee

- Power conversion equipment

- HVAC systems

- System management
- Software & controls algorithm development
- Controls & optimisation
- Communication

- Site control/acquisition
- Secure permits
- Develop pro-forma financials
- Negotiate financing (debt, equity)
- Negotiate offtake/ power purchase agreement (PPA)
- Obtain incentives

- Engineering & procurement
- Installation (Civil, mechanical, Electrical)
- Integration

- Operate
- Maintain
- Aggregator

The local battery value chain has mostly developed through the private sector, with little to no financial support from the public sector. There are several battery testing laboratories in the country, such as the uYilo Battery Laboratory, which provides ISO 17025 accredited testing to IEC 62620 and SANS 61960 for lithium batteries, covering both stationary and mobile applications. The facility has an 8 x 500 milliamp cell tester channel which allows for the testing of cylindrical cells ranging from 0-10V (uYilo, 2021).

Because of the limited EV uptake in the country presently, the LIB industry has yet to take off. An increase in EV demand and uptake would improve the business case for local battery manufacturing because of the inter-dependency and symbiosis between the two industries.

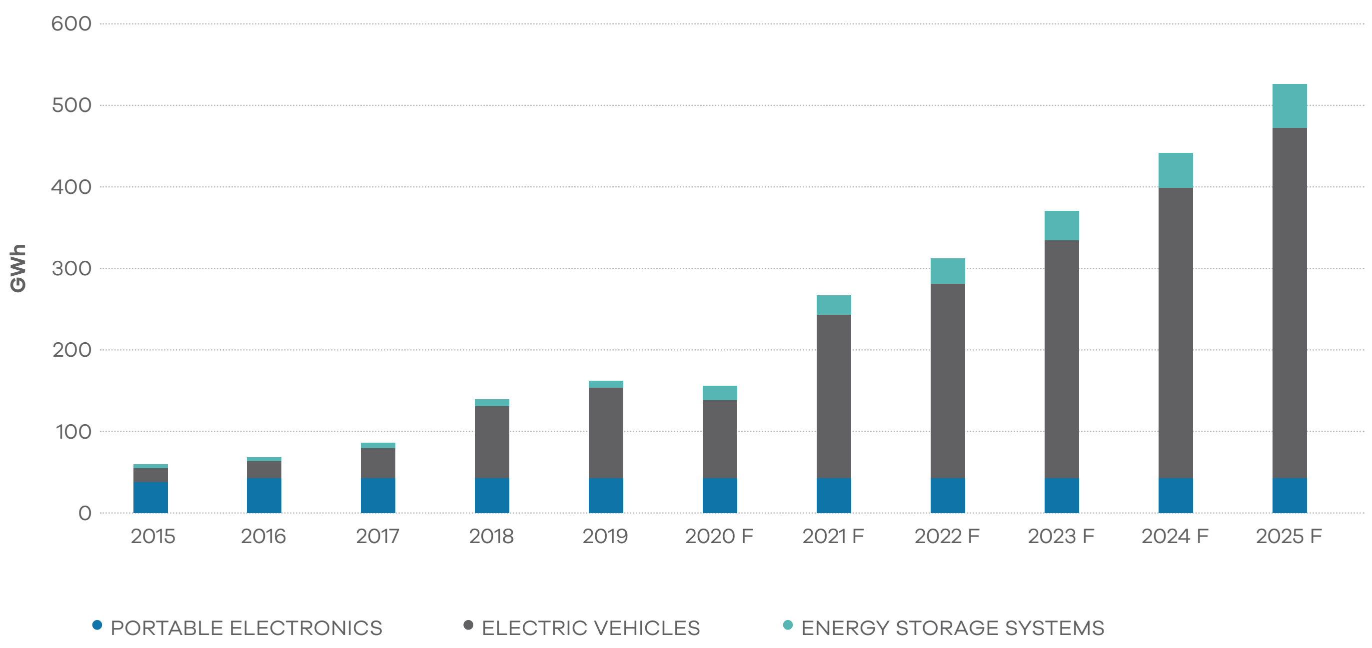
The uptake of EVs and the growth of the distributed generation market are projected to drive battery growth in the coming years, and they have already surpassed portable electronics as the main source of battery demand. Batteries are anticipated to drive innovation and growth in a wide variety of sectors in future, including;

- Electric mobility (EVs, e-bikes, etc)
- Consumer electronics
- Grid storage
- Off-grid storage
- Robotics
- Renewable energy

Figure 9 below, depicting the total storage demand per sector globally, illustrates this.

Figure 9: Total global storage demand per sector

(Source: Mackenzie, 2020) (The symbol F illustrates forecasts and projections)



4.2.

Composition of the lithium-ion battery cell

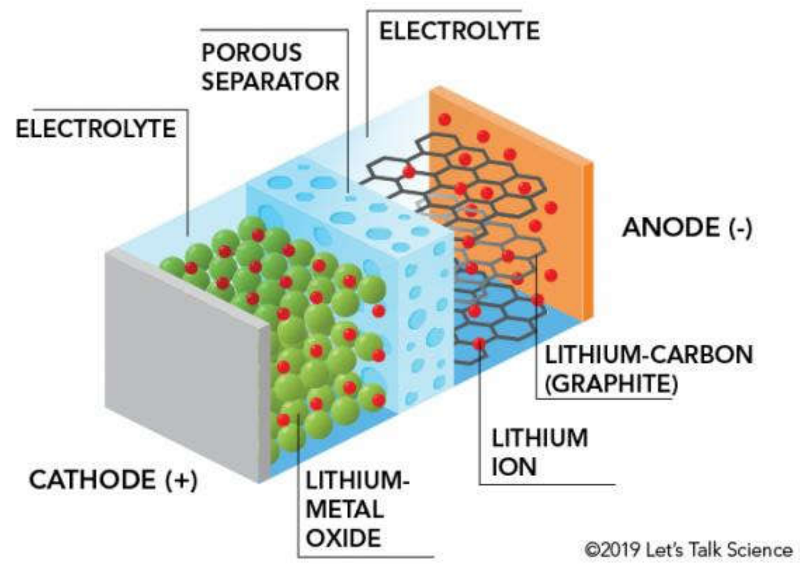
The lithium-ion battery cell comprises the following components:

- Anode;
- Cathode;
- Electrolyte;
- Separator;
- Current collectors;
- Cell casings; and
- Electronics.

The raw materials required include lithium, nickel, cobalt, graphite, manganese, titanium, aluminium, copper, phosphate, and iron. A battery management system (BMS) is also required for system monitoring and thermal regulation/temperature control.

Figure 10: Parts of a lithium-ion battery

Source: (Let's Talk Science, 2019)



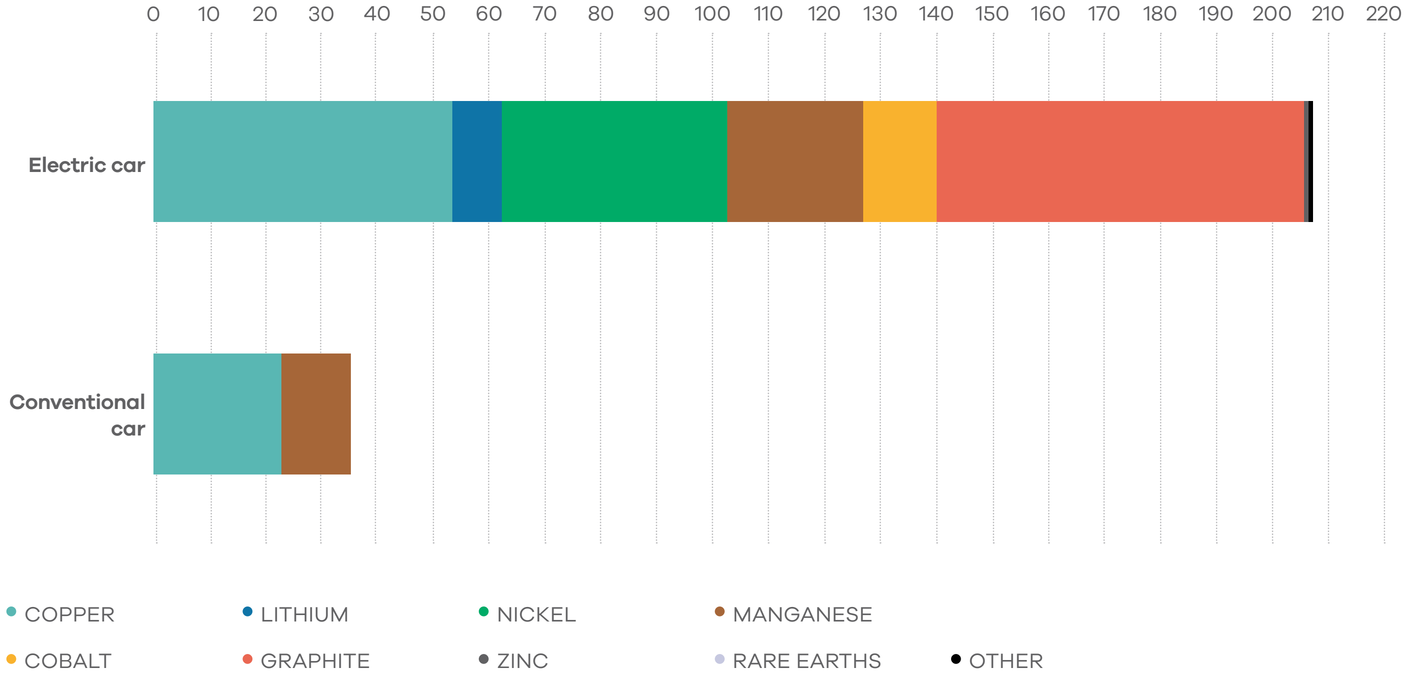
4.3.

Mineral demand from electric mobility

EVs require significantly more mineral resources, about six times as much as the conventional ICE vehicle, according to a study by the International Energy Agency (IEA, 2021) as shown in Figure 11.

Figure 11: Minerals used in EVs and the conventional ICE vehicle.

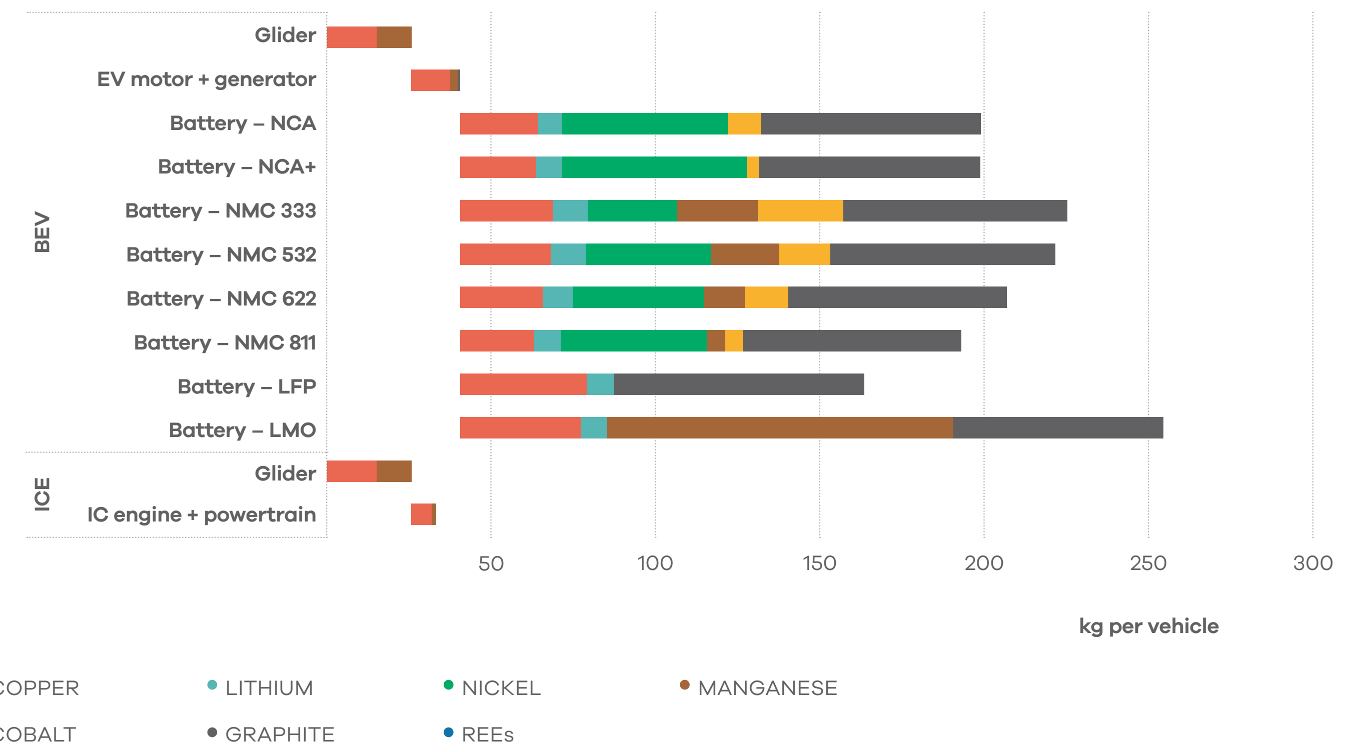
Source: (IEA, 2021)



BEVs use the most mineral resources depending on the battery chemistry. The lithium manganese oxide (LMO) battery type is the most resource-intensive, while the glider battery is the least resource-intensive for BEVs. This is summarised in Figure 12 below.

Figure 12: Mineral use between ICE and EVs in kg per vehicle

Source: (IEA, 2021)



4.4.

Battery demand from the renewable energy sector

Because of the simplicity and flexibility of lithium-ion battery energy storage systems (ESS), they are increasingly being touted as a complementary solution to support renewables in delivering flexible and distributed energy from the transmission system to households and businesses in an efficient, cost-effective, and reliable manner.

New applications of this evolving technology are creating a diverse range of growth opportunities.

Table 12: Lithium-ion battery applications

Application	Typical battery capacity
Lithium battery cell	< 6 Wh
Cell phone	10 Wh
Laptop	50 Wh
Electric bike (e-bike)	500 WH
Plug-in hybrid electric vehicle (PHEV)	15 kWh
Battery electric vehicle (BEV)	40 kWh
Electric bus (e-bus)	300 kWh
Energy storage systems (ESS)	>100 MWh

> The mineral needs vary among the different clean energy technologies; with the transition to renewables, there would be a significant increase in the demand for minerals.

Figure 13: The minerals used in select clean energy technologies.

Source: (IEA, 2021)

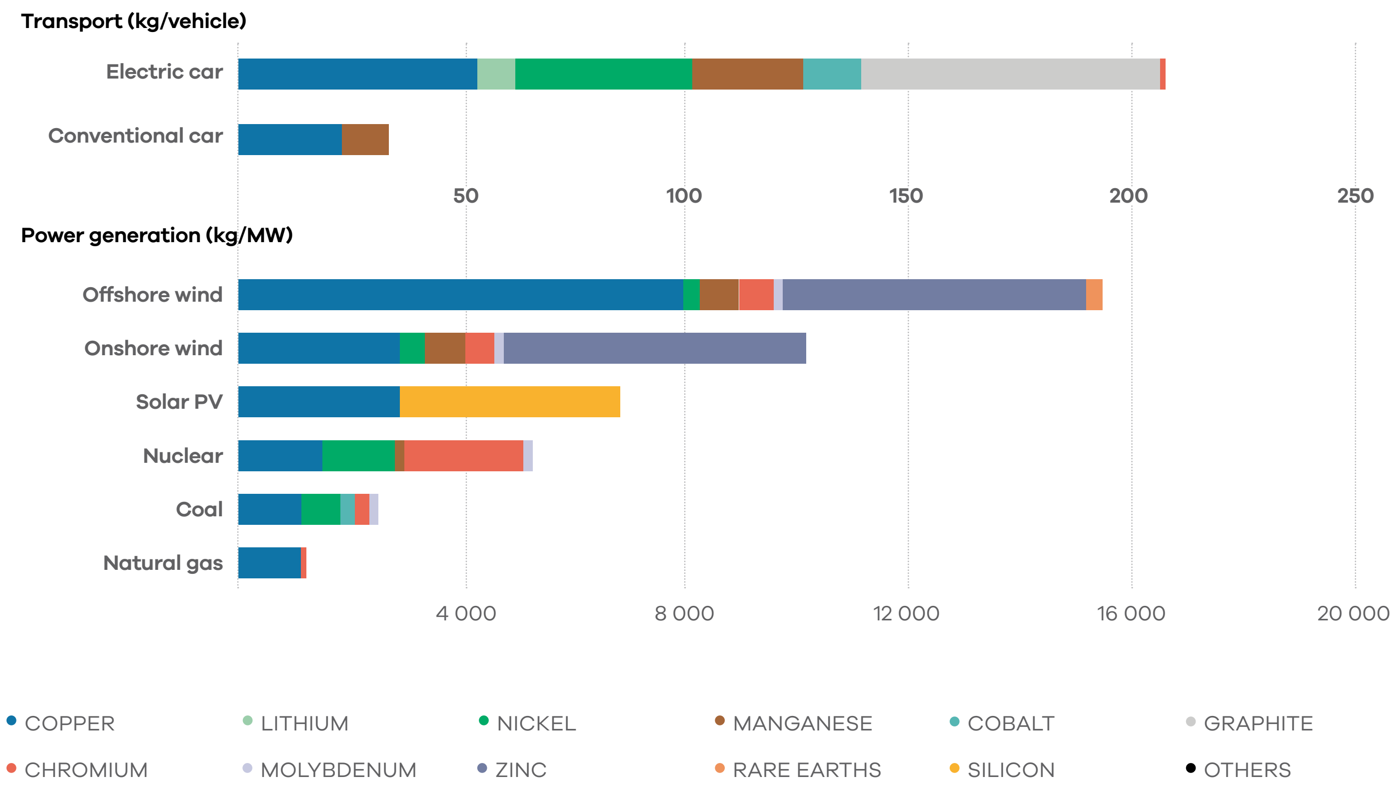


Figure 13 below summarises the critical minerals required by each clean energy technology, with an indication of their relative importance.

Table 13: Critical mineral requirements for different clean energy technologies, and their relative importance

Data sourced from the International Energy Agency (IEA)

	Copper	Cobalt	Nickel	Lithium	REEs (Rare earth elements)	Chromium	Zinc	PGMs	Aluminium
Solar PV	H	L	L	L	L	L	L	L	H
Wind	H	L	M	L	H	M	H	L	M
Hydro	M	L	L	L	L	M	M	L	M
CSP	M	L	M	L	L	H	M	L	H
Bioenergy	H	L	L	L	L	L	M	L	M
Geothermal	L	L	H	L	L	H	L	L	L
Nuclear	M	L	M	L	L	M	L	L	L
Electricity Networks	H	L	L	L	L	L	L	L	H
EVs & Battery Storage	H	H	H	H	H	L	L	L	H
Hydrogen	L	L	H	L	M	L	L	H	M

More on this is discussed in subsequent chapters of this report.

4.5.

Geographical concentration of battery minerals

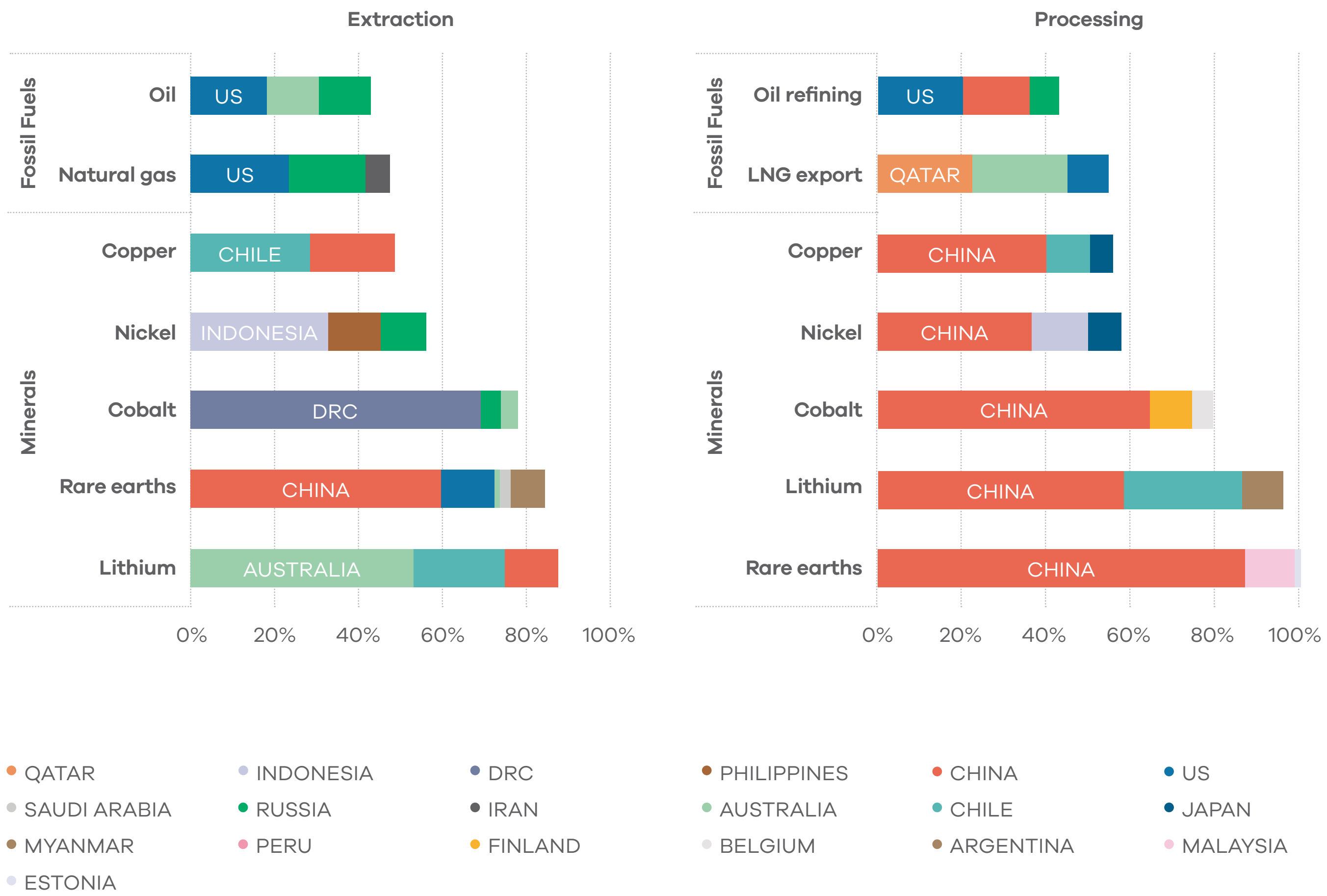
South Africa holds about 78% of the world's manganese. Other raw materials required in the cathode are mined in the sub-Saharan region of Africa. The logistical advantages of closer geographical proximity, coupled with improved regional free trade policies, such as the African Continental Free Trade Area (AfCFTA), the African Union (AU) Agenda 63, and the SADC Industrialisation Strategy and Roadmap (SISR), which provide a framework to fast-track the participation of member states in global value chains, could offer a range of advantages in accessing and utilising these raw materials.

On the global lens, however, the EV battery market is currently dominated by Asian countries and companies, with China, Japan and South Korea providing for up to 97% of the current global LIB demand. This dominance is expected to reduce in the coming years as other players invest in this market. The EU Commission recently approved multi-billion-dollar investments in developing battery production in Europe, and the United States is taking similar steps (Morris, 2021).

The production of many of the battery minerals is more geographically concentrated in certain countries and regions than fossil fuels, as shown in Figure 14.

Figure 14: Top 3 producing countries of select minerals and fossil fuels in 2019.

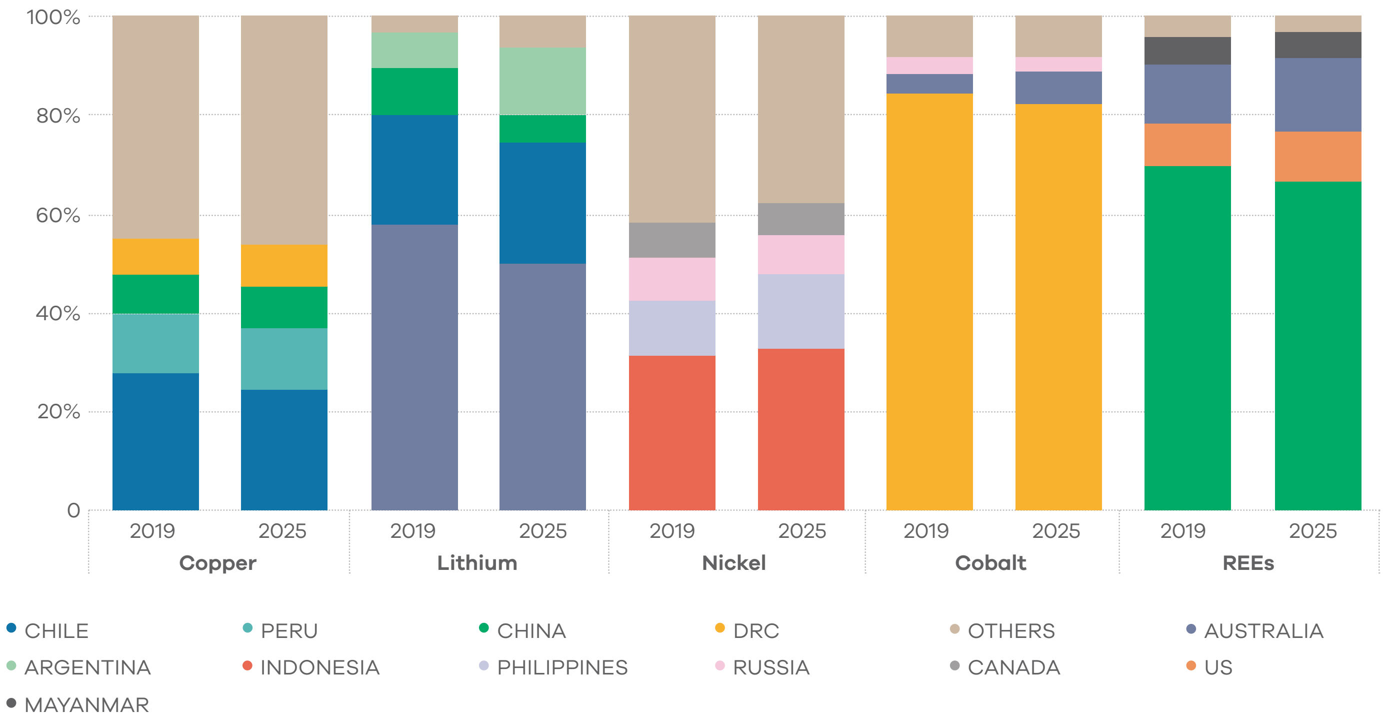
Source: (IEA, 2021)



This geographic concentration is unlikely to change in the coming years. The supply of some of the raw materials for battery cells such as lithium, nickel, and cobalt, is also affected by "economic shortages", which occurs when there are sufficient reserves of the minerals, but on account of their current market prices, they may not be feasible to mine profitably or provide value for the level of investment. Lithium-ion batteries are continuing to dominate the battery market globally.

Figure 15: Projections of future major sources of battery minerals

Source: (IEA, 2021)



4.6.

Mineral beneficiation in South Africa

South Africa is an attractive assembly and possibly future manufacturing destination for lithium-ion batteries because of its existing battery assembly (note: not manufacturing) and recycling industry. This is coupled with the SA mining sector's ability to provide some of the raw materials required for the nickel-manganese-cobalt-oxide cathode battery chemistry, particularly manganese of which the country has vast reserves (>70% of known reserves in the world). Despite its large manganese deposits, however, SA has a small share of beneficiated manganese, e.g., ferromanganese, while China has the largest share.

The mining industry contributed 8.1% (R360.9 billion) of South Africa's GDP in 2019 and employed 454 861 people throughout the mining value chain. Nevertheless, the country lags in the beneficiation of minerals to battery grade, with only manganese and aluminium that are refined to battery-grade as of 2020, by companies such as Manganese Metal Company (MMC) – the largest local producer of 99.9% manganese – that produces electrolytic manganese metal used in the battery cathode, and Hulamin Ltd that supplies aluminium battery base plates for EVs. Mintek Ltd is working on beneficiating lithium and nickel in the coming years (TIPS, 2021).

The southern Africa region is mineral endowed and possesses various mineral ores, which can be useful in the local production of lithium-ion batteries, as outlined in Table 14. The African Continental Free Trade Area (AfCFTA) could thus aid in accessing these raw materials. AfCFTA, enacted in May 2019, is the largest free-trade area in the world and is aimed at creating a single market for easy movement of capital and goods, eliminating tariffs, and creating a customs union.

Table 14: Availability of raw materials in the region for LIB production

Source: (US Geological Survey, Minerals Yearbook 2020)

Minerals and metals	Source Country
Nickel	South Africa (9th largest global producer – 4% of global reserves), Zimbabwe (<1%), & Botswana (<1%)
Manganese	South Africa (70% of the world's manganese reserves), Gabon (8% of global reserves), DRC, & Ghana
Cobalt	DRC (>60% of world supply and 85% of this is exported to China), Madagascar (2%), South Africa (<1%), & Zambia
Lithium	Zimbabwe (5th largest producing country – 1% of global reserves), South Africa, & Namibia
Graphite	Mozambique (20%), Tanzania (6%), Zimbabwe, & Madagascar (<1%)
Phosphate rock	Morocco (70%), Algeria (3%), South Africa (2%), & Egypt (2%)
Copper	DRC (2%), Zambia (2%), Namibia, South Africa, & Zimbabwe
Titanium	South Africa (8%), Mozambique (2%), & Madagascar (1%)
Bauxite	Guinea (24% of global reserves)
Iron ore	South Africa (1%)

Considering the safety challenges of transporting LIBs, manufacturing in SA also represents a strong entry point to the wider African market.

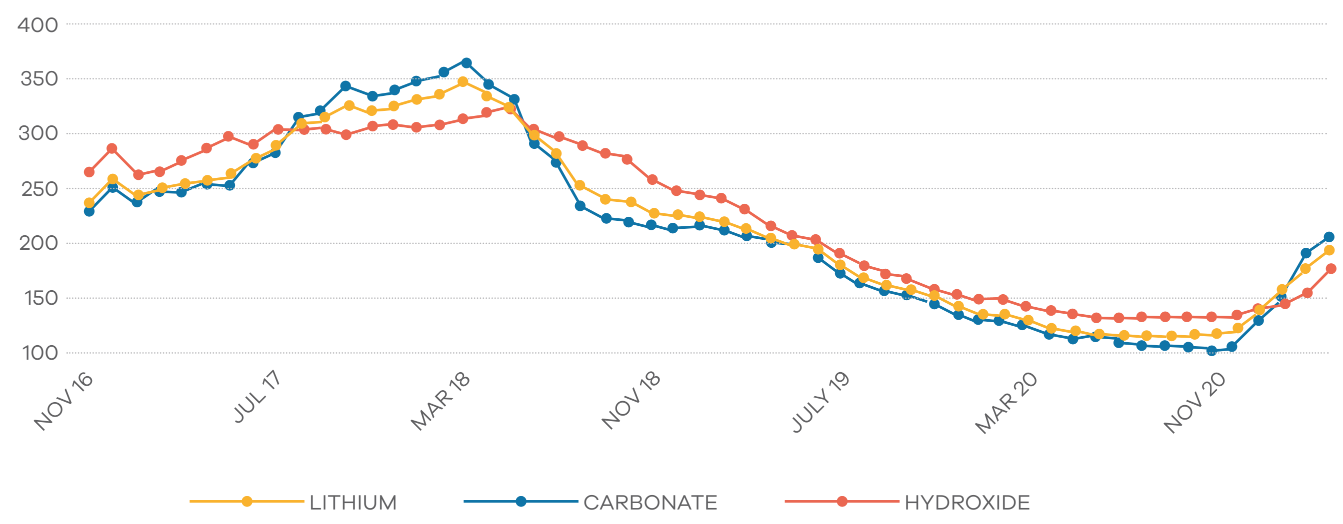
4.7.

Lithium-ion battery and cell manufacturing

As shown in the previous sections, LIB battery and cell manufacturing are still centred in a few countries. The cost of LIB depends less on the cost of the raw materials than on production volumes. This emphasises the need for scale to reduce the cost of LIBs and consequently of BEVs.

Figure 16: LIB price/kWh over time

Source: (Benchmark Minerals, 2021)



South Africa currently has no local commercial production of battery cells and relies on assembling imported cells. This is likely to continue being the case until significant scale is reached, providing demand and a business case for LIBs. The University of the Western Cape only has a pilot plant used for research and development purposes and to assess economic viability. The country has the skills and expertise, as well as the industrial capacity to establish a cell manufacturing plant locally. Being mineral endowed with many of the battery minerals also provides further impetus to assess the viability of setting up local commercial battery cell production. Metair, for instance, has cell manufacturing plants in Turkey and Romania and has been exploring setting up one at their South African subsidiary. Others such as Megamillion and AutoX are also working on establishing lithium-ion battery manufacturing plants in the country. Despite this, the existing local battery manufacturing plants use imported cells and assemble the battery packs locally.

Access to capital and financing remains the biggest barrier to the establishment of these industries. They are capital intensive industries requiring significant levels of initial investment and technical expertise. The cost of a LIB battery pack comprises cell materials (34%), pack materials (27%), capital costs (24%), and operating costs (15%). Sufficient volumes to create economies of scale would be required for the financial viability of setting up such plants (TIPS, 2021).

4.8.

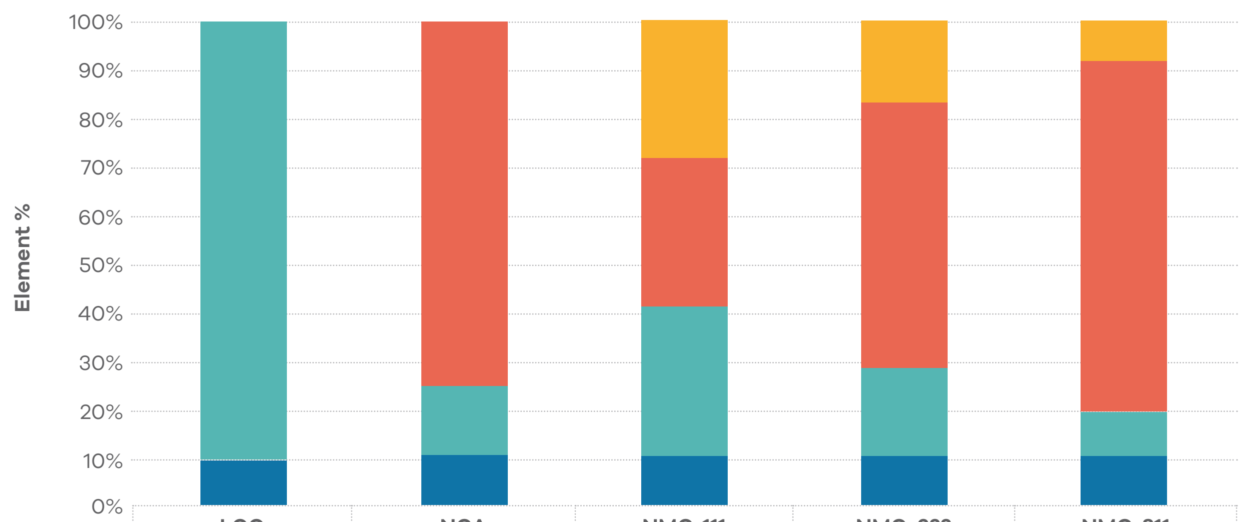
Lithium-ion battery chemistries

Earlier electric vehicles used Lithium Cobalt Oxide (LCO) chemistries, but in recent months and years, there is growing competition for varied lithium-ion battery cathode chemistries that offer significant improvements as consumers demand longer vehicle range, which requires larger battery capacities and faster charging. LCO has, however, been the cathode of choice for most applications, including mobile phones, tablets, and laptops.

4.8.1. Nickel-dominant chemistries

Battery chemistries with high levels of nickel typically have high energy densities.

Figure 17: Lithium-ion battery chemistry types (percentage of lithium in each chemistry)



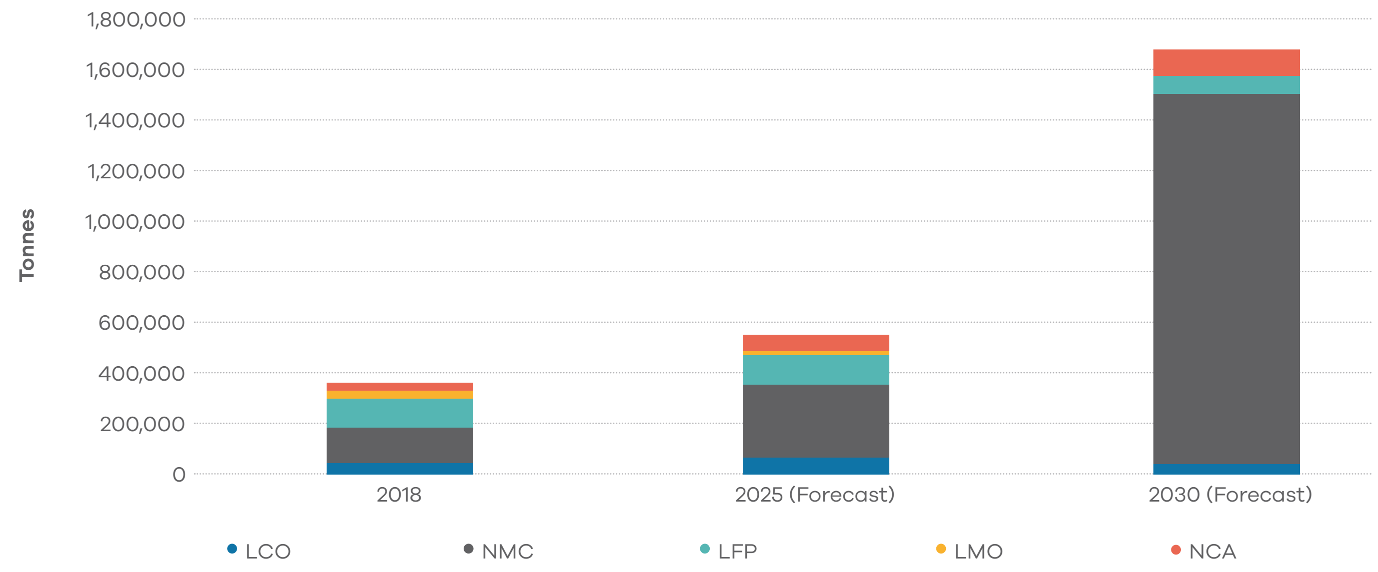
	LCO	NCA	NMC-111	NMC-622	NMC-811
Mn	0	0	0,367	0,2	0,088
Ni	0	0,759	0,392	0,641	0,75
Co	0,959	0,143	0,394	0,214	0,094
Li	0,113	0,112	0,139	0,126	0,111

where:
LCO – Lithium cobalt oxide
NCA – Lithium nickel cobalt aluminium oxide
NMC – Lithium nickel manganese cobalt oxide (numbers denote the ratio of Ni, Co, and Mn on a mole fraction basis).

(Olivetti et.al., 2017)

The nickel-based cathodes in lithium-ion batteries are expected to grow in the coming years as the number of battery electric vehicles grows. This is illustrated in Figure 18 below. Indonesia possesses the largest known reserves of nickel, followed closely by Canada and the Philippines.

Figure 18: Cathode-active materials in lithium-ion batteries



where:
LCO – Lithium cobalt oxide
NMC – Lithium nickel manganese cobalt oxide
LFP – Lithium iron phosphate
LMO – Lithium manganese oxide
NCA – Lithium nickel cobalt aluminium oxide.
Source: (Avicenne Energy, 2019)

About 2 million tonnes of nickel (Class I and Class II) globally are mined annually.

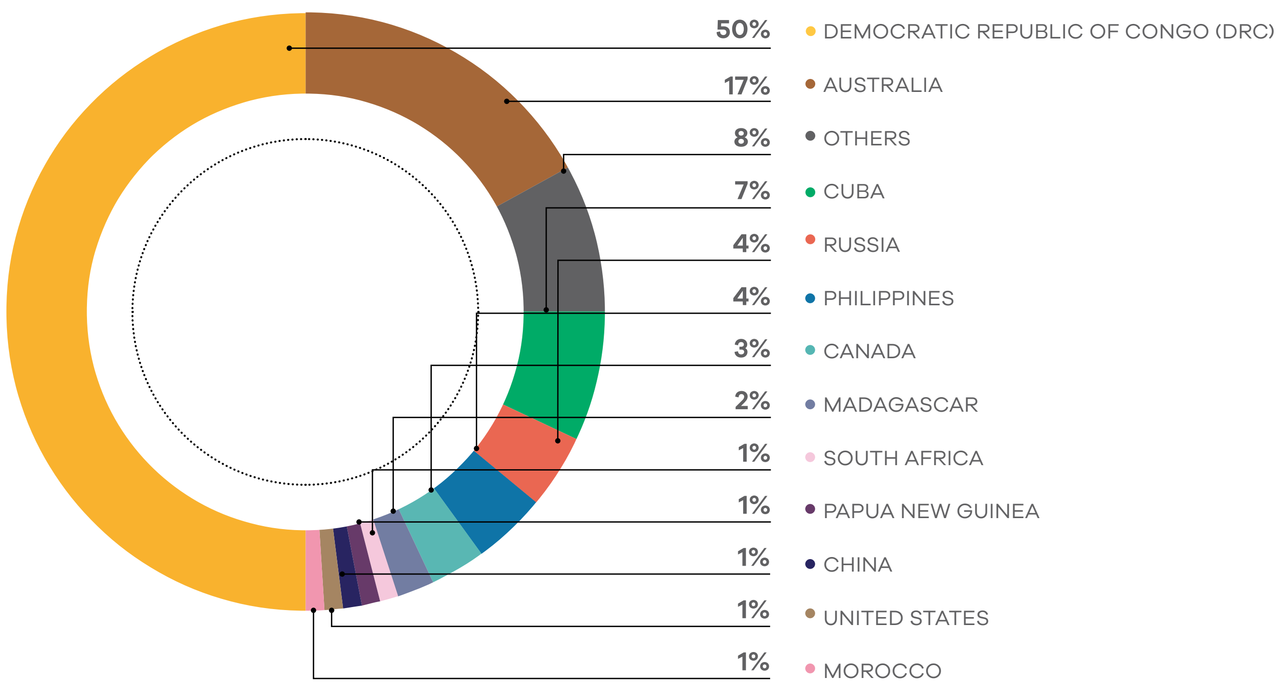
Class I nickel – This is a group of nickel products consisting of electrolytic nickel, powders, carbonyl nickel, and briquettes. With dwindling reserves of Class I nickel, alternative supply options for Class I nickel such as the conversion of nickel pig iron (NPI) to nickel matte are expensive and very emission-intensive.

Class II nickel – This comprises nickel pig iron and ferronickel; it typically has a lower nickel content and is primarily used in stainless steel production because of its high iron content.

4.8.2. Cobalt

The global supply of cobalt is heavily concentrated in a few countries, with South Africa having 1% of global reserves as of 2020. The Democratic Republic of Congo (DRC) has the largest reserves at about 51%.

Figure 19: Global cobalt reserves as of September 2020
(Source: US Geological Survey, Minerals Yearbook 2020)



The global supply of cobalt is heavily reliant on the DRC for production, and on China for refining (about 70%). However, DRC's supply of copper is risky and characterised by supply interruptions because it relies on artisanal small-scale mining, which makes it vulnerable to supply challenges. Additional supply is obtained from copper and nickel mining since up to 90% of cobalt is produced as a by-product of these minerals.

4.8.3. Lithium

Most countries, with the notable exception of China, use lithium-ion batteries mostly for automotive industry applications than for other uses. With China's 63% share of the supply of global lithium-ion batteries in 2016, only 44% was for automotive applications.

Figure 20: Lithium-ion battery cell capacities by application

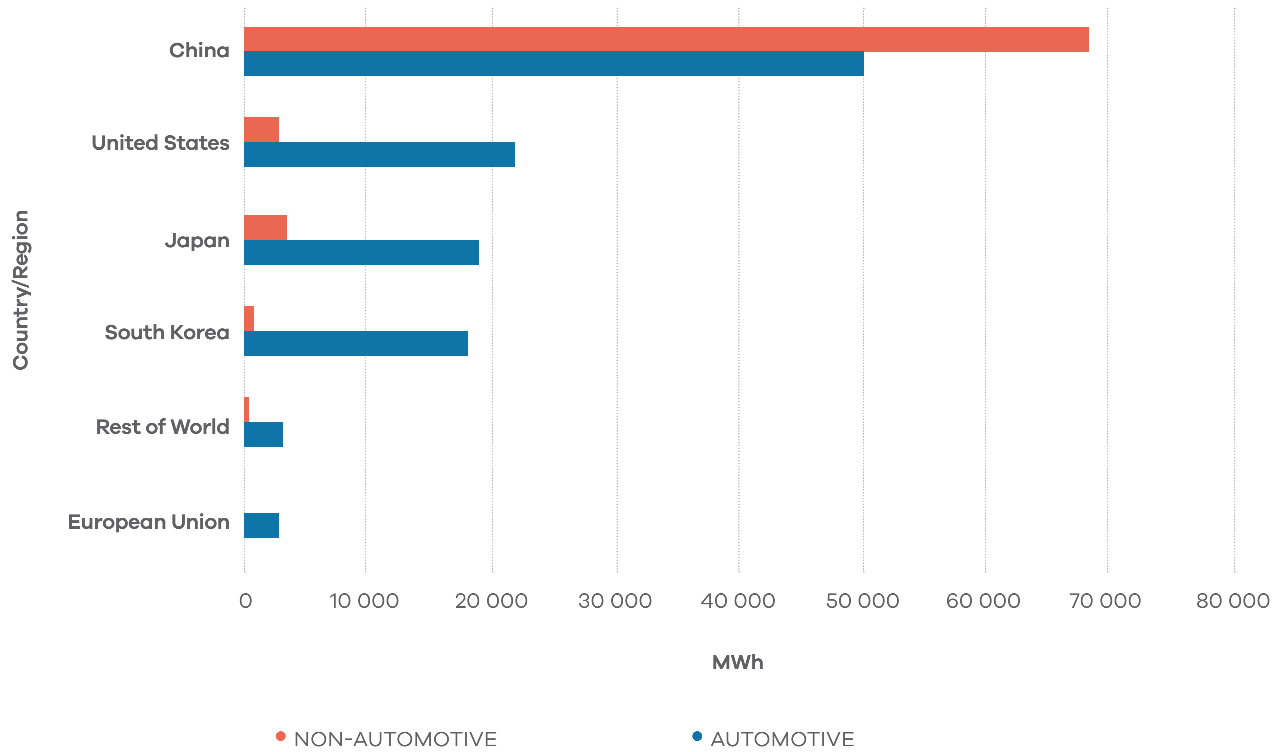


Table 15: Top lithium producing countries (2019)

Country	Production volumes (MT)	Size of Reserves (MT)
Australia	42 000	2 800 000
Chile	18 000	8 600 000
China	7 500	1 000 000
Argentina	6 400	1 700 000
United States	5 000	630 000

When it comes to lithium-ion batteries (LIBs), however, the top manufacturing countries change with China dominating the market. The mining of lithium is therefore not correlated with the production volumes of LIBs. In 2020, the global large-scale manufacturing capacity for LIBs was dominated by the following countries:

- China – 77% market share (projected to reduce to 63% by 2025)
- USA – 10% market share (projected to reduce to 9% by 2025)
- South Korea – 6% market share (projected to reduce to 2% by 2025)
- European Union – 4% market share (projected to increase to 15% by 2025)
- Japan – 2% market share (projected to reduce to 1% by 2025)
- Rest of the world – 1% (projected to increase to 10% by 2025)

(Source: TIPS, 2021)

Figure 21: LIB supply chain rankings in 2025 and projections for 2025

(Source: Bloomberg NEF, 2020)

Country	2020 rank	Raw material	Cell & component	Environ.	RII	Demand	2025 rank	Raw material	Cell & component	Environ.	RII	Demand
China	1	1	1	16	11	1	1	1	1	15(▲1)	11	1
Japan	2	12	2	6	7	6	2	8(▲4)	3(▼1)	7(▼1)	7	8(▼2)
S. Korea	3	17	2	9	5	2	8(▼5)	16(▲1)	2	13(▼4)	5	9(▼7)
Canada	4	4	10	4	10	11	5(▼1)	3(▲1)	12(▼2)	4	10	6(▲5)
Germany	4	17	6	12	2	2	6(▼2)	22(▼5)	6	9(▲3)	2	3(▼1)
U.S.	6	15	4	13	6	2	3(▲3)	13(▲2)	3(▲1)	7(▲6)	6	2
U.K.	7	17	6	9	4	6	8(▼1)	17	8(▼2)	10(▼1)	4	4(▲2)
Finland	8	11	13	5	3	13	7(▲1)	10(▲1)	8(▲5)	6(▼1)	3	17(▼4)
France	8	17	13	1	9	5	10(▼2)	17	12(▲1)	1	9	5
Sweden	10	22	13	3	1	8	4(▲6)	17(▲5)	7(▲6)	3	1	7(▲1)
Australia	11	2	13	21	12	8	11	2	12(▲1)	19(▲2)	12	11(▼3)
Brazil	12	3	13	2	24	23	12	7(▼4)	18(▼5)	2	24	15(▲8)
Poland	12	22	5	11	13	14	13(▼1)	22	5	12(▼1)	13	19(▼5)
Hungary	12	22	6	8	14	15	15(▼3)	22	8(▼2)	11(▼3)	14	18(▼3)
Czech Rep.	15	17	10	17	8	17	16(▼1)	17	12(▼2)	17	8	21(▼4)
India	16	9	13	19	18	11	16	13(▼4)	18(▼5)	21(▼2)	18	10(▲1)
Chile	17	6	13	18	16	20	14(▲3)	4(▲2)	12(▲1)	15(▲3)	16	23(▼3)
Vietnam	18	16	6	22	20	10	23(▼5)	17(▼1)	12(▼6)	23(▼1)	20	12(▼2)
S. Africa	19	5	13	23	17	19	20(▼1)	4(▲1)	18(▼5)	19(▲4)	17	22(▼2)
Argentina	20	12	13	6	22	24	16(▲4)	8(▲4)	18(▼5)	5(▲1)	22	25(▼1)
Indonesia	21	7	13	25	21	15	20(▲1)	4(▲3)	18(▼5)	24(▲1)	21	13(▲2)
Mexico	22	12	13	15	19	22	16(▲6)	12	18(▼5)	13(▲2)	19	16(▲6)
Thailand	23	22	10	19	15	17	22(▲1)	22	8(▲2)	21(▼2)	15	20 (▼3)
D.R.C.	24	8	13	14	25	24	25(▼1)	10(▼2)	18(▼5)	18(▼4)	25	24
Philippines	25	9	13	24	23	20	24(▲1)	13(▼4)	18(▼5)	25(▼1)	23	14(▲6)

Note: *"RII" is Regulations, Infrastructure, and Innovation. The number in brackets represents how many places the country has moved up or down.*

Source: (Bloomberg NEF, 2020)

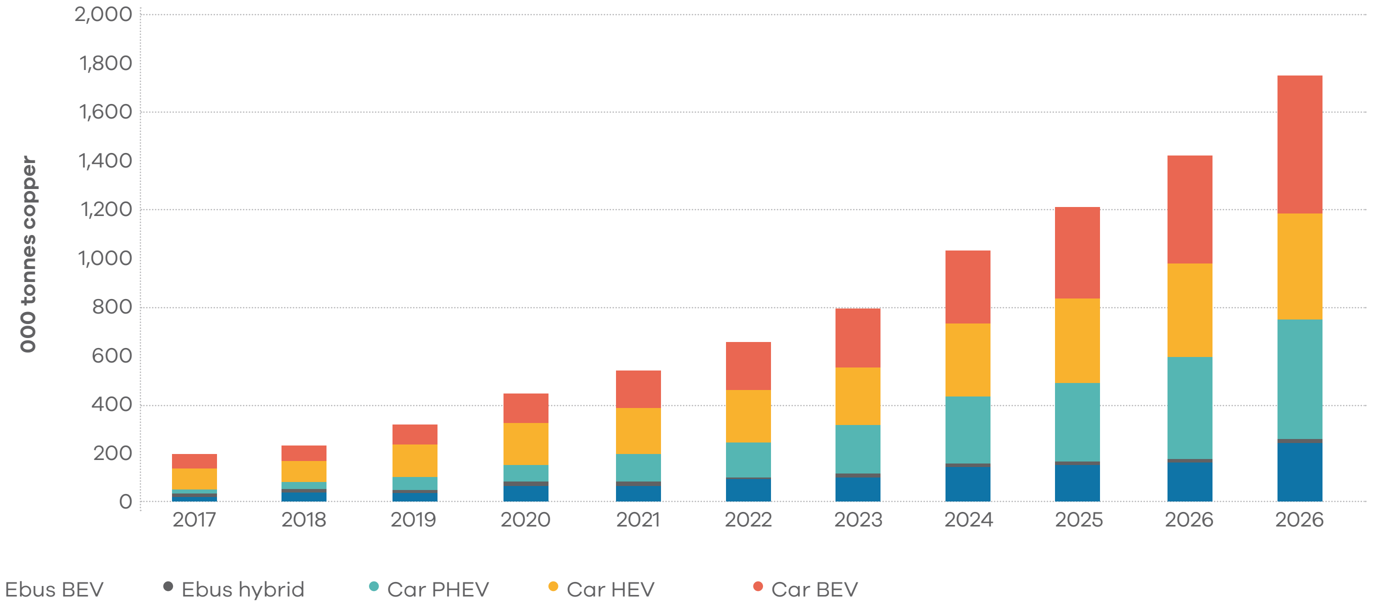
Lithium chemical production is highly concentrated in a small set of countries, with China accounting for 60% of global production (over 80% of lithium hydroxide). A key constraint and challenge is that lithium mines such as those in South Africa and Australia are often exposed to high levels of water stress.

4.8.4. Copper

As the demand for EVs and renewables grows, copper supply will need to increase because all EV types require significant amounts of copper. The copper is used in batteries, windings and rotors in electric motors, wiring, busbars, and charging infrastructure. Estimates by the International Copper Association (ICA) point to an exponential increase in the demand for copper over the current decade.

Figure 22: Electric vehicle copper demand forecasts

(Source: International Copper Association, 2017)



These projections from the International Copper Association are based on the following inputs and assumptions of the copper content in different types of vehicles.

Table 16: Copper content of different vehicle types

Vehicle Type	Copper Content
Internal combustion engine (ICE)	23 kg
Battery Electric Vehicle (BEV)	83 kg
Hybrid Electric Vehicle (HEV)	40 kg
Plug-in Hybrid Electric Vehicle (PHEV)	60 kg
Hybrid Electric Bus (HEB)	89 kg
Battery Electric Bus (BEB)	224-369 kg (depending on the battery size and the size/ capacity of the bus)

Due to copper's superior electroconductivity, it is not easily substitutable. This makes it one of the most critical minerals in electrical applications. Most copper mines globally are nearing their peak. The table below details the top-5 highest-grade open-pit copper mining operations in the world.

Table 17: The top highest-grade open-pit copper mining operations

Operation	Country	Majority owner	Copper grade in reserves (%)	Copper in ore reserves (in tonnes)	Copper grade in resources (%)	Copper in ore resources (in tonnes)
Las Cruces	Spain	First Quantum Minerals	5 %	360 000	1.8 %	780 000
KOV	DRC	Glencore	4.2 %	2 360 000	4.6 %	8 680 000
Kinsevere	DRC	MMG	3.5 %	490 000	2.8 %	1 500 000
Sepon	Laos	MMG	2.7 %	450 000	1.7 %	720 000
Antas	Brazil	Avanco	2.5 %	92 000	2.4 %	152 000

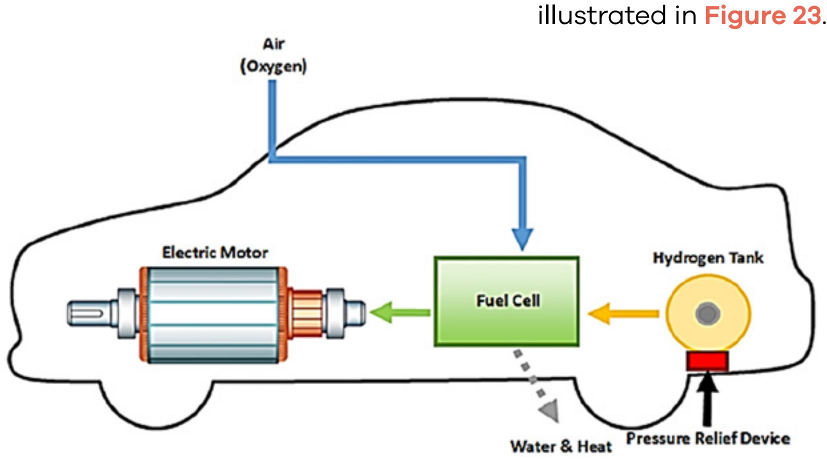
Supply could reduce due to the declining ore quality and exhaustion of reserves, which would have the effect of increasing production costs, emissions, and the amount of waste. The local South African mines are also faced with the challenge of high levels of water stress.

4.9.

Hydrogen fuel cell electric vehicles

An alternative to the BEV is the hydrogen fuel cell electric vehicle (HFCEV), which has the benefit of quick refuelling (with hydrogen) and has a much longer range than BEVs.

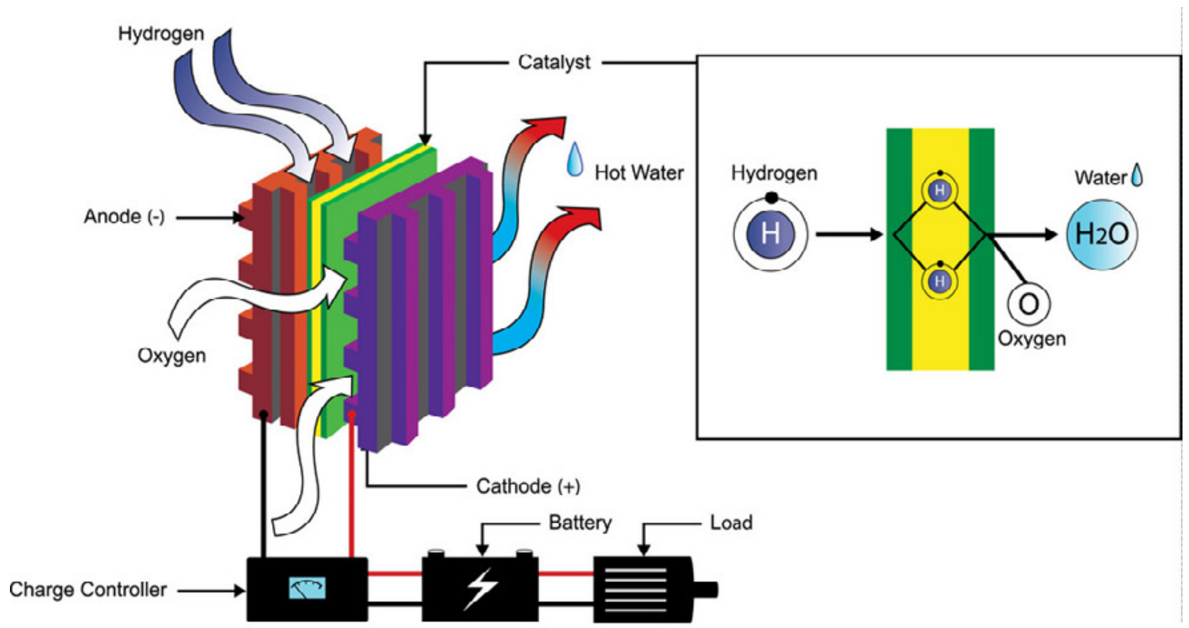
Like an electric battery, a fuel cell works by converting chemical energy into electrical energy from the movement of charged hydrogen ions across an electrolyte to generate a current. The hydrogen then recombines with oxygen to produce water and heat as the only emissions, as illustrated in Figure 23.



(Rivkin et al., 2017)

Figure 23: The hydrogen fuel cell

(MEED, 2019)



Autocatalytic converters used in ICE vehicles make up about 60% of platinum group metal (PGM) demand. The increased use of hydrogen to support a green economy has significant potential use for platinum. So much so that hydrogen fuel cell use in heavy-duty vehicles is projected to offset the declines in ICE vehicles through 2040.

4.9.1. Hydrogen (H_2)

The "green" credentials of this vehicle are determined by how the hydrogen used in the fuel cell is obtained. There are several types;

A. **Green hydrogen** – The hydrogen in this case is obtained from the electrolysis of water. The by-product of this process is hydrogen and oxygen, which can safely be released into the atmosphere, making this the cleanest process. The electrolysis of water, however, requires electricity obtained from renewable energy (solar and/or wind).

B. **Brown hydrogen** – The hydrogen, in this case, is obtained from fossil fuels, i.e., from the splitting of alkanes, and is, therefore, "dirty" for the environment.

C. **Blue hydrogen** – The hydrogen is obtained through the carbon capture process where natural gas is split into hydrogen and CO_2 either by steam methane reforming (SMR) or auto thermal reforming (ATR). Since greenhouse gases (GHGs) are captured, this negates the environmental benefits.

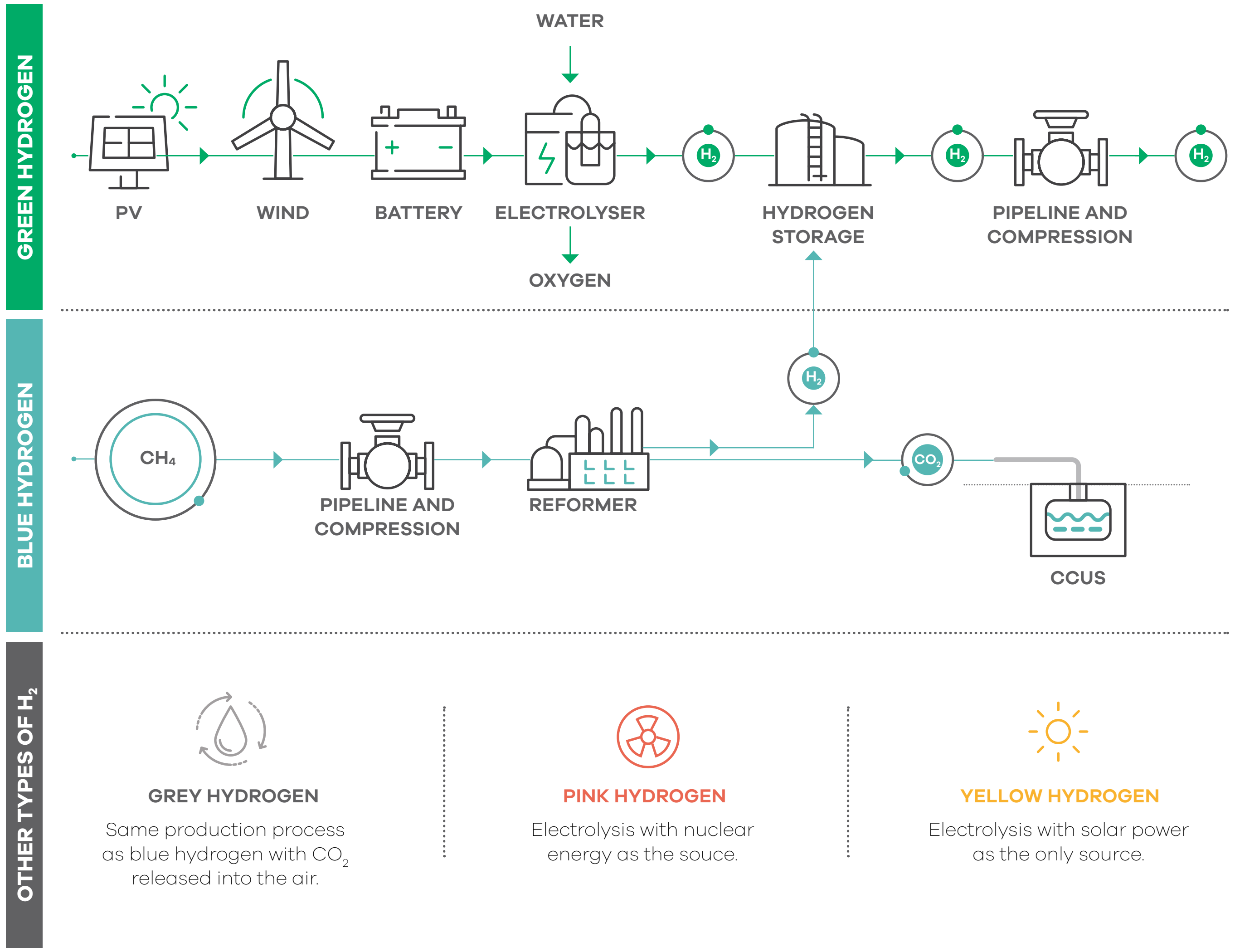
D. **Grey hydrogen** – Similar to blue hydrogen, steam methane reforming (SMR) or auto thermal reforming (ATR) can be used to split natural gas into hydrogen and CO_2. The CO_2 in this case is not captured but rather released into the atmosphere.

E. **Pink hydrogen** – Just like green hydrogen, pink hydrogen is made through the electrolysis of water, but using nuclear energy as the power source.

F. **Yellow hydrogen** – Just like green hydrogen, yellow hydrogen is made through the electrolysis of water, but solely using solar power (unlike green hydrogen which could use a combination of renewable energy sources like wind or solar).

Figure 24: The hydrogen extraction processes

Source: (Petrofac, 2019)



4.9.2. Platinum

The main material required in the fuel cell is platinum. South Africa has the largest known reserves of platinum (about 75%), and the country is also the largest supplier of other platinum group metals (PGMs). This concentration is likely to provide a competitive disadvantage since major markets would not push for a technology that is 75% dependent on one country – eggs in one basket.

South Africa platinum group metal mining:

I. **Platinum** – SA possesses 50%-60% of global reserves and provides 70%-80% of the world's platinum supply annually.

II. **Palladium** – SA possesses 25%-30% of global reserves and provides 40% of the world's palladium supply annually (Russia is the largest producer followed by the USA and Zimbabwe).

III. **Rhodium** – SA possesses 10% of global reserves and provides 80%-85% of the world's rhodium supply annually. In 2019, the mined supply of rhodium was over 750 000 oz. Recycled supply amounted to 315 000 oz, resulting in a deficit of approximately 50 000 oz.

(Source: Sibanye-Stillwater, 2021)

Hydrogen fuel cell electric vehicles have their benefits and disadvantages. There are a set of characteristics determining their viability and application for the local landscape, including the following:

1) Efficiency: The electricity requirements for HFCEV is much higher than for BEV because the electricity conversion process is up to three times more efficient for BEVs. In other words, hydrogen takes three times more energy over the same distance compared to a BEV, i.e., a limited proportion of the energy reaches the drivetrain. Studies have shown that of 100 kWh of electric power used, only 19 kWh / 23 kWh ends up on the wheels. With BEVs, the figure is three times as much, i.e., 69 kWh to the wheels.

In addition, even if the hydrogen is green (i.e., from wind/solar), more of the energy is wasted in the generation, compression, and transportation of the hydrogen, as compared to direct electricity in the case of BEVs.

2) Cost and ease of use: HFCEVs are currently much more expensive compared to BEVs – about 5 to 8 times the cost for the same vehicle per kilometre. Hydrogen is also very difficult to handle and requires specialist expertise, particularly for maintenance. It is very expensive to transport and handle cooled hydrogen. Thus, the required infrastructure is costly to install and maintain, and not as developed as battery technologies. BEVs, on the other hand, typically have lower total ownership costs and require less maintenance and care.

3) Environment: As of 2020, 95% of the global hydrogen supply comprises high CO_2 fossil-sourced 'brown' hydrogen. South Africa's electricity is also majorly coal-based.

4) Weight considerations: Hydrogen fuel cell vehicles still need batteries, and the H_2 tanks are heavy, thus weight savings over EV are not high.

5) Available infrastructure: As will be discussed later in this report, there is already an existing network of charging stations for BEVs in South Africa. There is no network of hydrogen refilling stations in the country. The hydrogen distribution is ideally almost like the current petrol system that must be rebuilt, incurring an additional cost.

Based on the factors above, the current state of the hydrogen technology does not make it economically feasible for single occupancy vehicles (SOVs) in South Africa, and there would likely be only very limited use of hydrogen. The hydrogen should rather be reserved for very specific-use cases, such as underground mining operations, heavy-duty trucks, excavators, and long-distance fleets, while BEVs can be driven for mass adoption. SA might therefore need to leapfrog onto BEVs, passing over other intermediate technologies such as plug-in hybrids, due to cost benefits, and other advantages. These are summarised in Table 17 below which compares the different types of electric vehicle options (buses are used for standardisation of the vehicle's size) on a set of parameters.

Table 18: Comparison of the various electric bus options on a set of parameters

Parameter	1) Hybrid BUS (HEV)	2) Plug-in Hybrid BUS (PHEV)	3) Opportunity Charge	4) Battery Electric Bus (BEV)	5) Hydrogen fuel cell bus (HFCEV)
Influence of climatic conditions and gradients	Slightly lower fuel savings in extreme temperatures and steep gradients	Lower fuel savings in extreme temperatures and steep gradients	Lower fuel savings in extreme temperatures and steep gradients	Up to 50% more electricity consumption in extreme temperatures and steep gradients	Same as a diesel bus
Bus operation flexibility	Same as a diesel bus	Same as a diesel bus	Same as diesel bus with hybrid buses – but opportunity charge only on equipped lines	Yes, but more flexibility on short routes without too many slopes	Same as a diesel bus
Bus operation range	Same as a diesel bus	Same as a diesel bus	Same as diesel buses with hybrid buses, but opportunity charge only on equipped lines.	Currently approximately 200 km without recharging (assuming a 300 kWh battery)	>400 km
Local availability of fuel	Available	Available	Available	Available	Not yet easily available
Direct GHG emissions (TTW) in gCO_2 / km	12 m bus: 870 gCO_2 / km 18 m bus: 1 449 gCO_2 / km	12 m bus: 814 gCO_2 / km 18 m bus: 1 400 gCO_2 / km	12 m bus: 589 gCO_2 / km 18 m bus: 1 056 gCO_2 / km	12 m bus: 600 gCO_2 / km 18 m bus: 1 100 gCO_2 / km	12 m bus: 1,832 gCO_2 / km
GHG emissions WTW incl. BC in g/km	12m bus: 1 070 gCO_2 / km 18 m bus: 1 783 gCO_2 / km	12m bus: 981 gCO_2 / km 18 m bus: 1 692 gCO_2 /km	12m bus: 624 gCO_2 / km 18 m bus: 1 056 gCO_2 / km	12m bus: 531 gCO_2 / km 18 m bus: 956 gCO_2 /km	12m bus: 1 832 gCO_2 / km
Emissions of PM $_{.5}$ in g/km	12 m bus: 0.002 g/km 18 m: 0.002	12 m bus: 0.001 g/km 18 m bus: 0.002 g/km	12 m bus: 0.0 18 m bus: 0.0	12 m bus: 0.0 18 m: 0.0	12 m bus: 0.0
NOx emissions in g/km	12 m bus: 0.46 g/ km 18 m bus: 0.46 g/ km	12 m bus: 0.384 g/km 18 m bus: 0.402 g/km	12 m bus: 0.079 g/km 18 m bus: 0.0	12 m: 0.0 18 m: 0.0	12 m: 0.0
Emissions of SO_2 in g/km	12 m: 0.008 18 m: 0.014	12 m: 0.007 18 m: 0.012	12 m: 0.001 18 m: 0.0	12 m: 0.0 18m: 0.0	12m: 0.0
Noise levels (in decibels)	3 dB less than diesel	3 dB less than diesel	3 dB less than diesel	10 dB less than diesel	n.d.

4.10. Battery recycling and the circular economy

Circular economy encompasses the use of resources in a manner that does not create waste, i.e., zero waste.

Figure 25: The circular economy

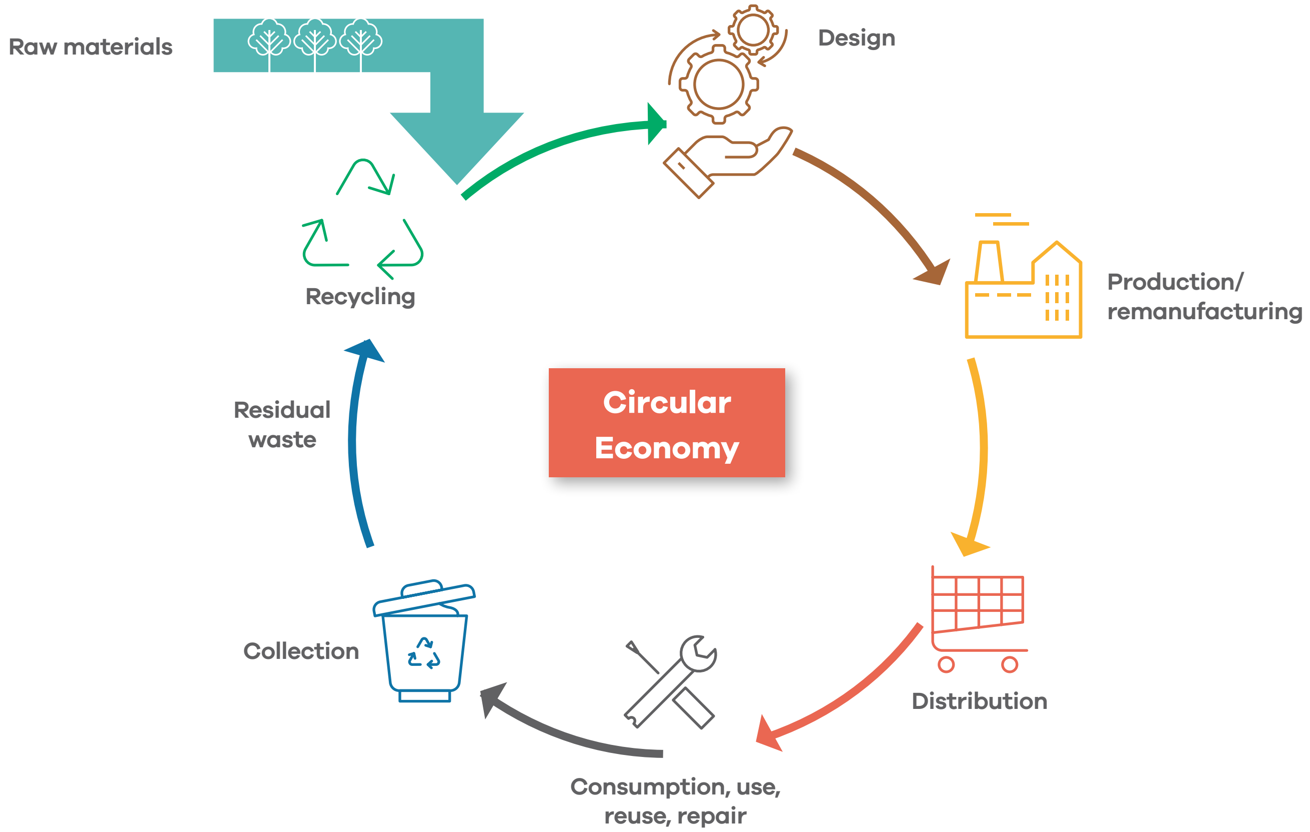
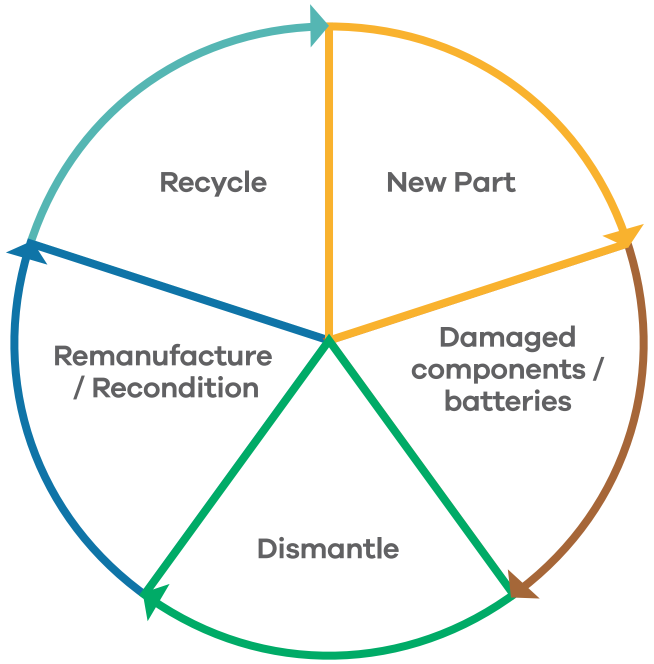


Figure 26: The recycling process for batteries



South Africa has no plant that commercially recycles lithium-ion batteries. With the 2020 Department of Environment, Forestry and Fisheries (DEFF) Extended Producer Responsibility (EPR) regulations banning the disposal of electronic waste in landfills, the batteries are either stockpiled or shipped outside the country for recycling and/or disposal. Several local companies sell imported second-life batteries (mostly from China), both to the local market as well as in the region.

There is a need to investigate ways in which to reduce metal usage in battery chemistries as well as new chemistries. Extracting the various mineral components of a battery has proven difficult and costly in the past, and recent research is focussing on ways to reuse cathodes and other battery parts mineral usage. Recycling would have the added benefit of reducing the demand for new mines.

For instance, lead-acid batteries were previously rarely recycled, but nowadays, nearly all lead-acid batteries are broken down for reuse in ICE vehicles. Domestic recycling would help further that goal by breaking down older EVs into parts for new vehicles and thus relying less on mining.

The EU is considering clamping down on exports of metal waste to encourage more regional recycling, part of an effort to become climate neutral by 2050.

A report by the University of Technology Sydney's Institute for Sustainable Futures found that recycling end-of-life batteries could cut the projected need for new sources of copper for EV batteries via mining by 55% by 2040, and by 25% for lithium, and 35% for cobalt and nickel (Hunnicutt & Scheyder, 2021).

On 05 November 2020, the Minister published the Extended Producer Responsibility (EPR) regulations (GN 1184 of 2020) as a framework for the development, implementation, monitoring, and evaluation of EPR schemes for identified specific products, and to which producers of those products must adhere. The Minister has identified, among others, the electrical and electronic equipment products and lighting products, and has subsequently published notices (GN 1185 of 2020 and GN 1186 of 2020) requiring producers of these products to either establish and register an EPR scheme or sign up to an existing registered EPR scheme.

The mining process of the various minerals is exhibiting high levels of GHG emission intensities, as shown in Figure 27. Consequently, several mining companies with a presence in South Africa have made commitments and pledges to reduce emissions. This information based on company fillings is summarised in Table 18 below.

Figure 27: Average GHG intensity to produce select minerals

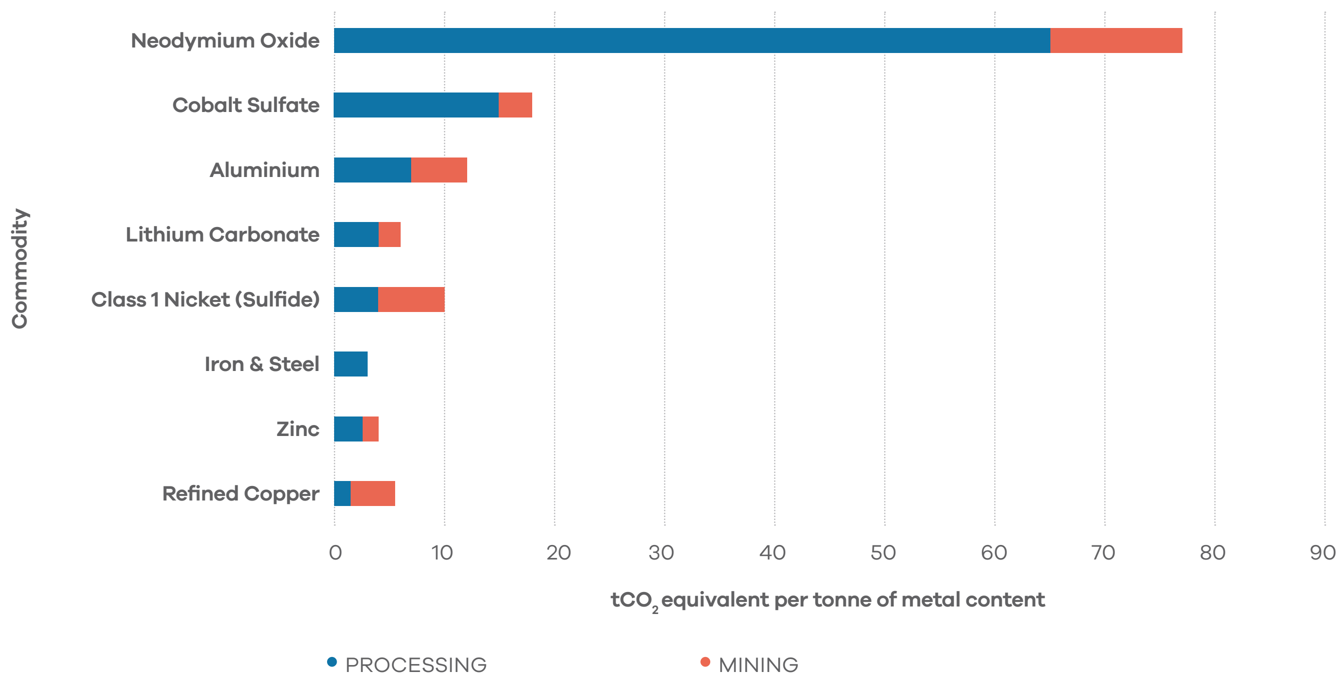
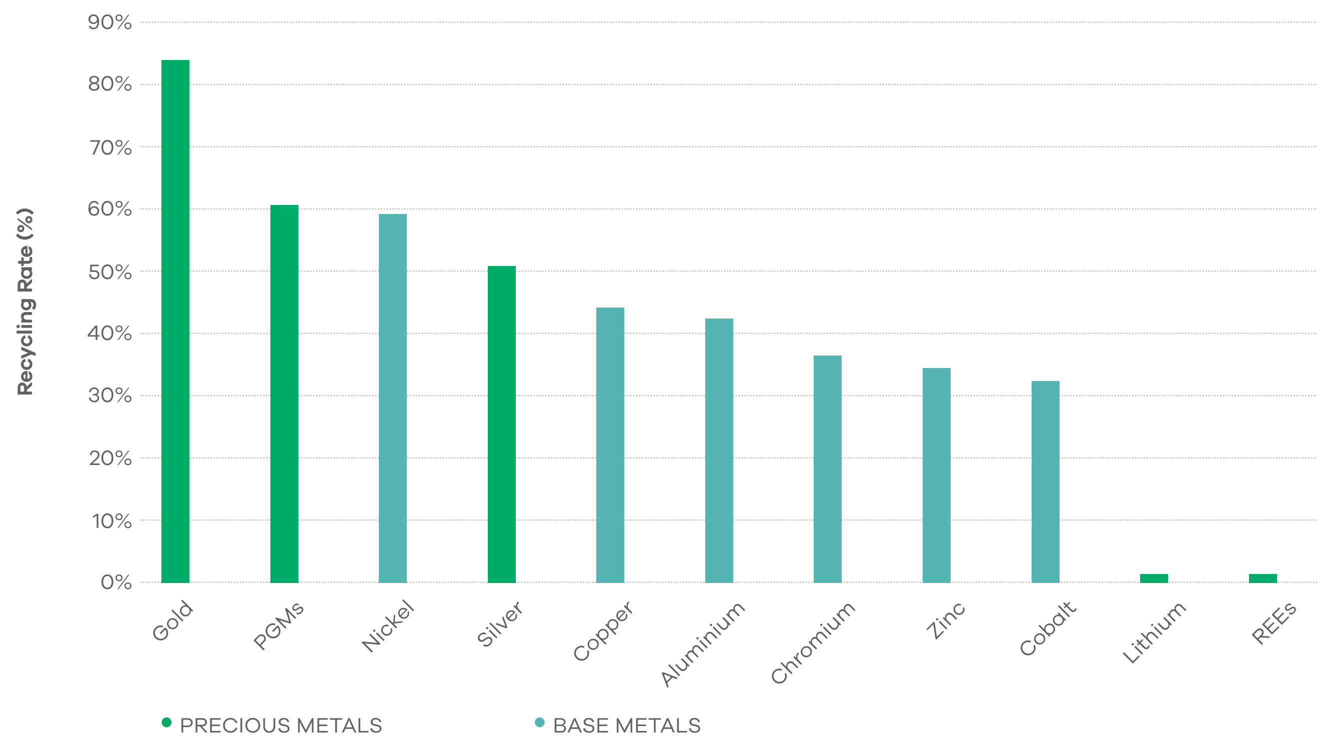


Table 19: Mining companies' net CO_2 emission reductions pledges (%)

Company	2021 to 2030 (&)	Long-term (up to 2050) (%)
Vale	33	100
BHP	30	100
Rio Tinto	30	100
Glencore	40	100
Norilsk Nickel	25	–
Barrick Gold	10	–
AngloGold Ashanti	TBC	–
First Quantum Minerals	TBC	–
Anglo American	30	100
Sibanye-Stillwater	27	–
Mitsui	50	100

Globally, the recycling rates for different metals vary, based on the cost, availability of technology, and ease of collection of the recycling materials. These rates are shown in Figure 28. The existing and expected LIB recycling capacity to come online by 2021 is shown in Figure 29.

Figure 28: The end-of-life recycling rates for select minerals

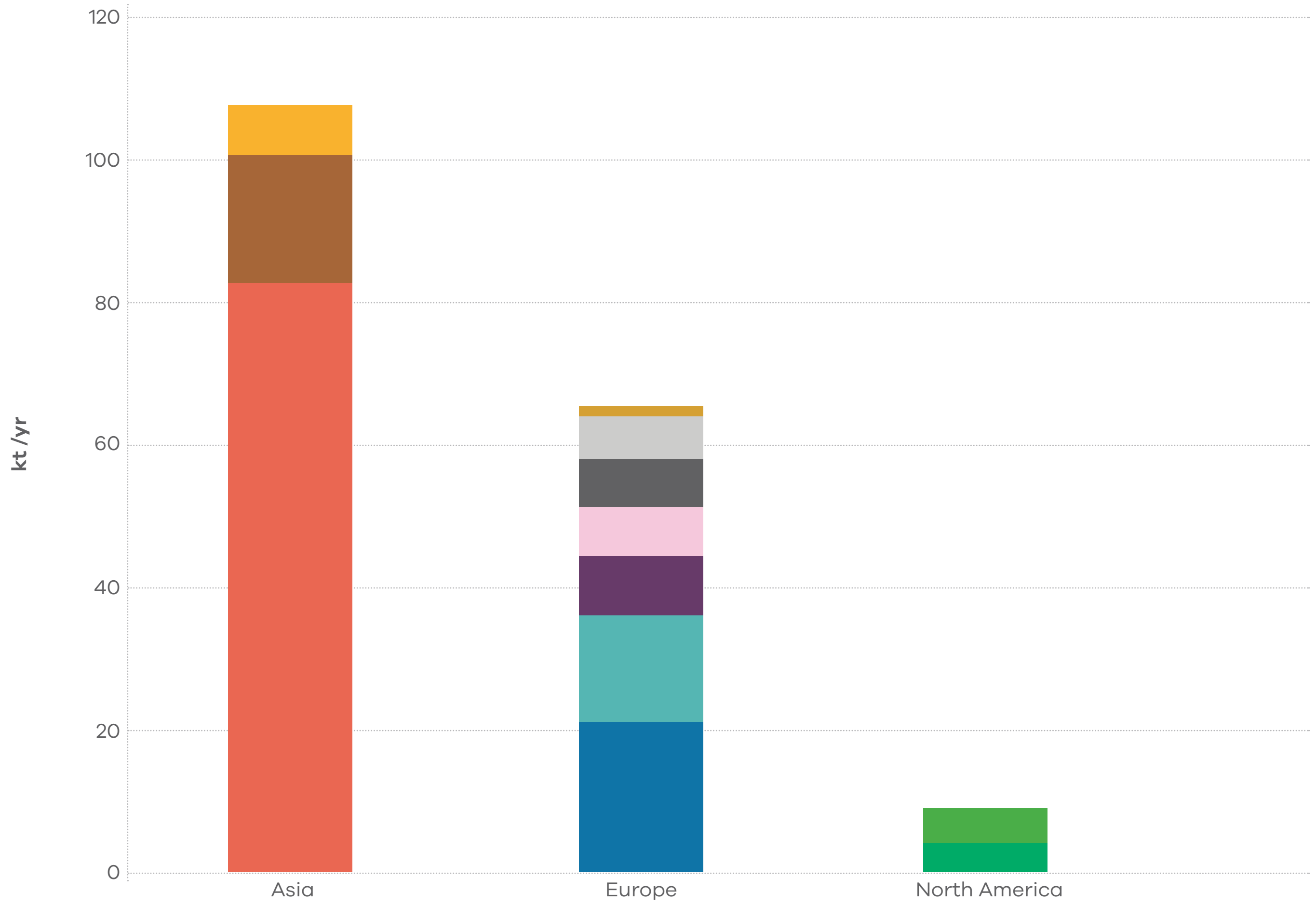


The potential for a battery recycling and second-life business case from EVs in South Africa is such that despite the environmental and circularity benefits, and as a source of raw materials, battery recycling is not yet viable because the number of EVs is still very low. The EVs available in the country have not yet reached their end-of-useful life point.

In addition to the investments into the mining of the battery minerals, China is still the dominant player in the refining of batteries, accounting for about 80% of the world's battery raw material refining capacity, 77% of cell production capacity, and 60% of battery component manufacturing capacity.

Figure 29: The existing and announced LIB recycling capacity coming online by 2021 per region

Source: (IEA, 2021)



ASIA
- JAPAN
- SOUTH KOREA
- CHINA

EUROPE
- SWITZERLAND
- FINLAND
- DENMARK
- NORWAY
- BELGIUM
- SWEDEN
- GERMANY
- FRANCE

NORTH AMERICA
- CANADA
- UNITED STATES

5

Charging Infrastructure

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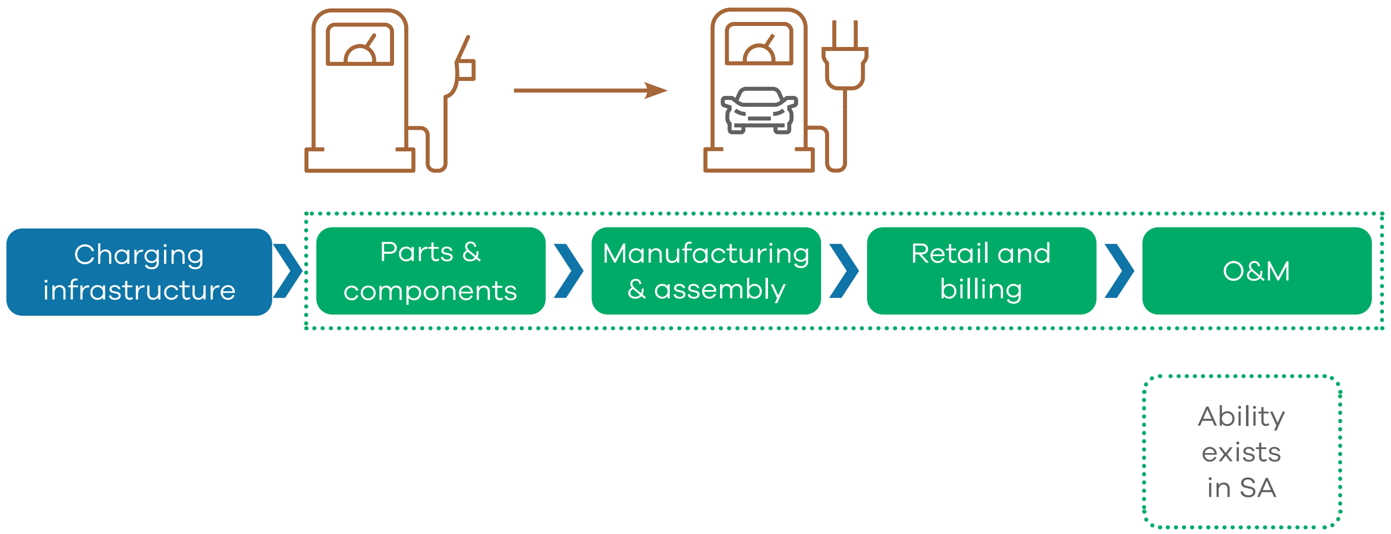
5.1.

Charging infrastructure value chain

Figure 30: The charging infrastructure value chain



The EV charging infrastructure market is projected to grow substantially as more people switch to EVs. The private sector has until now been driving the roll-out of charging infrastructure in the country with limited support from the government. The number of charging points globally was estimated at approximately 5.2 million at the end of 2018, up 44% from the previous year. Most of this increase was in private charging points, accounting for more than 90% of the 1.6 million installations (IEA 2019).

Alternating current (AC) chargers are projected to continue to dominate the EV charging market on account of the expected demand for EV charging from residential multi-dwelling buildings, commercial (offices), retail (shopping malls), and filling stations. Growth for direct current (DC) fast chargers is also projected to increase over time, but to a lesser degree than AC chargers, driven by the growth of public transport EVs (e-buses and potentially e-taxis), logistics and delivery services, and long-distance travellers.

EV charging stations market by end-user.

- **Commercial**
  - On-road
  - Public parking
  - Others
- **Non-Commercial**
  - Residential
  - Non-residential

EV charging stations market by type.

- Plug-in charging station.
  - Level 1 charging station – plugging into a 120-volt household electrical outlet circuit [very slow charging].
  - Level 2 charging station – plugging into a 240-volt household electrical outlet circuit [relatively slow charging, but faster than Level 1].
  - Level 3 charging station – plugging into a very high voltage and current electrical outlet [fast charging but is not supported on all vehicles].
- Wireless charging station

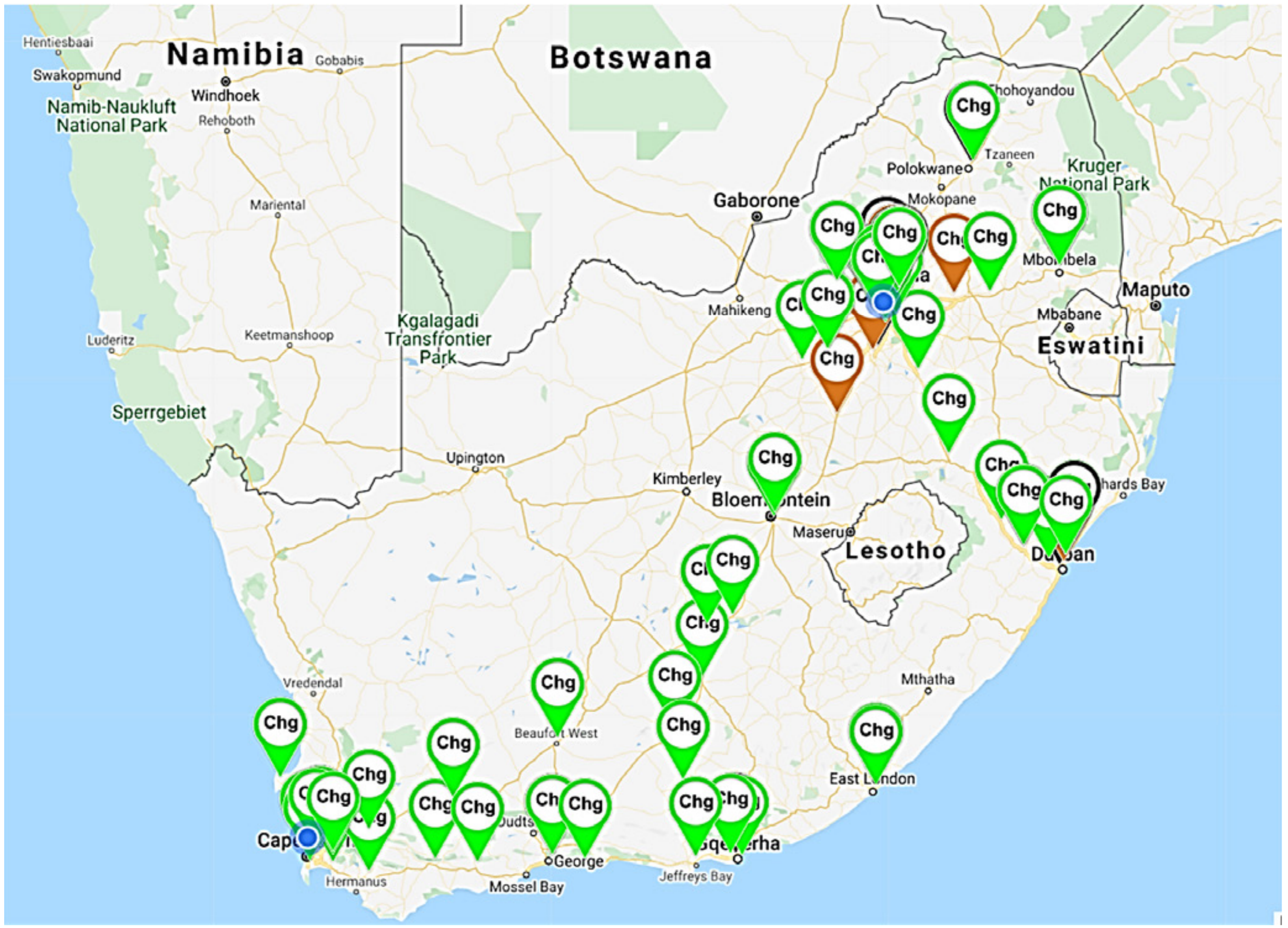
EV charging types.

- Conventional charging (AC)
- Opportunity (and depot) charging
- Fast, rapid, and ultra-rapid charging (DC)

Locally, the number of charging points is still very low at about 280 publicly accessible charging stations, and with a small geographical coverage as illustrated in Figure 31. Because of the small number of EVs in the country, there is one public charging station for four EVs in the country because the charging infrastructure is ahead of the EV demand. The market for charging infrastructure, both commercial (on-road and public) and non-commercial (residential and non-residential) will grow as the market for electric vehicles grows, but the timing of this is uncertain. Most of these charging stations are in the major metros of Cape Town, Durban, and Johannesburg, and most of them are AC charging stations.

Figure 31: Publicly available charging infrastructure stations in South Africa

(Plug Share, 2020)



There are several charging infrastructure providers (Charge Point Operators – CPOs) active in the local EV value chain, including GridCars, ACDC Dynamics, EvCrowdRoute, OneStopCharge, Powerway Network, Breev, EV Charge, and BMW Charge Now. The largest CPO based on the number of publicly available charging stations is GridCars, which currently holds about 80% of the market share, providing Electric Vehicle Charging Service Equipment (EVSE), charging station infrastructure, and management systems. GridCars is part of Alviva Holdings, which owns one of South Africa's largest Solar PV EPC firms, Solareff. The partnership with Solareff allows them to leverage a renewable energy option for charging, i.e., solar PV as part of the package.

Charge points have been placed strategically on the major inter-city/inter-provincial highways and national roads within 150 to 200 km of each other. This distance is theoretically sufficient, bearing the range of most modern EVs. The charge points would then have to be maintained long enough for demand to catch up in the coming years. These companies want to attain some level of first-movers advantage before larger private sector players such as Shell, who have announced their intention to provide some of their filling stations with EV charging facilities or the OEMs jump in and start rolling out their charge station networks nationally.

The challenge for CPOs in South Africa is that the infrastructure is required to create demand for EVs, but it is a challenge to build the infrastructure until some levels of demand and sales have been achieved – the classic chicken-and-the-egg problem.

5.2.

Business models in the local EV charging landscape

5.2.1. Asset light model

In this model, the CPO sells, installs, and operates charge points on behalf of a third-party owner, such as private individuals, a local authority, or a commercial sector host. The CPO does the installation, management, maintenance, and operation of the charge stations, both technical and administrative while minimising defaults and maximising uptime. The CPO and the entity in this way engage in value chain partnerships, vertical integration, joint projects, and investments.

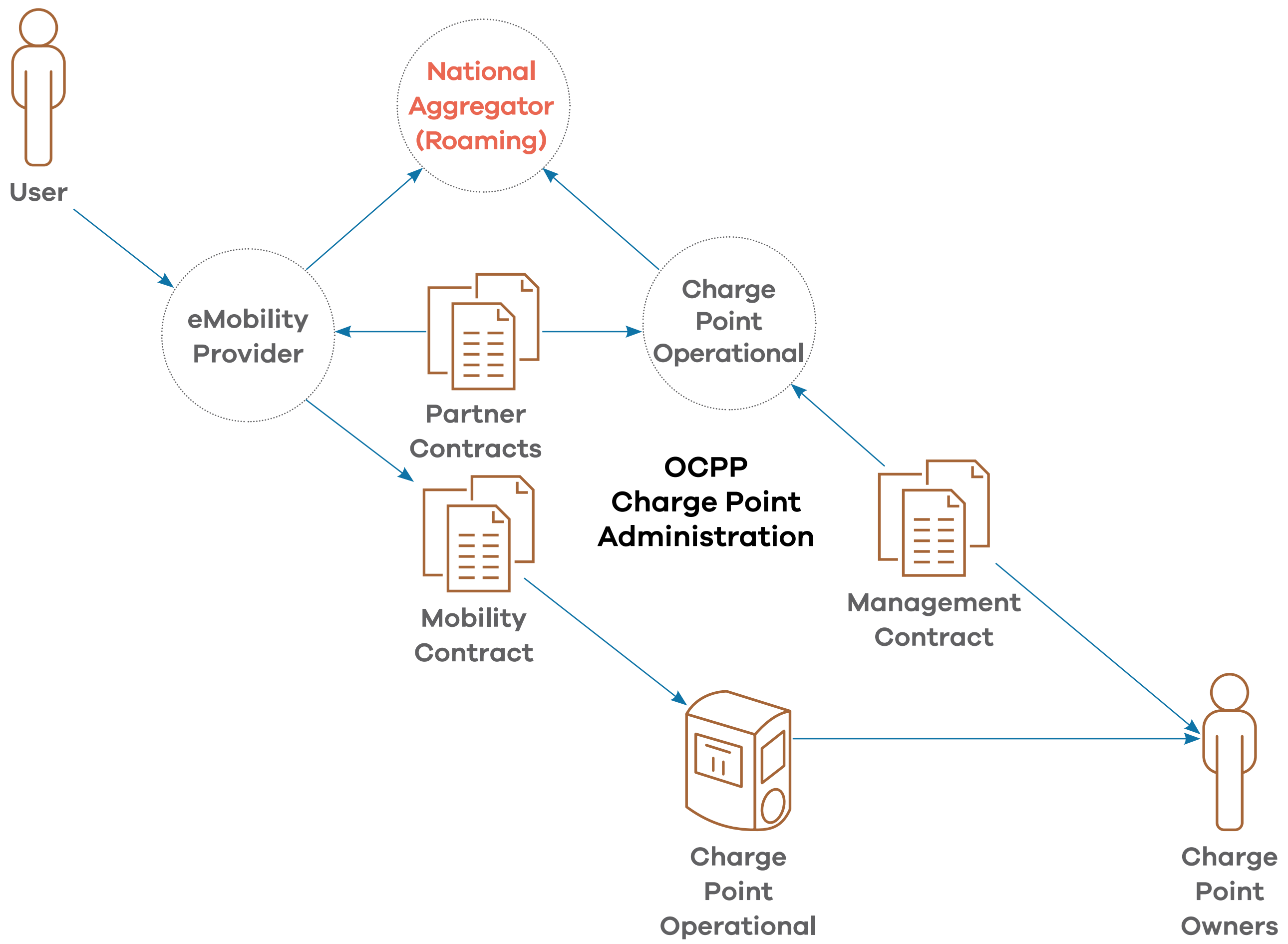
There is a range of benefits that accrue from collaborations, partnerships, and vertical integration as options for growth in the EV charging value chain. Partnership models can reduce upfront costs and accelerate overall adoption while allowing for increased product control. Innovation by SMMEs, start-ups and spin-off companies drives partnerships. Partnership models also increase the 'trust factor' of consumers, particularly if the partnerships go beyond the existing ecosystem.

An example of this is where GridCars installs, maintains, and operates charge points on behalf of Jaguar, as illustrated in Figure 32. GridCars has also partnered with BMW to install, run, and maintain charge points in the BMW ChargeNow network. Together with Nissan and Jaguar, they all have installed charge stations – typically AC systems – at their dealerships.

Figure 32: Jaguar's charge point operated by GridCars at Ilanga Mall, Nelspruit

Figure 33: CPO business model

Adapted from (GridCars, 2021)



5.2.2. Asset heavy model

In this model, the CPO finances, or co-finances EV charging infrastructure and invests it into its network of charging points. CPOs do the installation, management, maintenance, and operation, both technical and administrative, of their charging stations and infrastructure. The charge station cost and utilisation rates provide a variation in risk and return, as well as the possible business models. Shell SA has announced that it would be launching the first EV charging stations in their expansive retail network from 2020/21.

GridCars has of April 2021 installed 280 charging stations and 350 connectors across the country. Some of the charge points have two connectors, only 11 of which have the CHAdeMO connector type and are meant to provide charging to the 91 Nissan Leaf EVs, which are the only EVs in South Africa that utilise the CHAdeMO connector standard.

By installing a charging station network, GridCars has focused on the major national roads, ensuring the provision of a charge station within 200 km of each other and at strategic locations within the major cities in the country. This included the main parts of the N1, N2, N3, and N4, as well as some smaller routes such as the N9 and R75. The network intends to connect the major cities in an "electric highway" – Cape Town, George, Port Elizabeth, East London, Colesberg, Bloemfontein, Harrismith, Durban, Johannesburg, Pretoria, Polokwane, Gaborone, and Nelspruit.

- M1, M2, M3, and M4 – within 200 km
- N1 and N2 – within 100 km, e.g., the Garden Route in the Western Cape province.

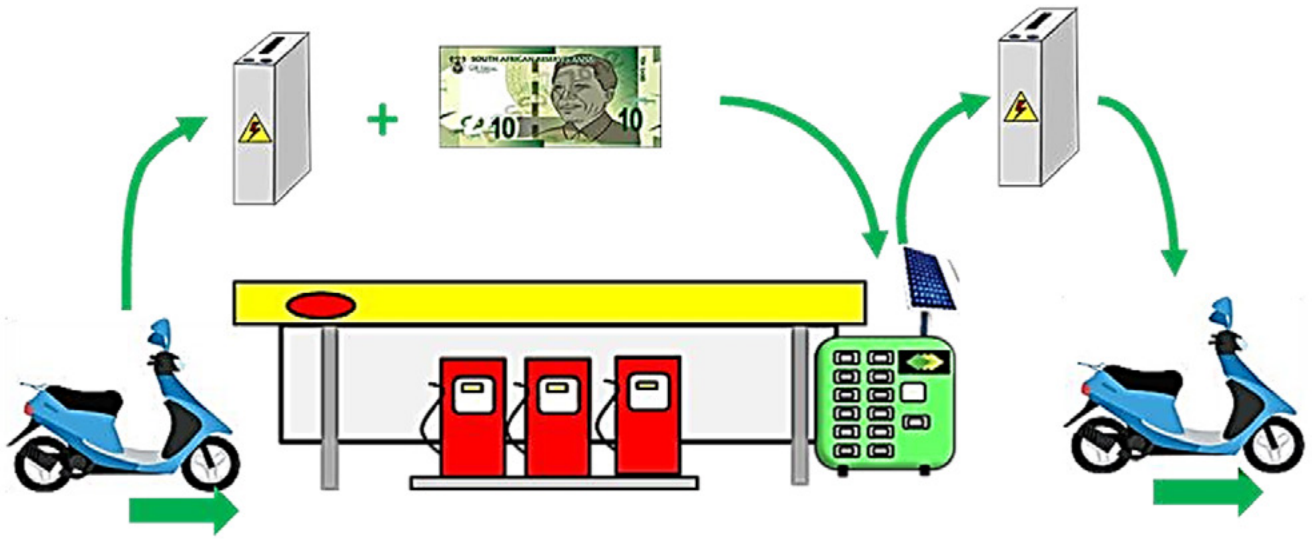
Additionally, GridCars has installed charge points at major shopping centres within the major cities. The network consists of 52 x 60-80kW DC Fast Chargers. Their primary clients so far include some of the OEMs, malls and office parks, hotels, BnBs (Bed & Breakfast), and portfolio investors such as filling stations and property investors.

5.2.3. Battery swapping as a service

This is another emerging business model globally as a viable solution to the challenge of long charging times in the absence of DC fast charging. Battery swapping is where the vehicles' depleted batteries are replaced with fully charged batteries at a swop station. Swapping inherently reduces upfront cost, range anxiety, and time required for charging. The simplicity and benefits of battery swops can be leveraged to increase adoption, especially in the two-wheeled and three-wheeled vehicle markets, with companies such as Go-Lectric in Cape Town piloting this model for electric scooters and e-bikes.

Figure 34: The battery swap concept

Source: (Go-Lectric, 2021)



5.3.

Charging technologies

The charging market is segmented on the connector type: CHAdeMO and Combined Charging System (CCS), with American and Japanese automotive OEMs such as Nissan using the former, and most other OEMs around the world using the latter. China, on the other hand, uses the GB/T connector type within the country and installs different connector types on exported EVs based on the country exported to. Interestingly, American manufacturer Tesla recently switched from CHAdeMO to the CCS connector type, and this trend is expanding to other OEMs.

- CHAdeMO – maximum of 90 kW
- CCS – maximum of 350 to 600 kW

A broader breakdown of the charging standards employed by automotive companies in SA is shown in **Table 19**.

Table 20: OEMs, industry and distributors' DC charging technology

Original Equipment Manufacturers			
CCS charging technology	**CHAdeMO charging technology**	**CHAdeMO/CCS charging technologies**	**TBA charging technologies**
• BMW (South Africa (Pty) Ltd • Ford Motor Company of Southern Africa (Pty) Ltd • Volkswagen Group South Africa (Pty) Ltd • Mercedes-Benz SA Ltd	• Nissan South Africa (Pty) Ltd • Toyota South Africa Motors (Pty) Ltd	N/A	• Isuzu South Africa
Importers & distributors			
• Audi (VW Group) • European Automotive Imports South Africa (EAISA) (Pty) Ltd (Maserati) • FCA South Africa (Pty) Ltd (Fiat Chrysler Automobiles Group) • Jaguar Land Rover • Mini South Africa • Porsche • Volvo Car South Africa	• Honda • Mahindra & Mahindra South Africa (Pty) Ltd • Mazda Southern Africa (Pty) Ltd • Mitsubishi Motors South Africa (MMSA) • Peugeot SA (Pty) Ltd • Renault South Africa (Pty) Ltd • Subaru • Suzuki Auto South Africa	• Hyundai Auto South Africa Pty Ltd (MOTUS Group) • KIA Motors South Africa (Pty) Ltd	• HAVAL Motors South Africa (Pty) Ltd (HMSA) • TATA Motors South Africa

6

Energy supply and the electricity grid

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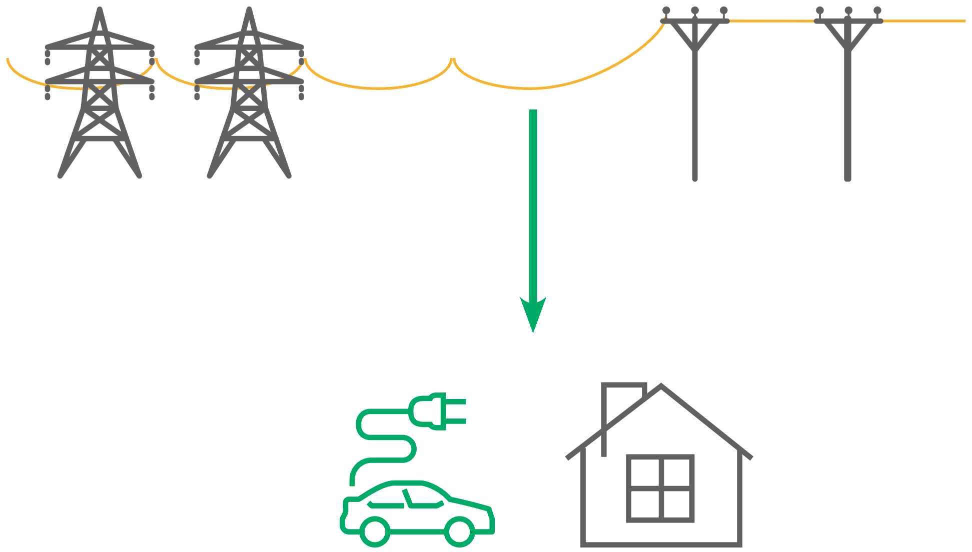


Table 21: Renewable energy value chain in South Africa

(GreenCape, 2021)

Developer	Construction	Operations	Equipment
Project Developers (& IPPs)	**EPC (Engineering, Procurement and Construction)**	**O&M (Operation & Maintenance)**	**OEM (Original equipment manufacturers)**
Enel Power	Nordex Energy	Nordex Energy	Nordex Energy
Mainstream Renewable Energy	Murray & Roberts	Globeleq SAMS	Siemens
Mulilo	Consolidated Power Projects	Juwi	SunPower manufacturing
Juwi	Juwi	Energy Systems Southern Africa (Pty Ltd)	SMA
ENGIE	Basil Read (Pty) Ltd	3E Renewable Energy Services	Canadian Solar
EDF Renewables	SunPower	SunPower	Bushveld Energy
Pele Green Power	Power Construction	Goldwind Africa	GE/LM Wind
–	Group Five	–	GRI Towers
Genesis Eco-Energy	Aveng Steel	–	Vestas
BiogasSA	Power Construction	–	Guodian United Power
BioTherm Energy	Grupo Cobra South Africa	–	Aeris
Botala Energy Solutions (biogas)	Lesedi Nuclear Services	–	Brits Textiles
Canadian Solar	Sustain Power (biogas)	–	–

Developer	Construction	Operations	Equipment
Globeleq	CTE Wind Civil Engineering	–	–
Mainstream Renewable Energy	Fountain Green energy (biogas)	–	–
Mulilo Renewable Energy	Logical Waste (biogas)	–	–
Kabi Solar	Reutech	–	–
Enerdigm Energy	IMPOWER	–	–
Golden City Solar	Ebenhaeser Engineering	–	–
Ngodwana Energy (Pty) Limited (biomass)	Basil Read (Pty) Ltd	–	–
Red Cap Energy	FALQON ENERGIA PVT LTD	–	–
Total Solar	Redheads Engineering Solutions (Pty) Ltd	–	–
Energy Systems Southern Africa (Pty Ltd)	–	–	–

As discussed previously, a prime challenge to the EV ecosystem, from the mining of lithium-ion battery minerals to the charging infrastructure value chain, is the availability of electricity. By the end of 2020, South Africa had 51.6 GW of wholesale/public nominal capacity, according to the CSIR. In the same year, load shedding occurred for 859 hours of the year (9.8%) with an upper limit of 1 798 GWh relative to an achieved energy shed of 1 269 GWh – the worst the country has experienced.

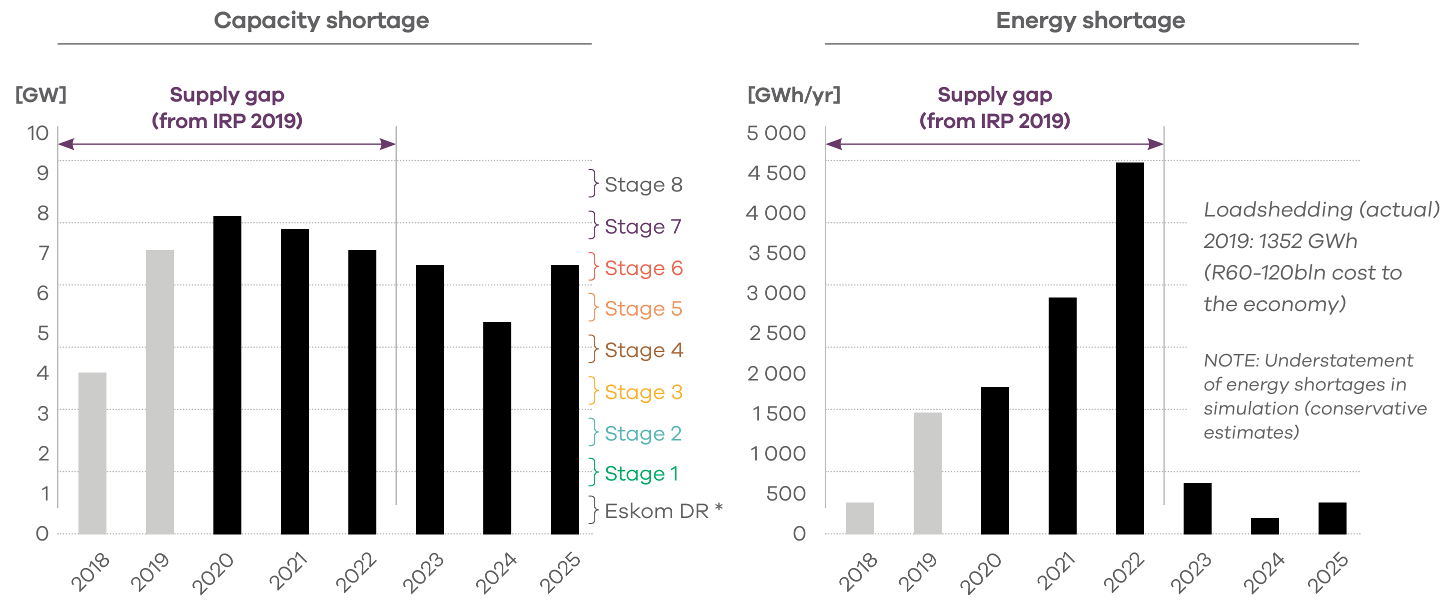
Table 22: Electricity capacity in 2020

Electricity source	Nominal Capacity (GW)
Coal (83.5% of the total system demand)	37.9 GW
Nuclear (5.2% of the total system demand)	1.9 GW
Diesel (OCGT– Open Cycle Gas Turbine) – (0.9% of the total system demand)	3.4 GW
Hydro	0.6 GW
Hydro and pumped storage	2.7 GW
Wind	2.5 GW
Solar PV	2.0 GW
CSP (Concentrating Solar Power)	0.5 GW
Total	51.6 GW

The CSIR projects a further increase in energy shortages in the near team, as shown in **Figure 35**.

Figure 35: South Africa's electricity shortage

(CSIR, 2020)



With the recent changes in regulations allowing for the procurement of energy from IPPs and the desire to increase procurement of renewable energy as expressed in the REIPPPP Bid Window 5 programme, several players have emerged in this landscape.

Table 22 outlines some of the players in the solar energy space in the country, while **Table 23** outlines those in the wind energy space.

Table 23: Solar PV energy value chain in South Africa

Solar										
Solar panels	Trackers	Founda-tions	Inverters	Cabling	Yield assess-ments for banks	Trans-formers	Steel structures	Bolts and nuts	Battery	Gear-boxes
BYD Energy	Ideematic (Germany)	Group 5	Siemens	ACDC Dynamics	SolarGIS	SMA Solar	LUMAX Energy	SA Bolts Manu-facturers	Tesla	ZRW Mecha-nika
Trina solar	Power-Way	Murray and Roberts	GP Tech (Australia)	Hellerman Tyton	Solar-Praxis	AllBro Group	Hulamin	T&I CHALMERS Engineering	First National Batteries	–
Jinko solar	PIA Solar	Aveng	SMA	IBC Solar	–	Actom	–	TELSCREW	–	–
Hanwha SolarOne	Reutech	–	Bonfiglioli	Alvern Cables	OST energy	Powertech	–	Transvaal Pressed Nuts Bolts & Rivets	–	–
Yingli	Tenesol (moun-ting)	–	AEG	Prime Electrical	Arup	Eloff Trans-formers (CT)	–	CBC Fasteners	–	–
SunPower (acquired Tenesol)	STI Norland	–	MLT Drivers	Walroflex	Rina	Revive Trans-formers	–	Heller-mann-Tyton	–	–
Solar Direct	–	–	Micro-care	South Ocean	–	SGB-Smit Power Matla	–	–	–	–
SetSolar			TUB	–	–	–	–	–	–	–
Canadian Solar	–	–	RWW Enginee-ring	–	–	–	–	–	–	–
Seraphim	–	–	–	–	–	–	–	–	–	–
ArtSolar	–	–	–	–	–	–	–	–	–	–
Suntech	–	–	–	–	–	–	–	–	–	–
Multilec	–	–	–	–	–	–	–	–	–	–

Table 24: Wind energy value chain in South Africa

Wind										
Turbines	Blades	Towers	Internals	Cabling	Founda-tions	Yield assessments for banks	Steel structures	Bolts and nuts	Gear-boxes	Grounding/ lighting/ Painting
Suzlon	Suzlon	CC Crane Hire	CS Renewables / Resolux	CS Renewables / Resolux	Group 5	Lloyd's Register	Arcelor-Mittal	SA Bolts Manufacturers	IEC Holden	Lectrotech
Acciona	Vestas	GRI Towers	Meco-ladder	Aberdare cables	Murray and Roberts	OST energy	ART Welding Engineering	T&I CHALMERS Engineering	–	DENH South Africa
Sinovel	Nordex	Concrete Units	–	–	Aveng	Arup	–	TEL-SCREW	–	Liphahla Group (painting)
Vestas	Siemens	–	–	–	–	Rina	–	Transvaal Pressed Nuts Bolts & Rivets	–	–
Guodian United Power	GE/LM Wind	–	–	–	–	–	–	CBC Fasteners	–	–
Nordex	–	–	–	–	–	–	–	Heller-mannTyton	–	–
Siemens	–	–	–	–	–	–	–	IMPALA Bolt & Nut	–	–
Enercon	–	–	–	–	–	–	–	–	–	–

7

Financing

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There are currently no specially tailored EV financing schemes in the South African market, yet all EV models currently available in the SA market cost more than R450 000, which is out of reach of most vehicle buyers in the country. Banks and other financial institutions are also not yet providing vehicle financing to EVs.

Table 25: The cost of importing a Tesla Model X from the United Kingdom to South Africa in 2021

Source: (My Broadband, 2021)

	Individual costs	Total in Rand (Exchange rate €1 = R20.87)
Purchase price of Tesla Model X Performance All-Wheel Drive in the UK	€ 96 900	R 2 022 303
+ 15% VAT of 10% mark-up	R 333 680	R 2 355 983
+ 25% duty tax	R 588 996	R 2 944 979
+ 30% Ad Valorem tax	R 883 494	R 3 828 472

Considering the high purchase costs of EVs compared to ICE vehicles, there is a need for original equipment manufacturers (OEMs), dealerships, and commercial banks to develop innovative vehicle ownership models, such as Mobility-as-a-Service (MaaS), vehicle leasing rather than ownership models, and/or enabling finance terms specifically tailored for EVs. As the EV ecosystem moves from private operations to fleets, OEMs collaborating with finance providers to configure ways of making purchasing EVs more attractive is required. This could include detaching batteries from the financing of the vehicle, so that batteries are financed separately over a longer time, thereby reducing the monthly cost.

The residual value of the batteries for second-life storage after the vehicle's lifespan could be factored in when determining the cost of an EV. For this to happen, a secondary market for second-life batteries (which now have reduced capacity, approximately 60%-80% of the original capacity) would need to be created. They can then be redeployed to residential or utility-scale storage systems, in micro-mobility applications like e-bikes and e-scooters, and as stationary energy storage in grid applications or energy arbitrage where grid service operators buy energy during low-rate periods.

Table 25 summarises the main equity and debt providers currently offering financing in the cleantech space.

Table 26: The funding landscape in South Africa

Funding	
Equity	Debt Providers
Thebe Investments	ABSA Capital
Old Mutual Life Insurance	DBSA
Future Growth	IDC
IDC	RMB/FNB
Enel	Old Mutual
Mulilo	Investec
Mainstream	Standard Bank
Standard Bank	Nedbank Capital
FMO – Netherlands Dev Finance Comp	
AREP	
H1 Holdings	
DEG – German Investment & Dev Corp	
Hulisani	
International Finance Corporation (IFC)	
Just Share NPC	
Mahlako A Phahla Investments (Pty) Ltd	
Pele Green Energy	
CAD Fund	
Metair Investment Limited	
World Bank	
Yellowwoods	

Several local banks have announced new policies to suspend financing of future fossil fuel and carbon-intensive projects to improve their environmental, social, and governance (ESG) credentials. This could be a watershed moment for the financing of e-mobility in the country.

- **Absa Bank** – Absa announced in October 2020 that they would soon be rolling out a green finance mechanism for electric vehicles (EVs). They intend to provide an all-in-one finance package to consumers that could incorporate a solar PV home installation for charging the EV. The solar PV home installation would increase upfront costs, but the combined green finance deal could still deliver a lower total cost of ownership compared with an ICE vehicle.

Absa also announced in 2020 that it would not fund any new coal-fired electricity generation projects unless there are extenuating circumstances. The bank is now also part of the United Nations Environment Program for Responsible Banking. Shareholders additionally approved a climate change resolution for the bank to include in its 2021 reporting an assessment of the banks' exposure to climate change risk in its lending portfolios. The company has also been authorised to identify opportunities to finance climate change mitigation. The bank had announced in 2020.

- **Nedbank Group** – Nedbank Group announced a new energy policy, committing to reducing its exposure to all fossil fuels to zero by 2045, and halting all new thermal coal-mine financing by 2025. The bank would also increase its renewable energy commitments to R2 billion worth of embedded generation financing by 2022 and committing R50 billion to South Africa's Renewable Energy Independent Power Producer Procurement Programme (REIPPP).

  Nedbank would not finance new oil and gas exploration projects from 2021 and not provide new financing for oil production from 2035.

- **First National Bank (FNB)** – FNB has cut its carbon footprint by 50% over five years with measures including the use of 3.7 MW capacity solar photovoltaic (PV) panels, currently producing 5.8 MWh/y at its branches.

- **FirstRand Limited** – FirstRand has announced it will publish all its fossil fuel carbon-related assets and lending, to reduce and eventually halt exposure to fossil fuels.

GreenCape compiles and continues to maintain a database of funding sources relevant to companies operating in the EV ecosystem and wider value chain.


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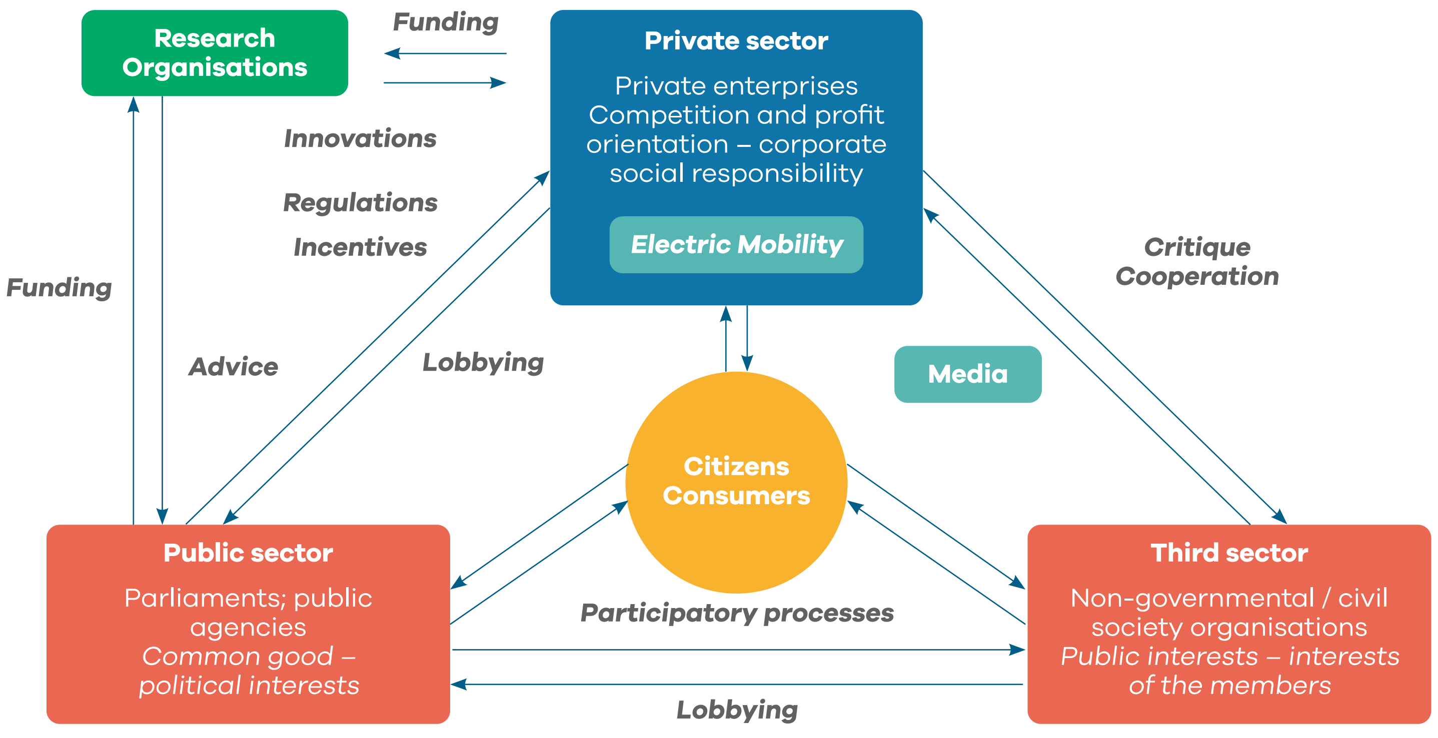
8

Research & Development Network

©Pxhere

Figure 35: South Africa's electricity shortage



The availability of skilled and qualified personnel is paramount to the continued growth and development of the electric vehicles value chain and the wider ecosystem, and for the industry to compete with global counterparts. For them to invest in the industry, OEMs are looking for sufficient local demand for electric mobility products, and sufficient qualified personnel. At present, however, the unavailability of skills throughout the value chain is a major constraint to the development of this industry.

Many of the local start-ups, cleantech organisations, and SMMEs in the EV value chain are primarily spin-offs from the academic and research institutions or local subsidiaries of the global players. They play a key role in skills development through training and upskilling their staff and investing in technical courses and certifications.

Table 27: The local battery research and development network

Battery research & development network	
Energy storage & batteries	
Battery & cell engineering (including fuel cells), fabrication, and chemistry	• University of Western Cape (UWC) – Hydrogen South Africa (HySA) • University of the Witwatersrand (WITS) • Council for Scientific and Industrial Research (CSIR) • Nuclear Energy Corporation of South Africa (NECSA) • Hulamin
Battery recycling and second life use	• Mintek
Battery diagnosis and testing	• uYilo – Nelson Mandela Metropolitan University (NMU)
Local battery solutions & service providers	• Balancell • BlueNova • BushVeld Energy • EV Dynamics • FreedomWon • Hulamin • Isondo Precious Metals • Maxwell and Spark • MellowCabs • Metair Investments • Mintek • Revov Batteries • Solar MD

Table 28: Local skills development stakeholders

Stakeholder category	Institution
Academic and Training Institutions	Institute of the Motor Industry (International institute – UK)
	Salesian Institute Youth Projects (SIYP)
	University of Stellenbosch
	University of Cape Town
Non-governmental organisations	uYilo Electric Mobility Programme
Industry associations	Retail Motor Industry (RMI)
	Automotive Remanufacturers' Association (ARA)
	South African Motor Body Repairers' Association (SAMBRA)
Original Equipment Manufacturer/ Manufacturing	Volkswagen Training Institute

8.1.

PAVE | PTRC-ZA project at the Salesian Institute – Cape Town, Western Cape

The Porsche Training and Recruitment Centre (PTRC-ZA) at Salesian Institute Youth Projects was launched in March 2017 in Cape Town. The international flagship program, which is officially called the PAVE | PTRC-ZA project (Porsche After-Sales Vocational Education) addresses the increasing importance of digitalisation, electrification, and connectivity across the automotive industry. The program creates an opportunity for the new centre to identify and train technical talent while tackling poverty and changing lives.

The program recruits 25 young men and women annually, from disadvantaged backgrounds, to complete a course in Automotive Service Mechatronics over two years. An additional third year is dedicated to on-the-job training at a partnering dealership. The total cost per student is about R 400, 000 for the 2 years.

The entry requirements for the program are as follows;

1. Applicants must have obtained a Grade 12 or N2 with Mathematics and Science.
2. Applicants need to be between the age of 18 and 24.
3. Applicants need to demonstrate good health. Applicants with heart conditions or who are colour blind are not approved.

The students participate in an internationally recognised PAVE assessment which covers new technologies. The assessment is, however, presently not recognised in South Africa. The students complete their Level 1 through the programme, and should they want to specialise in levels 2 and 3 for high voltage certification, they would be able to do so through high-end dealer training centres.

The competency-based learning content equips the students with the competencies and ability to diagnose, repair, and service the motor vehicles "of today and tomorrow". Upon completion, graduates are qualified as high-voltage technicians for defined works.

The brand-specific training ensures local capacity is developed to take up career opportunities in the Volkswagen group which includes working with brands like Porsche, Volkswagen, Audi, Bentley, and Lamborghini.

The program has had much success over the past three years. There are, however, challenges faced by the program, as listed below;

Challenges:

- The program is not MERSETA (Manufacturing, Engineering and Related Services Sector Education and Training Authority) accredited yet. Ideally, the program was supposed to be sustainable by year 3 as Porsche withdraw their support. The delay is also the subsequent aftermath of COVID-19 lockdown restrictions and a lack of clarity on submission documents for accreditation status.
- Porsche Germany donated a high voltage Volkswagen UP model equipment to assist with testing and practical training for the program. However, due to COVID-19, the globally certified training (accredited by Porsche Germany) of the trainers has been delayed. Currently, the donated vehicle cannot be used due to the trainers not having received adequate certification and safety training.
- To work on the vehicle, the trainers need to complete a safety course that will assist in understanding the safety fundamentals for a high voltage vehicle. The trainers need to also complete 3 levels to receive their High Voltage technician certification, also known as the Automotive Skilled Technician in Germany:

a. Level 1 - allows the trainers to deactivate components.
b. Level 2 - allows trainers to deactivate and remove a component.
c. Level 3 - allows trainers to deactivate, remove, and repair a component.

Trainees must meet very strict health criteria to participate in the high voltage qualification and it will not include individuals that have any heart conditions or have a pacemaker.

- The institute also highlighted they are working on creating relationships with the dealership to assist with the placement of students. Dealerships are often profit-orientated which implies that they do not always have additional capacity to assist the students training needs.
- The institute wants dealerships to contribute to the stipend of the trainees, but they have found that often dealerships are unwilling because they get free trainees from other institutions.
- The program is currently only attracting Cape Town applicants. Infrastructure is a challenge as the college does not have any accommodation. This becomes a bigger issue once trainees are deployed, as currently, all the partnering dealerships are based in Cape Town.
- The trainees are provided with a stipend as an incentive, however, due to the socio-economic circumstances, some of the students are forced to leave the program in search of employment.
- Due to the limited supply of EVs at dealerships, it makes on-the-Job training difficult, with trainees receiving very limited electric vehicle exposure.

Opportunities:

- There is an opportunity to collaborate, share knowledge, and learn from other international Porsche training institutions and motor businesses globally. This is an advantage with the deployment of students to receive on-the-job training.
- Career opportunities for trainees with dealerships locally and globally. The institutions associated with these high-end brand and quality of training is favoured by the industry.
- Trainers also can learn through collaboration with international partnering programs through the PAVE program.
- The PAVE-PTRC trainers are also recognised by other institutions, and new opportunities for further value add to be assessors, moderators, and facilitators for other training institutions should also be provided.

8.2.

uYilo Electric Mobility Programme – Port Elizabeth, Eastern Cape

The national uYilo e-Mobility Programme was established in 2013 as an initiative of the Technology Innovation Agency (Act 26 of 2008) to enable, facilitate, and mobilise electric vehicle mobility in South Africa. The programme is hosted by the Nelson Mandela University and seeks to ready South Africa for the introduction of electric mobility technologies.

uYilo is a multi-stakeholder programme that engages in various activities including – government lobbying, industry engagement, pilot projects, capacity development, enterprise development, and thought leadership. They are also involved in several national projects as listed in Table 28 below. The projects aim to promote e-mobility while evaluating testing in the field through multiple-stakeholder participation in showcasing e-Mobility technology and complementing local skills development.

uYilo has ongoing projects at their facilities which consist of a battery testing laboratory that can test lead-acid and lithium-ion batteries, a systems laboratory for component-level support, and a smart grid simulator for the integration and interoperability of the ecosystem components.

©uYilo

Table 29: List of uYilo's national awareness, capacity, and testing projects

Source: uYilo, 2021

Project Name	Description
Skills development and capacity building projects	
STRAPSA (Shifting the Transport Paradigm for South Africa)	The project aims to build capacity and knowledge on electric transportation through technical assistance for key institutions and decision-makers. It aligns with the Green Transportation Strategy and specifically to pillar 8 on capacity building and supporting international Finance.
Industrial development and enterprise development support for SMME's – Projects testing battery and materials capacity	
eBike Sharing Pilot	This project is a fleet sharing scheme using electric bicycles (eBikes) that has been deployed at the Nelson Mandela University North and South Campuses. The bikes are available for use by staff and students.
Eco-Tourism Mobility	The project aims to create awareness and test the performance of electric mobility as part of a safari mobility operation, thus determining the feasibility of eMobility for the eco-tourism industry. Micro electric vehicle platforms provided by Imperial Green Mobility are hosted at Shamwari Game Reserve for use in their mobility operations.
Electric Vehicle (EV) Field Testing Programme	uYilo has partnered with OEM's (BMW and Nissan) to pilot and test 100% electric vehicle models, as part of their field-testing programme. The vehicles are used to assess local user patterns, usage modes, and energy cycles, which allows for the development of multiple supportive technologies. Emphasis is placed on collecting credible data that can be used for marketing purposes and to create awareness of e-Mobility as a viable alternative to ICE vehicles.
Micro-Electric Mobility Vehicle Demonstrator	The demonstrator comprises a living lab to pilot electric mobility within utility platforms and people-movers in real-world applications. It aims to prove the viability of EVs, create awareness, and collect data to assist with the establishment of commercial processes around electric mobility. The project targets the replacement of standard vehicle platforms used in the provision of horticulture and technical services on Nelson Mandela University's Summerstrand campus. Both these departments make use of small light-duty vehicles to move around on campus.

uYilo has identified 3 key training needs for the South African market;

- **Awareness training for First Level Emergency Responder training** – uYilo and RMI are currently working on developing training materials that can be offered to this target group.
- **Dealership and aftermarket service** – This programme includes skills training for technical, maintenance, and service staff.
- **Awareness training for key stakeholders, decision-makers, and consumers to assist with reform and adoption of EVs.** Decision-makers are essential to regulatory reform.

What is evident from the above is that the adoption of new EV value chains is not only dependent on the engineering and manufacturing side but also on understanding the new needs and demands of the customer.

8.3.

Retail Motor Industry Organisation – Johannesburg, Gauteng

RMI is a member-driven South African organisation with over 8200 formal and informal members. The organisation is committed to sustainable development through a process of transformation of the economy, business, and the creation of job opportunities. Their objective is to give members a collective voice when negotiating for better trade conditions. As the primary voice in the industry, they constantly seek solutions to concerns raised by members in the day-to-day running of their businesses. They are also a major employer representative of the Motor Industry Bargaining Council, thus playing a crucial role in labour negotiations, benefits schemes, dispute resolution processes, and exemption procedures.

RMI Training Department assists its members in relevant interventions or awareness training. They also serve on various forums like MERSETA and provide input and technical expertise.

RMI has 8 industry associations under its umbrella, namely:

- ARA – Automotive Remanufacturers' Association
- MIWA – Motor Industry Workshop Association
- NADA – National Automobile Dealers' Association
- SAMBRA – South African Motor Body Repairers Association
- SAPRA – South African Petroleum Retailers Association
- SAVABA – South African Vehicle and bodybuilders' Association
- TEPA – Tyre, Equipment, Parts Association
- VTA – Vehicle Testing Association

RMI is in the process of establishing a professional body for the retail motor industry. The professional body will allow student members and designated members to accumulate CPD (Continuous Professional Development) points. According to the CEO of RMI, the professional body will be able to register designations, recommend best practices that will professionalise the sector and participate in SETAs as a Qualification Development partner and be involved in retail motor industry curriculum and learning material development.

RMI has identified 4 key phases training immediate training needs for their members as a sensitising process for the introduction of EVs in South Africa:

- Phase 1: Awareness training of First Level Emergency responders (including towing and emergency personnel) and motor body repairers – This will be done in partnership with uYilo.
- Phase 2: Working on non-energised vehicles (disconnected car)
- Phase 3: Working on energised vehicles (connected car)
- Phase 4: Health and safety Occupational compliance training for the dealership and retail sector (currently no registered occupational qualification registered).

The phase 2 and 3 interventions will be driven through training institutes and TVET colleges as this would require technical know-how. Introducing EVs in dealership networks would encourage independent awareness workshops and train with a specific focus on health and safety for independent or franchise aftermarket repair and maintenance workshops. Dealership and retailers will also receive product-specific training directly from OEMs.

9

Electric vehicle consumer demand – the end-user

©Green Scooter

Figure 36: Main barriers for EV uptake among consumers

A 2020 national EV perception survey conducted over 12 months on more than 3 000 car buyers on South Africa's biggest automotive marketplace has found that 1.8% of the respondents have owned an EV, 13% have driven one, and 68% would want to own one in future. Most of the respondents, i.e., 86% would be open to using an EV as their primary vehicle, rather than as a second vehicle.

The unavailability of public and home charging infrastructure (61%), charging times (59.6%), and cost (55%), were cited by the respondents as the biggest barriers to EV ownership in South Africa. Reduced emissions (80.5%), reduced noise pollution (63.9%), and cheaper running costs (54.7%) were the top three cited advantages of EVs.

An interesting finding was that most of the respondents aged 18-34 said they were more likely to purchase an EV in the next five years, while those aged 55+ were thinking of purchasing an EV within the next three years.

Table 30: How much EV consumers are willing to spend in purchasing an EV

The price you are willing to pay for an EV in ZAR (R)	Percentage share of respondents (%)
Up to 300 000	25.7
300 000	15.9
400 000	14.3
500 000	18.1
600 000	7.9
700 000	4.9
800 000	4.1
900 000	1.2
1 000 000+	5.9
Indifferent to the price	1.9

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Conclusion

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The study has found that the EV ecosystem in South Africa is nascent but developing rapidly. Moreover, not all elements of this ecosystem are at the same level of development, with some more advanced than others. Incorporating circularity and lifecycle thinking to the future of EVs shows that for EVs to be environmentally sustainable (ESG metrics), the value chains must be sustainable too.

The key findings are summarised as follows:

1) Local OEMs (Original Equipment Manufacturers) are starting to take decarbonisation seriously, driven by foreign export markets setting bans on internal combustion engine (ICE) vehicles (some as close as 2030). The OEMs are now also looking to tap into emerging opportunities in the local electric vehicle (EV) sector.

2) OEMs are looking to benefit from the landscape created by the new SAAM (South African Automotive Masterplan 2021-2035) which has set objectives including:

- Growing South Africa's vehicle production to 1% of global production by 2035 and improving the automotive industry's competitiveness to be at par with that of our global competitors. South Africa is currently positioned 22nd in vehicle production globally.
- Increasing local content in South African manufactured vehicles to at least 60%; and 70% for buses.
- Doubling the current employment levels in the automotive industry and supply chain, which currently stands at around 500,000 directly and through the value chain.

3) South Africa has a strong existing world-class automotive industry and a market for the assembly of internal combustion engine (ICE) vehicles, because of its competitiveness in automotive production mostly due to the relatively low labour costs. The country can leverage these levers and competitive advantages in pivoting to EV manufacturing and assembly. Other than the batteries (LIB) and drivetrain, an EV is not structurally different from an ICE vehicle. Thus, OEMs could make the transition to EV production quickly.

4) Many players in the local industry are waiting for a market (LIB, EV, etc) to develop and for demand to grow before they invest in this industry. Until then, the available market is the export market. Most of the companies focused solely on this industry are currently loss-making, with break-even points years ahead. This is attributable to limited economies of scale as there is no widescale adoption yet, in other words, high infrastructure costs and relatively low asset utilisation in these early years.

5) The increased demand for EVs is what will drive the demand for batteries and the minerals used in these batteries (commodity market and mineral beneficiation).

6) Battery recycling is not yet viable because the number of EVs is still very low, and those available have not yet reached their end-of-useful-life point.

7) Public transport demonstrates the best business case for alternative fuel applications locally.

8) There is an acute skills shortage in the automotive industry and the associated ancillary services. As the EV market grows, there will be a growing need to upskill existing technicians, first-level emergency responders, dealerships, and aftermarket services, to facilitate and support the transition towards electric mobility.

9) The main barriers affecting the EV industry include:

- limited financing, i.e., absence of innovative and cost-effective financing mechanisms/options and access to capital;
- inadequate infrastructure, i.e., limited charging infrastructure (number and geographic coverage);
- slow implementation of industrial policies — the Carbon Tax Act 15 of 2019, and the SAAM which comes into effect in July 2021 after the Automotive Production and Development Programme (APDP) lapsed in 2020;
- limited market (not yet enough EVs to create strong and viable business cases) due to the slow local uptake because of the high upfront capital cost of electric vehicles; and
- limited range of EV models available in the country; thus, consumers do not have a variety to choose from based on their preferences.

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11

Recommendations for the City of Cape Town

Table 31: Opportunity rating matrix

Opportunity	Economic & job creation potential (1-10)	Relevance for CCT (1-10)	Opportunity rating (1-10)
Automotive and component manufacturing and assembly	9	9	9
Battery and cell manufacturing and assembly	6	5	5.5
Mining (of battery minerals)	4	0	2
Charging infrastructure provision	3	4	3.5
Energy provision and electricity supply (renewable energy and grid services)	5	9	7
Innovative financing	2	1	1.5
Research and development	1	2	1.5
Skills development and training	9	9	9
Consumer demand	3	7	5

Table 32: Summary: Intervention breakdown

Intervention type	Intervention description	Responsible stakeholder
Incentives – Subsidies and support	Incentives and subsidies to reduce the upfront capital cost of purchasing an EV and allow EVs to compete favourably with ICE vehicles. These could include; • customs control providing duty and VAT advantages, i.e., suspension or complete elimination; • access to "Free Ports" and other duty-free areas adjacent to ports of entry where imported goods may be unloaded for value-adding activities, storage, repackaging and processing; • access to "Free Trade Zones" and other duty-free areas offering storage and distribution facilities for value-adding activities for subsequent export; • provision of land and properties for lease, with additional tax reliefs and building allowances; • reduced electricity tariffs for manufacturers; • access to worker recruitment and training services, with additional employment tax incentives; • preferential Corporate Tax rates; • security and other services in enclosed and fenced off areas; • logistical and telecommunication solutions facilitating increased accessibility to the market (major population centres); • access to export markets via ports and international airports; • enhanced access to municipal services; and • investor support and access to incentives available from the national, provincial, and local governments.	National government (DTIC) City of Cape Town – Enterprise & Investment Atlantis Special Development Zone (ASEZ)
Tax incentives and rebates	Import/export credit for EVs and incentivisation for increased levels of localisation (for domestic production).	National Government (DTIC)
Reduced EV charging electricity tariff	Favourable electricity tariffs for off-peak charging.	City of Cape Town – Electricity Generation and Distribution

Intervention type	Intervention description	Responsible stakeholder
Access to electricity	• Initiate, through enabling regulations, a customer-focused response at scale driven by small-scale embedded generation (residential), embedded generation (commercial/agricultural), Embedded Generation (EG) / Distributed Generation (DG) (industrial/mining), and storage. • Address remaining capacity/energy gaps through an accelerated DMRE RMPPP (Risk Mitigation Power Purchase Programme) process to ensure sufficient capacity is available and online when required. • Explore the need to upgrade the electricity grid, particularly in implementing smart grid, grid management, and smart charging to account for the increased electricity demand. • Explore the feasibility of vehicle-to-grid (V2G), vehicle-to-home (V2H), inductive charging, and wireless charging for electric vehicles. • Support the implementation of IRP 2019 as an immediate focus to ensure sufficient lead-time for procurement processes and technology-specific construction lead times. • Invest in a diversified source of new energy supply, i.e., from renewables such as wind and solar. • Promote research and technology innovation at all segments along the value chain for more efficient use of materials, facilitate material substitution, and foster resilience along the supply chains by conducting regular assessments of potential vulnerabilities and the potential collective responses. • Create policy frameworks to promote ESG (environmental, social, and governance) standards and incentivise recycling and strategically targeted R&D into new recycling and second-life usage applications and technologies. • Provide reliable and transparent data and promote knowledge transfer and capacity building to support SMMEs and grow the EV ecosystem.	City of Cape Town – Electricity Generation and Distribution National Government (DMRE) Eskom
Procurement of EVs	Procurement of EVs for future City of Cape Town (CCT) vehicle fleets.	City of Cape Town – Procurement/Supply Chain Management
R&D funding	A readily available pool of local technical and fundamental capacity, through skilled workers. Investment into training, academia, and skills development.	City of Cape Town – Enterprise & Investment
Access to capital	Through concessional funding, private and venture capital, loans, and grants, and non-financial investment promotion, partnerships, and vertical integration. The city's role could include offering credit guarantees for EV loans and working with OEMs, dealerships, and commercial banks to develop innovative vehicle ownership models, such as Mobility-as-a-Service (MaaS), vehicle leasing rather than ownership models, and/or enabling finance terms specifically tailored for EVs. This could also include detaching batteries from the financing of the vehicle; thus, the batteries could be financed separately over a longer time, thereby reducing the monthly cost.	City of Cape Town – Enterprise & Investment

Intervention type	Intervention description	Responsible stakeholder
Standardisation	Components such as connectors, safety systems, and power rating, which are at advanced stages, can be standardised to create standards and technical norms e.g., ensure vehicles can conveniently be connected to the grid to recharge and allow for interoperability. The goal should however be global standards to avoid technological islands, and this standardisation should exclude the technologies that are still innovating and are at a nascent stage of development - to allow the market to evolve freely.	South African Bureau of Standards (SABS)
Charging infrastructure	• Policy interventions such as updating the building codes to require provisions for workplace charging or home charging. • Technology standards to require interoperability in public charging.	City of Cape Town – Sustainable Energy Markets
Advocacy	Support in creating demand for EVs and the scale required to aid in the creation of a vibrant EV industry – i.e., automotive manufacturing, battery and component manufacturing, recycling, etc. Raising awareness of the benefits of EVs and a low-carbon future. The communication process should ideally focus on educating the consumer about electric vehicle ownership and viability compared to their existing ICE vehicle, and not just the environmental benefits.	City of Cape Town – Enterprise & Investment City of Cape Town – Transport

11.1.

Impact areas in automotive manufacturing

Despite the year-on-year automotive market growth, government support and subsidies are still vital, particularly to allow EVs to compete with the ICE market. This is because the upfront capital cost of purchasing an EV remains high, primarily driven by the cost of batteries. Still, the total cost of ownership over the lifecycle of the EV is significantly less than for ICE vehicles. The importance of support and subsidies was shown in 2019 when China's reductions in subsidies for new energy vehicles (NEVs) caused the first disruption in the trend of continuous growth in EV sales. This is evident from the change in 2019 sales after June 2019.

China cut subsidies on new EVs (and other energy vehicle types) by 10% as of April 2020. However, the subsidies and tax exemptions, which were initially scheduled to terminate in 2020, have now been extended to 2022 but will be subject to a further 20% cut in 2021 and 30% in 2022. Global EV sale volumes were drastically affected by the COVID-19 pandemic and subsequent lockdowns.

In the absence of scale, OEMs and component manufacturers can be incentivised for localisation through other financial and non-financial mechanisms. Localisation initiatives to strengthen domestic production represent a significant opportunity to transform the sector. OEMs have become cost-conscious and are rethinking their end-to-end supply chain for efficiencies and optimisations to remain competitive in the local, emerging, and global markets. Incentives could include the following:

- customs control providing duty and VAT advantages, i.e., suspension or complete elimination;
- access to "Free Ports" and other duty-free areas adjacent to ports of entry where imported goods may be unloaded for value-adding activities, storage, repackaging and processing;
- access to "Free Trade Zones" and other duty-free areas offering storage and distribution facilities for value-adding activities for subsequent export;
- provision of land and properties for lease, with additional tax reliefs and building allowances;
- reduced electricity tariffs for manufacturers;
- access to worker recruitment and training services, with additional employment tax incentives;
- preferential Corporate Tax rates;
- security and other services in enclosed and fenced off areas;
- logistical and telecommunication solutions facilitating increased accessibility to the market (major population centres);
- access to export markets via ports and international airports;
- enhanced access to municipal services; and
- investor support and access to incentives available from the national, provincial, and local governments.

In Cape Town, these incentives could be created at the Atlantis Sector Development Zone (ASEZ) to attract local automotive manufacturing to Cape Town. In assessing the requirements for local manufacturing at the Atlantis Special Economic Zone (SEZ), the best applications where EVs can be used profitably, and determining the set of incentives and their mix need to be explored further. This is to happen in tandem with the initiatives to increase the market demand for EVs (discussed later), and as purchase price parity for EVs is expected to be achieved somewhere in the next few years. Enough economies of scale could then be attained to bring down the cost of the vehicles.

Additional incentives could include procurement of EVs for all future City of Cape Town (CCT) vehicles and requiring public fleets to procure EVs in future to obtain or renew operating licences within the CCT. This will create incentives to manufacturers to produce EVs and help drive the transition as fleet owners progressively replace their fleets with an electric fleet.

These measures and incentives could create a unique opportunity to localise the electric mobility and automotive manufacturing/assembly value chain and incentivise and attract investments to Cape Town through the Atlantis Special Economic Zone (ASEZ) and industrial park. This will enable the CCT to benefit from the vast environmental, economic, and social opportunities in the transition to a low-carbon trajectory, particularly in the mobility sector. This would also assist CCT in its longer-term strategy to bolster city-wide resilience and help retain businesses within the city by making the ASEZ attractive to potential electric mobility and cleantech investors. There is also potential to replicate the work in other industrial areas, which is in line with the Economic Recovery Plan post the COVID-19 pandemic, and to increase the flow of investment into sustainable infrastructure projects in support of the city's Economic Action Plan.

The implementation of the SAAM provides further government support and long-term policy certainty to the industry, which are key drivers to support the growth of the EV ecosystem. South Africa's existing trade agreements with the EU and SADC, coupled with manufacturing and financial incentives such as the SEZs, could position South Africa as a suitable automotive manufacturing destination, particularly for companies targeting the rest of Africa, and the EU to some extent.

The push towards higher levels of localisation may not be feasible in the short term as it would lead to increased costs in the absence of scale, i.e., before the market takes off. The localisation drive should therefore be phased, starting with those components that have lower capital investments, or those where scale has already been achieved, or incentives provided. The development of clusters with common facilities would support (scale) and even accelerate the localisation drive.

11.2.

Impact areas in developing the local battery value chain – battery manufacturing, recycling, and mining

The CCT can provide support in creating scale which would aid in the creation of a battery and component manufacturing (and recycling) ecosystem. Increased access to technology and R&D focus would also lead to an increase in localisation and the adoption of new and sustainable manufacturing processes that reduce greenhouse gas emissions and improve environmental wealth. The city would need to guide issues such as:

- what happens after battery warranty or usable life for vehicular use expires; and
- how would resale work (residual value of batteries).

These industries also require a mix of financial (through concessional funding, private and venture capital, loans, and grants) and non-financial investment promotion, partnerships, vertical integration, and other support, including supportive regulations and improved ease of doing business. EVs, due to their component spread and technology dependence inherently create a need for strategic partnerships, beyond the existing ecosystem. A readily available pool of local technical and fundamental capacity, through skilled workers, is also required. For this to happen, heavy investment into research and development, training, academia, and skills development will be required.

Raw materials, skilled talent, and technology/machinery are required for the extraction of the battery materials, as are factories to process the raw materials into cell components, and then the factories to turn those components into cells.

Investment should also be made in battery testing infrastructure/equipment and plants, and a common set of standards and certification systems for battery technologies. This would incentivise further investments into this industry for it to develop and grow to potentially serve a wider market beyond South Africa's borders.

A major concern for these types of industries is the availability of consistent and reliable energy. This has been a challenge in recent years due to load-shedding and load reduction of electricity supply in the country. A reliable energy supply is paramount for a local battery manufacturing industry to thrive.

Global players and others not traditionally engaged in the automotive industry are joining the EV space. Toyota, for instance, has announced plans to unveil a solid-state battery EV prototype later in 2021. Other non-traditional players are also getting into the EV space. The largest smartphone maker, Apple, has announced plans to start EV production by 2024 and is eyeing developing "next-level" battery technology. Huawei as well has ventured into the automobile market, building an EV, the Series SF5 hybrid, which it plans to sell at its flagship stores in China from 2023.

There are opportunities for investment into raw material beneficiation, battery pack assembly, manufacturing of battery cells and cell components, and recycling and repurposing batteries, and making use of their residual value for second-life use after an EV is retired.

They can then be redeployed to residential or utility-scale storage systems, in micro-mobility applications like e-bikes and e-scooters, and as stationary energy storage in grid applications or energy arbitrage where grid service operators buy energy during low-rate periods. Replacing the CCT's (and wider government's) own vehicle fleets with EVs could aid in stimulating demand and create public awareness.

South Africa has no plant that commercially recycles lithium-ion batteries. With the 2020 Department of Environment, Forestry and Fisheries (DEFF) Extended Producer Responsibility (EPR) regulations banning the disposal of electronic waste in landfills, the batteries are either stockpiled or shipped outside the country for recycling and/or disposal. Several local companies sell imported second-life batteries (mostly from China), both to the local market and in the region.

11.3.

Impact areas in standardisation

Standardisation, though important for scale to be achieved, requires time as the EV market and technologies are rapidly evolving and the ecosystem is at a nascent stage. Complementary technologies, including connected and autonomous vehicles, are anticipated to further drive this growth in the long term.

Technology standardisation at this point is unwise as most of the technologies are still innovating and being developed at a rapid pace. For instance, lithium-ion battery sizes have been gradually reducing, especially over the last decade, hence standardisation of battery sizes at this point would be counter-productive. Regulating bodies should limit defining technology standards in policies and let the market evolve freely. EV adoption should be the goal but having caveats around technology may not be appropriate at this nascent stage in the development of this industry.

Consequently, policies should not be technology-led. Rather, components such as connectors, safety systems, and power rating, which are at advanced stages, can be standardised through a common standards platform by the South African Bureau of Standards (SABS). It is also necessary to create standards and technical norms to ensure vehicles can conveniently be connected to the grid to recharge and allow for interoperability. The goal should be global standards to avoid technological islands.

11.4.

Impact areas in the charging infrastructure landscape

A nationwide charging infrastructure is one of the major factors that will help propel e-mobility to achieve wide adoption in the country. There are three areas where the CCT can intervene in the charging space that would help to counteract the lack of price competition from the public charging market due to potential consolidation:

1) Provide policy interventions to promote options for EV charging in addition to public charging stations, such as policies requiring provisions for workplace charging or home charging.

2) Set technology standards to require interoperability in public charging. With interoperability, an EV driver could charge at a variety of public networks and not be limited to a certain type of charger or connector. This would also ensure that networks are driven to maintain price competitiveness.

3) Promote partnerships in the charging infrastructure space (beyond the existing ecosystem) to widen the reach of services, which in turn would accelerate EV adoption by addressing issues such as range anxiety, financing, and higher upfront cost.

11.5.

Impact areas in energy provision and the electricity grid

The following measures are proposed to tackle the energy supply issues:

1) Initiate, through enabling regulations, a customer-focused response at scale driven by small-scale embedded generation (residential), embedded generation (commercial/agricultural), Embedded Generation (EG) / Distributed Generation (DG) (industrial/mining), and storage.

2) Address remaining capacity/ energy gaps through an accelerated DMRE RMPPP (Risk Mitigation Power Purchase Programme) process to ensure sufficient capacity is available and online when required.

3) Explore the need to upgrade the electricity grid, particularly in implementing smart grid, grid management, and smart charging to account for the increased electricity demand.

4) Explore the feasibility of vehicle-to-grid (V2G), vehicle-to-home (V2H), inductive charging, and wireless charging for electric vehicles.

5) Support the implementation of IRP 2019 as an immediate focus to ensure sufficient lead-time for procurement processes and technology-specific construction lead times.

6) Invest in a diversified source of new energy supply, i.e., from renewables such as wind and solar.

7) Promote research and technology innovation at all segments along the value chain for more efficient use of materials, facilitate material substitution, and foster resilience along the supply chains by conducting regular assessments of potential vulnerabilities and the potential collective responses.

8) Create policy frameworks to promote ESG (environmental, social, and governance) standards and incentivise recycling and strategically targeted R&D into new recycling and second-life usage applications and technologies.

9) Provide reliable and transparent data and promote knowledge transfer and capacity building to support SMMEs and grow the EV ecosystem.

11.6.

Impact areas in the local research and development network

The EV value chain needs a specialised skills set of personnel available once production comes online for it to invest in new production capacity and supply chains. Due to the chronic skills gap in the country, many of the OEMs and content suppliers are experiencing labour shortages, which is a problem likely to get worse as the country tries to capture some of the jobs that decarbonisation will bring.

The shortage of technical skills remains a major concern. This is an area in which the public sector and academic and training institutes could play a role to develop the necessary training materials and courses and provide funding for the related technical courses such as engineering.

There is a need for increased focus on value-added manufacturing and skills development through industry-academia partnerships, training, and R&D centres. These centres are capital intensive but may be set up in PPP models for use by the EV ecosystem.

The EV transition however creates an opportunity for re-training and re-skilling and could also be an avenue to create additional jobs, in ensuring the right skills are available for the design, engineering and manufacturing of electric vehicles and related components and systems.

11.7.

Impact areas in driving consumer demand for EVs

The CCT should focus more on e-mobility investment into public transportation, which is used by most commuters as per the last National Household Travel Survey in 2013. This is where, from an efficiency standpoint, the biggest value for money can be realised. Subsidies and tax rebates for electric vehicles are often not justifiable for a product that can be afforded by only a very small segment of the population.

There is a need for the CCT to provide a set of incentives to drive the adoption of EVs through initiatives and a regulatory framework to generate momentum and obtain buy-in from the public and fleet owners. Examples of such initiatives include special electricity tariffs for EV charging at off-peak times, tax advantages to reduce the upfront capital cost of an EV purchase and building codes that require EV charging provisions in public and residential complexes. Supply-side incentives are not effective until sufficient scale is achieved. These adoption incentives can be phased out over a period.

Public transport investment to reduce emissions would accrue greater health benefits, and reduced costs to consumers (through fares) because of the operational and cost savings from electrifying public transport. This is especially so because the average South African spends more than 30% of their income on transport. Electric buses have significantly lower maintenance costs, for instance, so the operator would end up with more money in his pocket, and the commuter would be paying lower fares because it is cheaper to run and operate the vehicle.

The CCT can play a role in enabling financial institutions, both private and state-owned, to provide financial solutions at attractive rates to catalyse EV demand, particularly among fleet operators and logistics companies. The city's role could include offering credit guarantees for EV loans and working with OEMs, dealerships, and commercial banks to develop innovative vehicle ownership models, such as Mobility-as-a-Service (MaaS), vehicle leasing rather than ownership models, and/or enabling finance terms specifically tailored for EVs. This could also include detaching batteries from the financing of the vehicle. Thus, the batteries could be financed separately over a longer time, thereby reducing the monthly cost.

Finally, the CCT can play a role in communicating to the public and raising awareness of the benefits of EVs and a low-carbon future. This would be aimed at obtaining buy-in from the public to consider an EV for their next vehicle purchase, and fleet operators to pivot to greener fleets for their economic, environmental, and social benefits. The communication process should ideally focus on educating the consumer about electric vehicle ownership and viability compared to their existing ICE vehicle, and not just the environmental benefits.

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Appendix

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GreenCape

Green Economy Enterprise Development and Investment

A Cape Town-based company is demonstrating the viability of battery-powered electric vehicles in the neighbourhood watch and armed response industry.

Purpose

This case study describes the resilience-based rationale and outcomes of District Watch Group's new battery-powered electric vehicle fleet. The Cape Town-based company is one of the leading neighbourhood watch and armed response services in South Africa.

The green economy holds significant potential financial value for small and medium-sized enterprises (SMEs) and the uptake of green technologies has the potential to make them more resilient in the face of acute shocks and chronic stresses of society.

District Watch Group has implemented water saving interventions (using of greywater and groundwater), increased electricity efficiency and has now transitioned to electric vehicles (EVs) across all of the company's locations.

In the developing world, SMEs are considered engines for national job creation and economic growth, and their agile nature allows them to pivot quickly, particularly during times of acute shock. It is becoming clear that green economy innovations will be at the heart of the continued growth and resilience of South African SMEs.

KEY INSIGHTS

- The global electric vehicle market was valued at ~R1.6 trillion (USD 118.9 billion) in 2018/19, with 783 000 units sold, and the global stock of electric passenger cars passing 5 million (Global Electric Vehicle Outlook 2019/20).
- The SA market is slowly growing, with >500 EVs sold.
- This growth is based on a strong business case in specific local industries.

For more information on our sustainable mobility support work visit the GreenCape website: https://www.greencape.co.za/content/sector/sustainable-transport To contact GreenCape, email us at: info@greencape.co.za

GreenCape | CITY OF CAPE TOWN ISIXEKO SASEKAPA STAD KAAPSTAD | INVEST CAPE TOWN | RESILIENT CAPE TOWN

The case study discusses:

- The emerging business case for battery-powered electric vehicles (BEVs) in South Africa.
- How continued investment into green innovation strengthens the resilience of the local companies, thereby helping them to survive, adapt and thrive in the face of acute shocks.
- The role that SMEs play in the resilience of local and regional economies.
- How partnerships can be mobilised to stimulate green and sustainable development through supporting innovation.

It is written for:

- Companies in similar industries that are exploring cost-saving, resilience and sustainability measures.
- Businesses and entrepreneurs that are looking to capitalise on climate-induced business opportunities.
- Cities and regions that are seeking to harness innovation and decentralised smart-city responses to climate change challenges.
- Cities and regions focused on building economic resilience.
- Funders and other organisations seeking to replicate similar programmes

What is resilience?

In human terms, resilience refers to "the ability of an individual to recover from setbacks, adapt well to change and to keep going even when facing difficult circumstances". A resilient Cape Town is a compassionate, connected, and capable city, where Capetonians collaborate across households, communities and institutions, to build collective responses to the current and future social, environmental and economic challenges.

Background

The District Watch Group (District Watch), a Cape Town-based company, was established in 1994, offering a service that combines the key elements of neighbourhood watch and armed response. Initially, District Watch was limited to the Monte Vista and Plattekloof Glen areas. Today, District Watch has expanded to include suburbs all around Cape Town.

District Watch's drive for an improved customer and community service has meant the company is constantly seeking means of reducing costs, improving efficiencies, and protecting the environment. In this case, protection also includes a company-wide aim to increase efficiency whilst reducing water use and the company's carbon footprint.

Electric vehicles are the future of transportation in South Africa. Based on our experience over the last year with our EVs, we can't wait to convert our entire fleet to EVs; and we encourage our industry to do the same"

- Pierre Gouws, District Watch Group

Towards a solution

District Watch is the first and only security company in South Africa to have incorporated EV's into its fleet. The average useful life of a vehicle in their internal combustion engine (ICE) fleet is between 3-4 years (which includes significant repairs and maintenance).

The EVs are used on a rotational basis with three out on patrols whilst one is charging (to be used for the night shift). The EVs are, therefore, only charged once a day/shift.

District Watch doesn't believe in overextending the vehicles' designated patrolling area as this can compromise response times. This means that the operational range is 200 km (max) per shift - The company only requires a maximum of 200 Km operational range to minimise wear and tear in their vehicles and to ensure swift response times. Range anxiety is, therefore, not an issue with the BMW i3s expected range of between 290 - 320 km. On average, their vehicles are travelling an average of 100 000 km a yeah, per vehicle, and the driver's driving behaviour is monitored, e.g. harsh braking, and speeding.

The company intends to ultimately convert the entire fleet to EVs; except for the 4x4s, which are needed in off-road situations, such as farm protection.

The company also wishes to eventually incorporate solar charging (solar PV carports) at all its properties, but the main barrier is the cost of installation.

District Watch Electric vehicle pilot:

EV model	BMW i3
EV fleet size	8 electric vehicles in a total fleet size of 60 vehicles
EV type	Full Battery EV
Cost per EV	R 565 000 (was purchased outright from BMW)
Vehicle life	5-6 years vs 3-4 years for the current ICE fleet – which is the industry standard.
Battery guarantee	10 years
Chargers	Wall-mounted AC chargers
Charging cost	R30 – R40 per charge (comparative petrol costs of R150-R200 per shift)
Tariff	Small Business

Impact

District Watch has seen an overall cost reduction of ~80% over the life of the vehicle. This is mainly due to very low maintenance costs associated with EVs. In most cases, the company's ICE vehicles need gearbox replacements in the second year. This has not been an issue for the EVs. There is also a significant "fuel cost-saving" of between R120 and R160 per shift.

The only increase in cost that has been experienced has been tyre replacement - because regenerative braking[1] on the BEVs can result in increased tyre wear and tear.

All the company's drivers have reported that they have enjoyed using the EVs. There has also been positive feedback from customers, highlighting their quietness, especially in commercial centres, residential estates, and office environments.

Challenges and barriers

The vehicle chassis structure hampers the installation of radio communication equipment that requires a flat surface.

Mitigation: The company had to innovate to create the needed surface on the roof of the vehicle to allow for effective communication technology.

Installing security lights on the roof with no mounting grooves. **Mitigation:** The company had to use chemical anchors, i.e. some glue that is easily cleaned off. Drivers had to be re-trained since the electric vehicles necessitate a different driving style.

Mitigation: Operators driving behaviour is monitored, e.g. harsh braking, speeding, etc.

The current lack of safe and accessible public charging infrastructure is also a barrier that needs to be overcome.

The upfront cost of purchasing the electric vehicles remains high compared with other equivalent vehicles in South Africa.

Cost comparison vs ICE fleet:

Capital cost = Higher
Tyres costs = higher
Insurance -= Higher
Maintenance = Much lower
Repair = Much lower (EVs have fewer moving parts to be repaired and/or replaced)
Fuel = Much Lower

Opportunities for development

The following represent areas for development and growth when exploring the impact of EVs in the City of Cape Town:

1. The development of an EV electricity tariff or model that includes the installation of rooftop solar PV
2. Roll out of a public charging station network in safe and accessible locations – this can be a paid-for service.
3. Safety of the public charging locations (rather have them in enclosed areas like malls and convenient places, e.g. McDonald's, so the EV charges while one is having lunch).
4. Spot charging - Installations such as churches allowing for spot charging in exchange for free security.

[1] Regenerative braking is an energy recovery mechanism that slows down a moving vehicle or object by converting its kinetic energy into a form that can charge the battery as the car slows.

IN THE CONTEXT OF CAPE TOWN'S RESILIENCE STRATEGY, THIS ENTERPRISE & INVESTMENT CASE STUDY ADDRESSES

Stresses / Shocks

Economic crisis | Rapid urbanisation | Unemployment | Infrastructure failure | Crime

Qualities of a resilient city

Job-creating city | Adaptable city | Robust city | Fexible city | Resourceful city

RESILIENT CAPE TOWN PILLARS

PILLAR 1:	PILLAR 2:	PILLAR 3:	PILLAR 4:	PILLAR 5:
People **Compassionate,** holistically healthy city	Place & Space **Connected,** climate adaptive city	Economy **Capable,** job creating city	Disaster readiness **Collectively,** shock-ready city	Governance **Collaborative,** forward-looking city

PILLAR 3
Cape Town is a capable, job-creating City

VISION
Capetonians turn the challenges of resource constraints and rapid technological change into new opportunities.

GOAL 3.1	GOAL 3.2	GOAL 3.3	GOAL 3.4
Foster green economic growth	Enable enterprise development in the informal economy	**Connect the workforce with a changing economy**	Collaborate with businesses to achieve a resilient local economy

WHAT IS THE GREEN ECONOMY?

The working definition for the green economy as it relates to Cape Town is: "expanded economic opportunities created through the provision of goods and services and the use of production processes that are more resource-efficient, enhance environmental resilience, optimise the use of natural assets and promote social inclusivity."

For more information on our sustainable transport support work visit the GreenCape website: https://www.greencape.co.za/content/sector/sustainable-transport To contact GreenCape, email us at: info@greencape.co.za

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