Flagship Report

South Africa & Southern Africa
Battery Market & Value Chain Assessment Report

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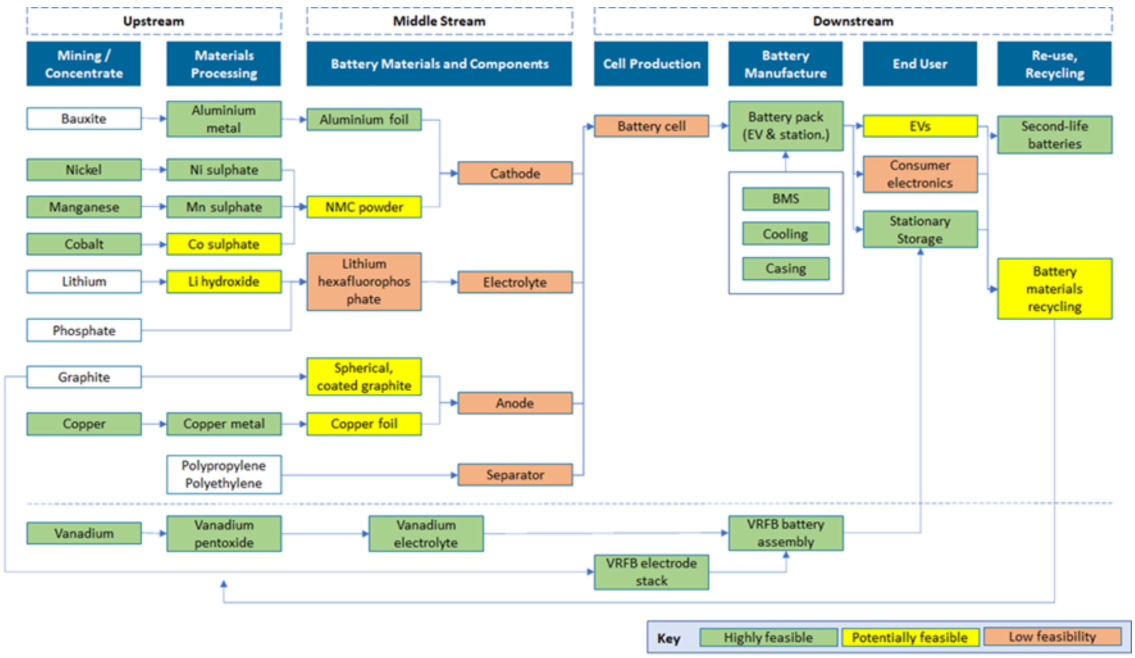
Executive Summary

South Africa has an opportunity to play a significant role in the global battery value chain, which is likely to grow over 3000 GWh by 2030 as per the market analysis done by Customized Energy Solutions (CES) for the World Bank. It is analyzed that the South African battery storage market can be expected to grow from 270 MWh in 2020 to 9,700 MWh in 2030 under the base-case scenario and 15,000 MWh under the best-case scenario. In both cases, the electric vehicle (EV) sector is expected to drive the bulk of this growth.

From this study it is noted that Lithium-ion battery (LIB) chemistries will continue to be the dominant battery technology by 2030, with Nickel Manganese Cobalt (NMC) expected to be the leading LIB chemistry, while vanadium redox flow batteries (VRFBs) are expected to gain a significant market share in the stationary energy storage space. South Africa and even more so the Southern Africa sub-region is well-endowed with many of the battery minerals that are required for LIB manufacture. Moreover, South Africa has some early-stage activities in the LIB value chain as well as a diversified automotive industry that is strongly dependent on exports that would eventually need to transition to the manufacturing of EVs, if it is to continue as a major exporter to its neighboring markets in the long-run. In addition, the clear global and, to a lesser extent, local trend towards renewable energy and electric mobility provides a strong incentive for South Africa to actively develop their local LIB and VRFB value chains.

Battery value chain opportunities and feasibility for South Africa



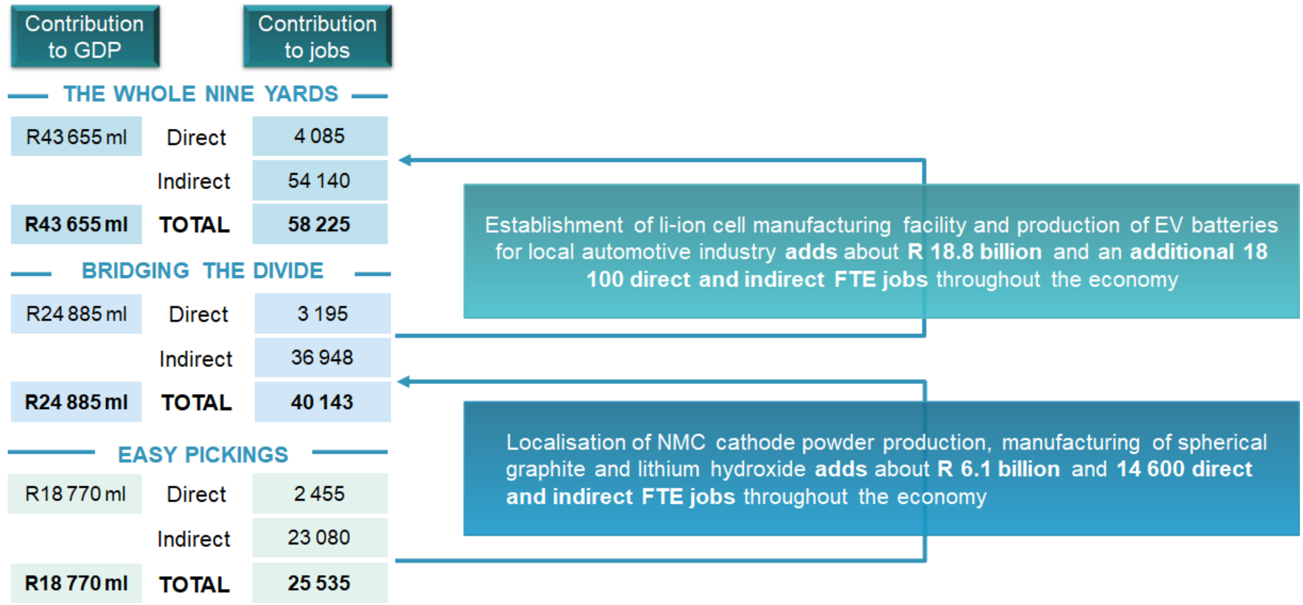
Referring to the figure above, with plenty of resources like Nickel, Manganese, Copper, and Vanadium being already mined in the country, South Africa has a significant opportunity in exploring Up-stream and Mid-stream battery value chain activities. As such, upstream minerals mining and refining as well as opportunities minerals beneficiation (any process that improves the economic value of the ore by removing the unwanted minerals, which results in a higher-grade product and a waste stream) and processing opportunities should be targeted as low-hanging fruits. Furthermore, if South Africa can aspire to succeed in developing an integrated supply chain, it will help in significant job creation and positive impact on GDP growth.

Downstream and most of the Mid-stream opportunities can be targeted around the local market which is likely to grow to 10 GWh by 2030. Battery pack assembling and Battery Energy Storage System (BESS) integration opportunities are the low hanging fruits here. Cell manufacturing is also possible at the estimated scale of the market with support from the government. Manufacturing of cathode active material, Li salts and separators would be the most difficult part for South Africa in this value chain as the scale for manufacturing (15-20 GWh equivalent) and technology knowhow barriers would require South Africa to work at the larger scale than its existing domestic market and the local companies would also require technological support from companies with significant market presence.

The report also debates different aspirational scenarios for South Africa, which may be considered by the government as shown below. These scenarios can also be considered as developmental steps for the government. Like the scenario of 'EASY PICKINGS' of investing in local battery minerals beneficiation and BESS integration is a possible target for 2022, however the scenario defined as 'THE WHOLE NINE YARDS' which focuses on local cell manufacturing, EV manufacturing on top of activities mentioned in the other two scenarios can be targeted for 2030. These scenarios can be seen as incremental steps for achieving the final goal of having an integrated battery value chain in South Africa.

It is clear that the impact on GDP and job creation increases significantly from the lowest to the most ambitious scenario. As summarised in the figure below, the EASY PICKINGS scenario is already estimated to lead to positive impact on GDP and job creation of R 18.8 billion and 25,500 direct and indirect jobs, respectively.

Impact on GDP and jobs in South Africa through battery value chain scenarios



The establishment of the local production of spherical graphite, lithium hydroxide, and/or lithium carbonate as well as NCM cathode powder in the BRIDGING THE DIVIDE scenario has the potential of adding a further R 6.1 billion and 14,600 direct and indirect jobs. Finally, in the WHOLE NINE YARDS scenario, the establishment of battery value chains at scale could add a further R 18.8 billion to GDP and an additional 18,100 direct and indirect jobs.

It is very important for South Africa to focus on the WHOLE NINE YARDS developmental scenario and beyond to play a significant role in the global and regional markets. The Recommendation section of the report elaborates a set of recommendations that the South African industry and the government may consider in accomplishing this scenario. These recommendations are informed by the existing industries and policies in South Africa as well as analyses of battery industry development and policies of other countries in the world, which have already progressed or are planning to progress to increase their share in the battery value chain. Following are few major recommendations that South Africa can focus to achieve the target of integrated battery value chain development in the country.

Recommendations 1

Strategic intent

i. Support the growth of the nascent battery minerals refining and battery pack manufacturing industry in South Africa (1 – 2 years)
ii. Support the expansion of local battery mineral refining/beneficiation to include lithium, graphite and cobalt from other African countries (regional battery mineral beneficiation hub) (3 - 5 years)
iii. Target the development of an integrated value chain including EV battery and battery cell production as a 10-year policy ambition.

Recommendations 2

Overarching recommendations for battery value chain policy

i. Send clear, positive policy signals for the development of the local battery value chain.
ii. Focus on maximising domestic production across the whole battery value chain.
iii. Develop mutual trust and coordination by extensive engagements between public and private sector as part of the design of programmes and incentives.
iv. Consider establishing a directorate in the DTIC for the establishment of a battery value chain in South Africa. This should work closely with relevant other directorates such as automotive.

Recommendations 3

Easy Pickings – Minerals Refining and Battery Manufacture

i. Facilitate an increase in the proportion of renewables in the South African energy mix to improve access to green energy (Integrated Resource Plan, green funding)
ii. Consider the introduction of a beneficiation policy for battery minerals (could take the form of an export tax).
iii. Facilitate access to finance through streamlining and accelerating application processes at financing institutions and leveraging international green funding (e.g. World Bank).
iv. Establish a competitive battery testing and certification facility in South Africa.

Recommendations 4

Bridging the Divide – Regional Minerals Beneficiation Hub, larger-scale BESS production

i. Explore bilateral trade discussions with African countries that possess battery mineral reserves (Zimbabwe, Mozambique, Tanzania, DRC, Zambia)
ii. Stimulate demand for locally manufactured battery storage by specifying higher and increasing levels of local content in public sector energy storage tenders (including IPP tenders that include storage), and issuing tenders early with longer delivery deadlines to allow for the build-up of local manufacturing capacity.

Recommendations 5

The Whole Nine Yards – Integrated battery value chain including EV batteries/cells

i. Accelerate the policy development and implementation process outlined in the Auto Green Paper published by the DTIC in May 2021, to assist the local automotive industry in pivoting to EV vehicle and components production, including batteries.
ii. Stimulate local EV demand by
    - Introducing electric buses on a trial basis in all major metros with a view to roll-out;
    - Specify a significant percentage of EVs for public sector passenger vehicles typically used for urban trips by government departments (light vehicles);
    - Specification of a significant (15%) percentage in the taxi recapitalisation programme to stimulate EV adoption.
iii. Launch a feasibility study on the development of a BESS Special Economic Zone (possibly within an existing SEZ).

Recommendations 6

Skills Development and R&D

i. Facilitate the establishment of a training programme for the battery industry by the EWSETA, in collaboration with the tertiary education sector and the battery industry.
ii. DSI to consider establishing a research programme on energy storage systems, with strong focus on engineering, manufacturing technologies, and systems integration.

1. Introduction

The primary objective of this report is to develop a comprehensive understanding of the opportunities in developing battery value chains in South Africa. For the purpose of this study, thorough research and analysis was conducted on different parts of the battery value chain across up-stream, mid-stream, and down-stream segments to map opportunities and assess strengths and weaknesses as it relates to South Africa's battery market, the local economy, and the availability and access to natural resources.

This study was initiated in the second year of the pandemic in early 2021, in the backdrop of the South African government announcing its plans to add more than 26 GWs of Renewable Energy by 2030 onto its power grid while retiring 15 GW of coal power plants, based on the updated 2019 Integrated Resource Plan (IRP) document. Under existing conditions, the power grid operated by Eskom has frequently been affected by reliability issues that has resulted in frequent load shedding, averaging two hours daily in several parts of the country. These factors have created a strong business case for scaling utility-scale energy storage solutions to facilitate the integration of renewables into South Africa's power grid as well as enhance back-up power options in the customer-side. Moreover, the recent surge in global electric vehicle sales have increased demand for sourcing metals globally for battery production, which as a result is further driving the development of upstream battery value chain in South Africa, mostly on mining and mineral beneficiation. These factors collectively have drawn attention to the role to be played by South Africa to scale their nascent battery industry. It also begs the question, can the battery industry sector drive growth of the country in the post-pandemic recovery period?

South Africa is rich in mineral resources such as Vanadium, Manganese and Nickel. These minerals are mostly sought after as key raw materials for manufacturing lithium-ion and vanadium redox flow battery chemistries. As such, these factors position the focus of this research study to assess the potential of South Africa to develop a regional battery (lithium-ion) manufacturing hub; which can ultimately supply batteries to meet local, regional (Southern Africa sub-region), and global demand, particularly for lithium-ion battery chemistries supporting both stationary and e-mobility storage applications.

Globally, at present, more than 80 percent of the demand for lithium-ion batteries is accounted for e-mobility applications. By 2030, electric mobility is considered to be the biggest driver for many advanced battery chemistries. On account of this, the demand for the e-mobility sector in South Africa including the Southern Africa sub-region were incorporated into the broader market assessment study.

1.1 Introduction to Chapters in the Report

The geographic scope in conducting research for this study covered South Africa and selected countries from the Southern African Development Community (SADC) within the Southern Africa region. Studying the nearby region helped in estimating and aggregating the demand from them, as well as assessing the availability of key battery raw materials in these regions. Additionally, to assess the feasibility of setting up a lithium-ion battery manufacturing hub in South Africa, detailed research was conducted into the supply side and demand side analysis of the lithium-ion battery market. These topics are arranged in 6 chapters under this study, starting with this *Introduction* chapter.

Chapter 2 Current Battery Landscape in South Africa covers the existing battery market landscape in the country, and it's current players with their capabilities in various battery chemistries such as lead acid, lithium-ion and vanadium redox flow.

Chapter 3 Battery Market in South Africa scans the policy and regulatory framework affecting the stationary storage and e-mobility markets for batteries in South Africa as well as a Market Assessment of demand for batteries in the Southern Africa (South Africa and chosen countries within SADC) sub-region.

Chapter 4 The Case for Battery Value Chain Development in South Africa represents the findings of the Battery Market Value Chain Assessment and case for its Development in South Africa. This section delves deep into the feasibility of establishing the up-stream, mid-stream, and down-stream battery value chains in South Africa. Up-stream refers to mining and refining (processing) of minerals for battery manufacturing. Mid-stream refers to the beneficiation of raw materials including component manufacturing (e.g., Cathode powder, electrolyte, and separators and so on). Down-stream refers to battery cell manufacturing, cell to pack assembling, supply to end-users and recycling of batteries.

Chapter 5 Developmental Scenarios discusses three different ambitious scenarios of growth for battery value chains including each of their impact on the economy and their job creation opportunities in South Africa. Besides, the chapter also compares the difference in impacts from these three scenarios and comments on the gaps which needs to be covered to aspire the respective growth plans.

Chapter 6 Global Case Studies elaborates a set of global case studies that the South African battery industry and the government may refer to while making policy decisions. These case studies includes analysis of the development and policies in battery value chain in other countries. These countries have already progressed or are planning to progress to increase their participation in the battery value chain.

Chapter 7 Project Relevance from a Policy Perspective discusses relevance of investing in battery value chain from current policy stand point in South Africa.

Chapter 8 Recommendations section summarises recommendations regarding a potential development path for a South African battery value chain based on development scenarios mentioned in Chapter 5. The chapter also builds on key takeaways mentioned in Global Case-studies section and details arching policy interventions that would need t

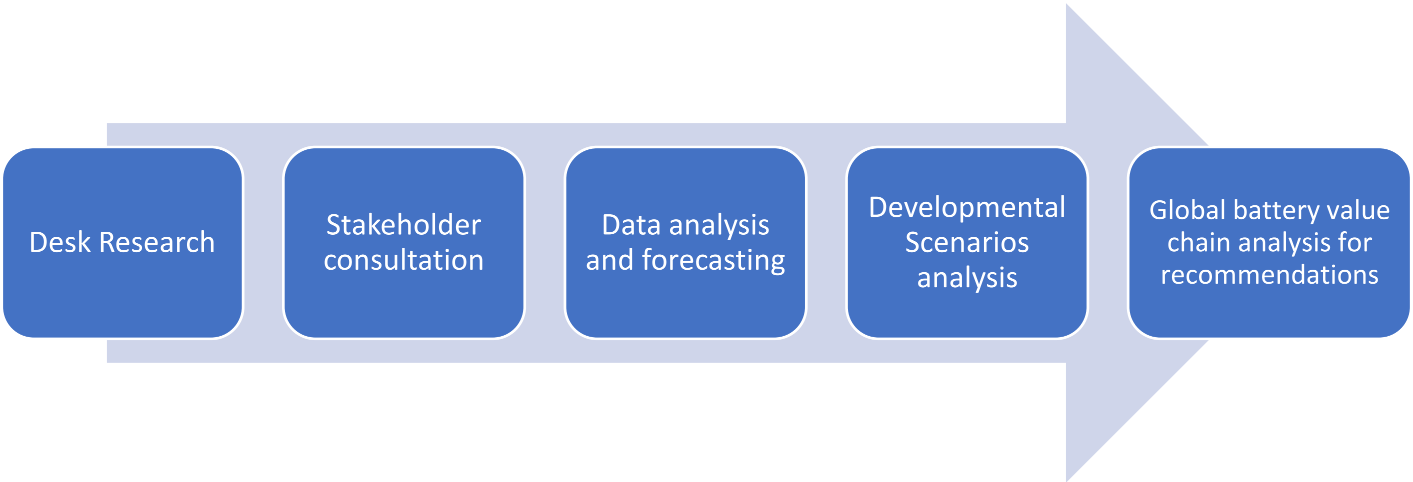
1.2 Research Methodology

The research methodology and processes are outlined under Figure 1 below to highlight how various topics were researched in developing the battery market assessment as well as the battery value chain assessment. The reports and papers referred for this study have been listed in Chapter 9.

For the battery market assessment section, a bottom-up market research approach was conducted to study the demand for lithium-ion and other advanced battery chemistries based on their various applications such as distributed energy storage for power backup, grid-level storage for renewable energy integration, and different e-mobility applications in the chosen countries. For the battery market value chain assessment section, the research methodology/approach looked at assessing the existing drivers and bottlenecks, import duty structures, the regulatory framework, and public incentive schemes in South Africa.

The battery raw material section delves deep into research and analysis of various mineral reserves available in the Southern African region for producing battery raw materials (Up-stream) including their economic feasibility of beneficiation (Mid-stream).

Figure 1: Five phases in the research process



Desk Research: During the first phase of the study, a detailed desk research on documents mentioned in Chapter 9 was conducted by a group of analysts to understand the battery landscape and scope for energy storage in the Southern Africa region. This preliminary research focused mostly on the key areas highlighted below:

- Mapping out key industry stakeholders within the battery value chain in South Africa.
- Researching existing policy and regulatory frameworks and scanning the national renewable energy targets set by the countries in Southern Africa, as well as targets for electrification of the transport sector
- Studying current market trends, key drivers, and constraints for scaling the demand for energy storage

Stakeholder Consultation: In this phase, we engaged in discussions with key stakeholders in the Southern Africa battery industry to collect their insights on the present status of the industry, the customers' appetite for new storage technologies, state of battery R&D in the country, the viability for minerals beneficiation and so on. This list of companies or bodies whose inputs were collected is listed in Figure 2. This activity which was initiated first prolonged till the end of the entire market assessment study, as interviews were conducted during each phase of the study with numerous industry participants to collect key data and inputs.

Figure 2: List of Industry Stakeholders interacted for the research

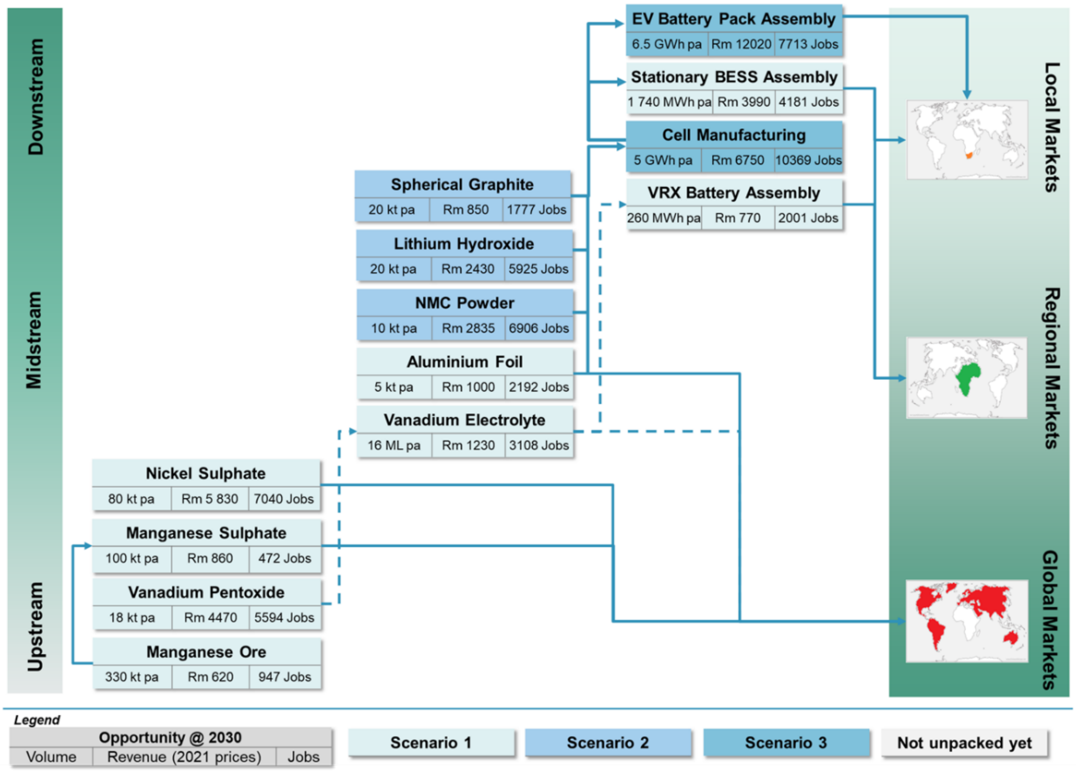
Data Analysis and Forecasting: On the demand assessment side, the inputs received from the industry participants via interviews as well as content from the literature reviews were analysed to estimate the current demand for energy storage in the country and to forecast the demand up to 2030. The growth estimates were derived from inputs received from primary sources, global benchmarking, LCOE and TCO analysis done for storage and EV markets respectively. Three different forecast scenarios namely worst case, base case, and best case were projected in the study for stationary storage and e-mobility applications in South Africa the Southern Africa region.

The battery markets analysed are **South Africa** (section 3.1), **Southern Africa** (section 3.2), also referred to as the regional market, and the **Global Market** (section 3.3) for the period 2020 to 2030. The total battery market is classified into stationary and mobile (e-mobility) storage. The base year for the study is 2020. For the base-year market estimation, a bottom-up approach is applied. In this approach, extensive primary interviews were conducted with key market participants in each of the market sub-segments [such as UPS manufacturers, telecom tower operators, diesel genset suppliers, South African Local Government Association (SALGA), lead-acid battery suppliers, lithium battery pack-makers, and so on]. The battery potential from each of these sub-segments was estimated to arrive at the stationary battery potential for South Africa and the chosen Southern African countries (list of countries by application is provided in Table 1) in 2020. In the battery raw material analysis, a SWOT analysis of the battery materials in South Africa was conducted to identify which minerals have high feasibility of beneficiation over others. The future production of various minerals to meet the battery manufacturing demand till 2030 was also projected in the report.

Developmental Scenario: As a result of the research, analysis, and forecasts of the market till 2030, the opportunities and shortfalls were evident for the battery manufacturing ecosystem creation in South Africa. Customized Energy Solutions (CES) suggests three developmental scenarios for the industry to approach this market via three different stages.

These stages can be visualized as short term (1 to 2 years), medium term (3 to 5 years), and long term (6 to 10 years) scenarios for the country. The developmental scenarios also explore the impact that each of these scenarios have on GDP growth and the creation of jobs for supporting mining, minerals beneficiation, material processing, cell manufacturing, and battery pack manufacturing in the country.

As shown in the figure below, Easy Pickings developmental scenario activities are shown in Scenario 1 boxes, Bridging the Divide scenario is demonstrated through activities mentioned in Scenario 1 and Scenario 2 boxes combined. Whereas, Scenario 1, Scenario 2 and Scenario 3 combined shows the battery value chain components that should be targeted in the Whole Nine Yards developmental scenario.



Global Case-studies: This chapter incorporates global case studies and policy analysis, including key takeaways which are extended to industry stakeholders to help in bridging the current gaps existing in the market. Case studies are picked from different emerging markets which can provide certain key takeaways for South Africa.

Recommendations: This section summarises recommendations regarding a potential development path for a South African battery value chain based on development scenarios mentioned in Chapter 5. The chapter also builds on key takeaways mentioned in Global Case-studies section and details arching policy interventions that would need t

It is expected that the in-depth research conducted by the analyst team for nearly a year to develop this study would be highly beneficial in supporting the battery value chain creation in South Africa while helping the country to establish a regional battery hub for lithium-ion and vanadium redox flow battery manufacturing.

2. Current Battery Landscape in South Africa

Globally, the advanced battery chemistry market has seen a sharp rise with increasing demand from mobile storage (electric mobility) and stationary storage applications. The market in South Africa is at the cusp of a change in terms of the demand for batteries. Among other aspects, the National Development Plan 2030 focuses on reducing CO_2 emissions from the electricity sector by improving electricity supply in rural areas and across the nation. The Integrated Resource Plan 2019 (IRP 2019) focuses mainly on setting ambitious renewable energy (RE) targets, expanding distributed generation, and retiring old coal power plants.

To balance a large quantity of renewable power, especially solar PV and wind (both intermittent sources), they have to be supported with energy storage systems such as pumped hydro and/or battery energy storage systems (BESS). As such, South Africa released the first grid-scale energy storage tenders in 2020-21. Furthermore, countries across the globe have set electric vehicle (EV) adoption targets to reduce carbon emissions from the transportation sector. On the other hand, South Africa is yet to set its EV target. However, even without an EV target, there have been telltale signs of growth of EVs for commercial transport segments (i.e. public bus transport) in South Africa.

South Africa has a mature battery market mostly in the lead-acid battery chemistry with over 75% market share in 2020 as estimated by CES. Presently, these batteries are being used in stationary storage applications for back-up power in residential, rural microgrids, commercial & industrial (C&I), and automotive[1] (starting, lighting, ignition) segments. In addition, Lithium-ion battery pack manufacturers are mushrooming in the nation, and at present, a handful of them are also supplying to stationary applications for uninterruptible power supplies (UPS), telecoms (cell towers), and automotive (forklifts, golf carts) segments.

In 2020, the total stationary storage battery market in South Africa and Southern Africa was estimated to be 440 MWh as analyzed by CES.

The various battery applications for the Southern African countries are analysed in the given table below:

Table 1 List of battery applications covered in Southern Africa Market.

Countries/Applications	Telecom	UPS	EV	Rural Electrification	Diesel Genset	FTM
Tanzania	✓			✓		✓
Uganda			✓	✓		
Kenya	✓		✓			✓
DRC	✓					
Mozambique	✓					
Botswana			✓	✓		
Zambia				✓		✓
Namibia				✓		
Angola			✓			✓
Zimbabwe			✓			✓
SADC (16 countries) [The Southern African Development Community]		✓			✓	

[1] SLI application is not covered in the scope of this report.

Currently, the market is purely driven by behind-the-meter (BTM) battery installations in UPS, telecom, rooftop solar, solar home lighting systems, and microgrids. The BTM segment, which is currently dominated by lead-acid batteries in South Africa, is going to provide opportunities for advanced chemistries. Moreover, this advanced chemistry penetration through lithium-ion batteries is already being adopted in telecom towers and solar home lighting systems. In 2021, Eskom launched tender for over 800 MWh of grid scale batteries to be deployed in the country. Li-ion batteries with 20% local content requirement are likely to be deployed under this tender, which is supported by the US$ one billion World Bank Group global program to accelerate investments in BESS industry.

2.1 Mapping of Current Battery Landscape in South Africa

The South African battery landscape has been steadily developing since 2013. With the rise of start-up companies focused on new advanced battery chemistries like Li-ion based LFP (Lithium Ferro Phosphate) and NMC (Nickel Manganese Cobalt), as well as Flow batteries (Figure 3), the competition has been intensifying between the new entrants and the proven lead-acid battery producers, particularly in the legacy battery applications such as telecom back-up and industrial UPS batteries. The local battery manufacturing landscape in South Africa is detailed in the sections below.

Figure 3: A timeline of the emergence of advanced chemistry battery companies in South Africa.

2.1.1 Lead-acid Batteries

The local supply chain comprises battery manufacturers that produce automotive lead-acid batteries and industrial batteries. The secondary lead smelters recycle used batteries and supply lead to the battery manufacturers. The major battery manufacturers in South Africa are:

- **First National Battery** – First National Battery manufactures automotive starter (SLI), mining traction, DIN and BS materials handling batteries, standby, leisure (boats-caravans), and solar/rural power storage systems. Established in 1931, it is a leading battery manufacturer in South Africa. Today, it is a wholly owned subsidiary of JSE-Listed Metair Investments and is considered the most progressive of all battery manufacturers in South Africa. The company has produced batteries for most of the

OEMs in South Africa, and hence, their product range is influenced mainly by the OEMs. First National Battery also provides options for RE off-grid and hybrid applications.

- **AutoX** – AutoX manufactures automotive batteries, surface, and mining traction batteries, standby, and stationary batteries, solar energy solutions, etc. The company primarily manufactures and markets lead-acid batteries under the well-known Willard and SABAT brands. Through its subsidiary Rentech, AutoX also supplies lithium iron phosphate (LFP) batteries for solar and UPS applications. These batteries are imported from China (Shenzhen BAK Power Battery Co. Ltd).
- **Dixon Batteries** – Dixon Batteries manufactures lead-acid automotive batteries, traction batteries for golf carts, and UPS batteries. It is a Johannesburg-based family business, which has been manufacturing automotive batteries since its establishment in 1955.

The estimated production volumes of the lead-acid battery producers together with imports are approximately 4 million units per annum.

2.1.2 Lithium-ion Cells

Lithium-ion (Li-ion) battery cells are currently not manufactured in South Africa. The only company that has announced plans to establish Li-ion cell manufacture in South Africa is the Megamillion Group of Companies. Their concept includes the construction of a pilot plant in the Coega industrial park in the Eastern Cape with a production capacity of 0.5 GWh, commencing in Q1 2022, and expanding to 32 GWh by 2028. The venture is to operate with Chinese technology and expertise, but presently it is only at a conceptual stage with no tangible progress made to date. According to statements by the company's founder in April 2021, the company is still searching for investors.

Metair Investments is a group of local and international companies that manufacture, distribute, and retail automotive components and energy solutions to the automotive industry, telecoms, mining, and materials handling industries. A key strategic focus is growing the energy storage business and ensuring that Metair moves with the technological requirements needed to shift towards Li-ion technology and electric mobility. Metair is already engaged in the manufacturing of Li-ion battery cells through its Romanian subsidiary Prime (35% shareholding). Prime is a technology-focused company that develops and manufactures cells and battery packs in Romania for automotive and industrial storage solutions.

In South Africa, Metair has collaborated with UWC (University of Western Cape), which houses the only pilot Li-ion cell manufacturing facility in the country. Initiated in 2017, the R3 million, three-year collaborative program was aimed at piloting the manufacture of Li-ion cells, primarily for mining cap lamps used in the mining industry. In combination with its international LIB activities and well-established market linkages, Metair is well positioned to potentially localize Li-ion cell production in South Africa.

2.1.3 Lithium-ion battery systems

Other components within the Li-ion battery landscape include the development and manufacture of lithium-ion battery systems by four companies in South Africa, as listed below.

Table 2: Lithium-ion battery assemblers, South Africa, 2020

Products/Market sectors

Company	Management	UPS	RE storage (home, commercial)	Industrial mobile machines (forklifts)	Refrigeration (trucks/trailers)	Lead-acid replacement	Chemistry
Maxwell and Spark	**Dr. Clinton Bemont** CEO			▪	▪		**LFP, [LFP doped] [Dopants-Y/Mn]**
Balancell	**Dr. Ian de Vries** Founder, CEO & CTO			▪	▪	▪	**LFP**
BlueNova	**James Verster** CEO	▪	▪			▪	**LFP [Yttrium doping]**
Freedom Won	**Antony English** and **Lizette Kriel** Co-owners	▪	▪	▪		▪	**LFP**

Source: CES analysis based on primary research.

The summary profiles of the manufacturers are contained in the table below, while more detailed descriptions are provided in the following sections.

Table 3: Lithium-ion battery assembler profile, South Africa, 2020

Company	Technology and Intellectual Property	Additional Insights
Maxwell and Spark	▪ Proprietary battery system designs, IoT telematics ▪ Independently test Li-ion cells and new chemistries ▪ Integrate bought-in cells and components into battery systems ▪ Forklift battery systems integrated into forklift ▪ Developing a third, non-mobile industrial energy storage product	▪ The largest manufacturer of Li-ion forklift batteries in Africa ▪ In-house engineering and assembly, components manufactured to specification ▪ Work in partnership with larger customers, e.g., Scania (refrigerated trucks) and Goscor (forklifts) ▪ Selling to the US and Australia with a focus on forklift batteries, these are rapidly growing markets for the company ▪ Forklift batteries make up 80% of revenue, very successful in Australia ▪ Planning to set up a factory in Europe in three years
Balancell	▪ Proprietary hardware, connectivity, and own IoT platform, modular BMS ▪ Patented active cell balancer ▪ Direct cell to pack assembly – hence, can develop new batteries and scale production fast ▪ Forklift batteries as a replacement for lead-acid batteries	▪ Range of standard batteries in 26, 39, 52, 81V, and 3.7 - 44 kWh ▪ More than 1,000 batteries delivered, full battery monitoring, and history ▪ Sell mainly through forklift and industrial machine suppliers, installers

BlueNova	▪ System integrator, using mainly bought-in components ▪ BlueNova Multicap™ technology - firmware solution allowing the parallel connection of batteries with different capacities ▪ Wide product range: • Standard, stand-alone batteries • Integrated solar control and storage • Integrated systems up to 250 kW /1 MWh (containerized, own IoT control and monitoring)	▪ Focused on RE and off-grid storage solutions at residential, industrial, utility-scale ▪ Partnered with Reutech, developing market opportunities in the Southern African region ▪ Sell mainly through independent installers in South Africa and Africa
Freedom Won	▪ Proprietary CAN communication compatible with most third-party system controllers ▪ Distribute imported batteries (e.g., lead-acid replacements), integrate bought-in components into standalone ESS. BMS is imported from the USA ▪ Has a wide product range ▪ Electric vehicle conversions (safari vehicles)	▪ Sell through distributors and resellers/installers distributors in many African countries, Europe, Australia, New-Zealand

Source: Primary Inputs

Maxwell and Spark

Based in Durban, Maxwell and Spark is one of the top two LIB manufacturers in South Africa. It originated from a research group at the University of Kwazulu-Natal (UKZN), under the leadership of Dr. Clinton Bemont, the founder and CEO of Maxwell and Spark. The firm currently employs 40 – 50 staff, 15 of whom are engineers, most with a postgraduate qualification. Maxwell and Spark designs and assembles LIBs in their factory in Durban and independently tests Li-ion cells and new chemistries, to maintain up-to-date cell technology. The company's focus is on the LFP chemistry, and for cost and safety reasons, the LFP cells are imported from China. NMC cells are used to a lesser extent, and these are typically imported from Japan.

Apart from the battery cells, Maxwell and Spark design and develop all other battery pack components in-house, i.e., Battery Management Systems (BMS), electronics firmware and software, wiring harnesses, and enclosures. The firm has developed significant intellectual property in this area and holds two patents.

Most of the component manufacturing is outsourced but all are made according to Maxwell and Spark design and specifications:

- Metal enclosures outsourced to local metal fabricators, several of whom depend on Maxwell and Spark for around 50% of their business.
- Electronics and wiring harnesses outsourced to China due to a lack of competitiveness of local electronics manufacturers.
- Busbars used to be made in South Africa, but the designs are now more sophisticated and require specialized manufacturing equipment, which does not exist in South Africa; hence, these parts are made overseas.

From a product perspective, the focus is on forklift batteries (Maxwell and Spark is Africa's largest manufacturer of forklift batteries). The company has formed a strong relationship with South Africa's largest supplier of forklifts, Goscor. Goscor uses Maxwell and Spark as their sole supplier of Li-ion forklift battery packs. A second product line is LIB-based refrigeration solutions for the trucking industry. Launched in October 2019, the Fridge. Li mobile refrigeration systems are supplied to the SPAR group as well as other retail chains and large fleet owners. By using proprietary remote telematics systems (IoT), batteries, and refrigeration, systems can be monitored for performance and system health. The data also enables the company to better understand the operation of the systems and identify areas for improvement.

Maxwell and Spark have strong international ambitions. The company is already selling forklift batteries and Fridge.Li systems in Australia and North America with great success and sees great growth potential in these markets, as well as in Europe. The company is planning to establish a manufacturing plant in Europe within three years.

Figure 4: Fridge.Li: Fully integrated, battery-electric mobile refrigeration system solution

Source: Maxwell and Spark

Figure 5: HARDcore: Lithium-ion forklift battery solutions

Source: Maxwell and Spark

Blue Nova

Blue Nova is the largest Li-ion battery maker in South Africa with approximately 70 staff. It is 51% owned by Reutech (Pty) Ltd, which in turn is a part of the listed Reunert Group. The company focuses on the development and assembly of energy storage solutions based on the LFP cathode chemistry and offers a wide range of products for RE and off-grid storage solutions for residential, industrial, and utility-scale. They offer:

- Standalone storage
- Mobile storage, i.e., standard batteries for lead-acid battery replacement
- ICT backup storage batteries.
- Integrated solar control and storage systems (for PV installations).
- Large intelligent energy storage systems (iESS) – containerized, utility-scale systems (250 MW, 1 MWh) for commercial, agricultural, manufacturing, and mini-grid applications.

While the LFP cells are imported from China, the remaining system components are designed and developed in-house. This includes Sand energy management systems (EMS), electronics and mechanical components, displays, software and remote monitoring systems, and enclosures. Blue Nova considers its capabilities in electronic hardware/firmware and software as a key differentiator and a focus area for the company. They have also developed a firmware-based solution that manages the performance of parallel-connected BlueNova batteries and allows for continued performance, even when the batteries have varying capacities.

This Multicap™ solution allows end-users to increase the capacity of their BlueNova storage system by adding batteries of varying capacities.

The standard batteries for lead-acid replacement are manufactured in China to BlueNova's designs and specifications. Local manufacture will be contemplated once the local market has reached a sufficient scale. The other product offerings are assembled in the BlueNova factories in Somerset West, while the iESS systems are manufactured in a factory in Centurion near Pretoria. Most of BlueNova's products are sold through independent installers and re-sellers while a direct channel is followed for the iESS.

BlueNova sees substantial market growth opportunities in South Africa and neighboring countries and is actively developing opportunities, leveraging the Reunert linkage. Most recently, the company has successfully exported an iESS system to Namibia, as well as battery packs to Botswana and Mozambique.

Figure 6: iESS intelligent energy storage solution by Blue Nova Energy.

Source: Blue Nova Energy

Balancell

The Cape Town-based company is focused on the local development and manufacture of LFP batteries and Battery Management Systems (BMS) for commercial and industrial (C&I) applications. The primary focus is on industrial motive batteries (also known as traction batteries) for forklifts and other industrial mobile equipment. Balancell also produces batteries for solar energy storage and refrigerated truck (reefer) conversions, as well as ancillary products such as chargers and auxiliaries.

Balancell imports only the LFP cells from China and all other parts of the batteries are sourced or manufactured locally and with local suppliers. This includes the enclosures, electronics, assembly, integration, and software. The addition of laser welding for the cells is planned. The company produces some 100 batteries per month at its Cape Town factory. It is similar in size to the other manufacturers with a staff of around 40 people but has grown rapidly in the past two years and is planning to double this number.

Balancell considers their proprietary Battery Management System (BMS) software as their key value-addition and differentiator, including their patented cell balancer technology and power electronics. The company builds on its 20 years of experience in the design and development of BMS that incorporate its connectivity (IoT) modules for remote battery monitoring and diagnostics. By using data collected remotely from every battery in operation, Balancell is developing models to represent each battery and provide analytical means to diagnose problems, see performance degradation, generate early warnings, and do lifetime predictions. The aim is to develop this concept further as a tool for evaluating large amounts of battery data in the field and of new chemistries (e.g., data-based modeling of battery lifetime). The analysis capabilities also enable the generation of business metrics and reports, e.g., on usage patterns, hours operated, and hours charged. It further enables the analysis of customer machines for efficiency, utilization, and generates data and alerts to facilitate utilization optimization. This enables Balancell to offer value add services to its customers.

Figure 7: Balancell lithium-ion battery forklift solution in partnership with Mass lift delivered 32 lithium-powered forklifts to the RSA Group

Source: Balancell

Freedom Won

Freedom Won produces LFP battery packs for industrial and residential storage applications such as:

- Residential backup and solar systems
- Uninterruptible power supplies (UPS)
- Telecommunications towers
- Backup storage systems for mines
- Power quality improvement

Figure 8: A solar ESS hybrid site in South Africa with Freedom Won Battery

Source: Specialized Solar Systems

The company has a wide product range and also includes the distribution of imported Li-ion batteries for lead-acid replacements for applications in industrial mobile machines such as forklifts, tow vehicles, mining vehicles, and even golf carts.

Freedom Won locally assembles battery packs using LFP cells imported from China. The remaining battery pack components such as the wiring harnesses, electronics, and enclosures are either manufactured by Freedom Won or sourced from local suppliers. The BMS is imported from the USA.

Freedom Won sells its products through a multitude of distributors and resellers/installers, mainly in Southern and West Africa but also in Europe, Australia, and New Zealand.

Support Required for Scaling of Industry

The local LIB manufacturers all import their battery cells from Asia, mainly from China but have established considerable capabilities, expertise, and intellectual property in battery pack design, firmware, and software for BMS and EMS, as well as online remote monitoring systems. The standard Li-ion batteries intended for lead-acid battery replacements are typically manufactured in China to local designs or sourced from Chinese manufacturers for local distribution, due to the current lack of economies-of-scale in the local and regional markets.

As noted above, this industry is yet quite small and limited in both scope and scale but is in an early growth phase. One manufacturer reported a five-fold annual increase in revenue in the past two years. The companies have evolved by focusing on niche market opportunities, both locally and in selected geographies. As described in the profiles, the companies typically sell and distribute their products via many re-sellers and installers, the latter providing the capabilities to integrate the battery systems with existing electrical infrastructure and renewable energy systems at client premises.

Some key constraints noted by the manufacturers include:

- Lack of market scale;
- Lack of capital; and
- Difficulty in obtaining software engineering skills in the country.

(This is due to competition from other sectors, particularly Amazon, where salaries are high and not affordable to the battery makers)

In terms of the local assembly in South Africa, a large proportion of the BTM battery market is mostly served by imports, with multi-disciplinary groups such as Schneider Electric and Delta Electronics being the major players in this space.

2.1.4 Vanadium Redox Flow Batteries

Bushveld Energy is the only company involved in the introduction of vanadium redox flow battery (VRFB) solutions in South Africa. The parent company is Bushveld Minerals, which also owns Bushveld Vanadium, a vertically integrated vanadium producer that operates a vanadium mine and owns two of the world's four primary processing facilities.

Bushveld Energy is in the process of constructing a vanadium electrolyte production facility in the Coega Special Economic Zone (SEZ) in the Eastern Cape. The plant will have an initial production capacity of 8 million litres per annum. Bushveld Energy is also involved in two significant energy storage demonstration projects, outlined below:

- In the first quarter of 2019, a 120 kWp, 450kWh vanadium redox flow battery was installed at the Eskom RTD (Research, Technology & Development) premises, in cooperation with the IDC. The aim was to subject the battery to an 18 month-long testing period to validate the operational performance of the VRFB system in local conditions and to demonstrate the applicability of the VRFB technology for broader commercial use in South Africa and the rest of Africa.
- A hybrid mini-grid project is being developed at the Vametco vanadium mine and processing facility, owned by Bushveld Minerals. This mini-grid comprises 3.5 MW of solar PV generation coupled with 4 MWh of VRFB energy storage. The project is intended to demonstrate the technical merits of long-duration VRFB systems when paired with renewable energy and to provide a commercial return to the company shareholders by reducing energy costs.

Bushveld is also already exploring the feasibility of establishing the manufacturing of VRFB batteries in South Africa, both for the local market and exports. To this end, the company is engaging with potential technology partners and finance providers.

From a localization perspective, it is important to note that vanadium contributes ~30% of the cost of the total VRFB system. Given South Africa's ample vanadium reserves, it is not unreasonable to expect that South Africa could achieve a local content of ~80%, with great potential for further development of this battery value chain. The Bushveld Group is particularly well-positioned to leverage synergies along the VRFB value chain through its vertically integrated nature.

Figure 9: Vametco Hybrid-Mini-Grid project by Bushveld Energy consists of a 3.5MWp solar PV plant with a 1MW / 4MWh Vanadium Redox Flow Battery to provide storage solutions.

Source: Bushveld Energy

2.2 Identification of Key Stakeholders in the Value Chain

Important stakeholders in the battery value chain, other than manufacturers and assemblers discussed above, are the project developers and EPC contractors. As a result of the highly successful rollouts of large renewable energy projects through the REIPPP Program in South Africa, this stakeholder group is already very prominent in the local energy industry. Some of the major companies in the value chain are listed below.

Table 4: LiB Downstream Value Chain Stakeholders, South Africa

Project Developers/EPC	
Enel Green Power RSA (Pty) Ltd	InnoWind EDF Energies Nouvelles
EP Solar	LTM Energy (Pty) Ltd
juwi Renewable Energies	New Southern Energy
MBHE Group (Pty) Ltd	oneSolar
Solareff (Pty) Ltd	Romano Solar (Pty) Ltd
ACDC Dynamics	Scatec Solar
ADZAM Solar (Pty) Ltd	Solar MD (Pty) Ltd
Blockpower	Solec South Africa (Pty) Ltd
Emergent Energy	Soventix
Emesco Holdings (Pty) Ltd	Sustainable Power Solutions
Enertrag South Africa	Synergy Energy Solutions (Pty) Ltd
Gransolar (Pty) Ltd	IMPOWER Solar Energy & Storage

For Front-of-the-Meter (FTM) battery applications, suitable project development and EPC capabilities exist in South Africa. Many of the above companies will likely express interests and submit bids for recently published tenders as well as any future battery storage projects, given their experience. For the smaller Behind-the-Meter (BTM) battery applications, existing battery manufacturers offer suitable installation, system integration, and servicing support services, either directly or through approved installers, particularly for more complex solutions to larger Commercial & Industrial (C&I) customers such as data centers, hospitals, and key industries.

3. Battery Market in South Africa

Globally, the advanced battery chemistry market has seen a sharp rise with increasing demand from mobile storage (electric mobility) and stationary storage applications. The market in South Africa is at the cusp of a change in terms of the demand for batteries. Among other aspects, the National Development Plan 2030 focuses on reducing CO2 emissions from the electricity sector by improving electricity supply in rural areas and across the nation. The Integrated Resource Plan 2019 (IRP 2019) focuses mainly on setting renewable energy (RE) targets in the state, expanding distributed generation, and retiring old coal power plants. To balance a large quantity of renewable power, especially solar PV and wind (both intermittent sources), they have to be supported with energy storage systems such as pumped hydro or battery energy storage systems (BESS). South Africa also released the first grid-scale energy storage tenders in 2020-21.

Countries across the globe have set electric vehicle (EV) adoption targets to reduce carbon emissions from the transportation sector. South Africa is yet to set its EV target. The report delves into the battery market potential in South Africa for both stationery and mobile (e-mobility) storage applications. Besides South Africa, the battery market potential of nearby Southern African nations such as Zimbabwe, Zambia, Namibia, Botswana, Kenya, DRC, and Mozambique are also assessed in this chapter of the Market Study report.

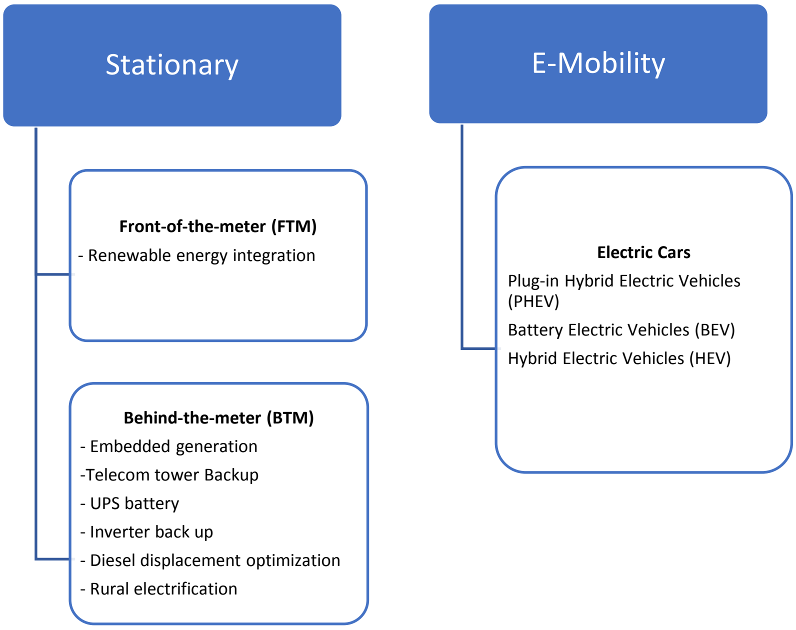
The various battery applications for the Southern African countries are analysed in the given table below:

Table 5: List of battery applications covered in Southern Africa Market

Countries/Applications	Telecom	UPS	EV	Rural Electrification	Diesel Genset	FTM
Tanzania	✓			✓		✓
Uganda			✓	✓		
Kenya	✓		✓			✓
DRC	✓					
Mozambique	✓					
Botswana			✓	✓		
Zambia				✓		✓
Namibia				✓		
Angola			✓			✓
Zimbabwe			✓			✓
SADC (16 countries) [The Southern African Development Community]		✓			✓	

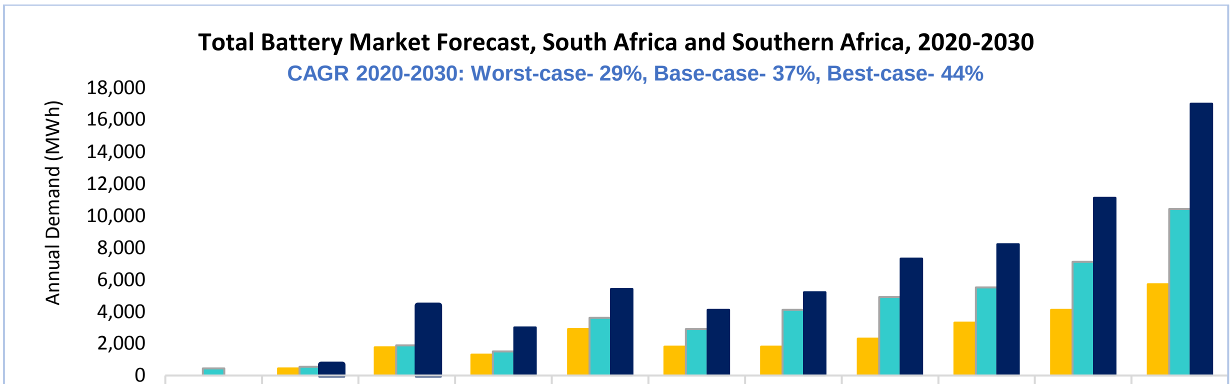
The scope of the battery market is covered in **Error! Reference source not found.**. It is broadly split into stationary and mobile (e-mobility) storage applications. Stationary applications cover front-of-the-meter (FTM) and behind-the-meter (BTM) storage installations.

Figure 10: Scope of Battery Market



Based on the analysis conducted by Customized Energy solutions (CES) for this study, in 2020, the total stationary storage battery market in South Africa and Southern Africa was estimated to be 440 MWh. This market is forecasted to grow to 10.4 GWh with a market revenue potential of USD 1 billion in 2030, see Figure 10 below. Currently, the market is purely driven by behind-the-meter (BTM) battery installations in UPS, telecom, rooftop solar, solar home lighting systems, and microgrids. The BTM segment, which is currently dominated by lead-acid batteries in South Africa, is going to provide opportunities for other advanced chemistries such as Lithium-ion and Flow battery technologies. Moreover, this advanced chemistry penetration with lithium-ion batteries is already being adopted in telecom towers and solar home lighting systems. The BTM segment forecast considers all regulations and trends including a recent update on the lifting of the capacity limit on small-scale embedded generation (SSEG) from 1 MW to 100MW in South Africa.

Figure 11: Total Battery Market Forecast, South Africa & Southern Africa, 2020-2030.

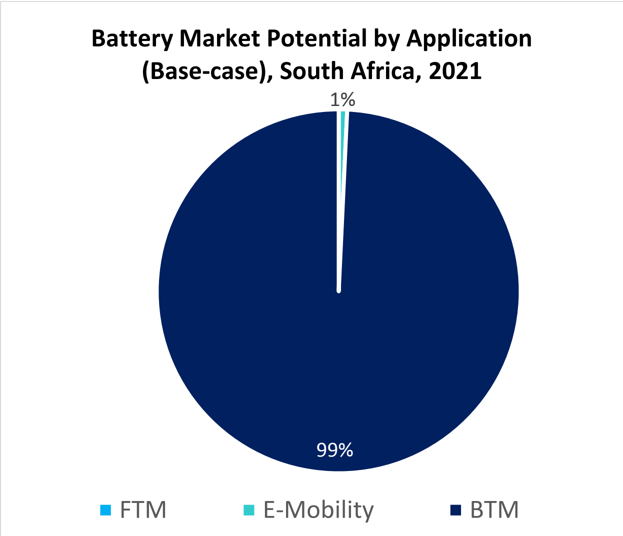


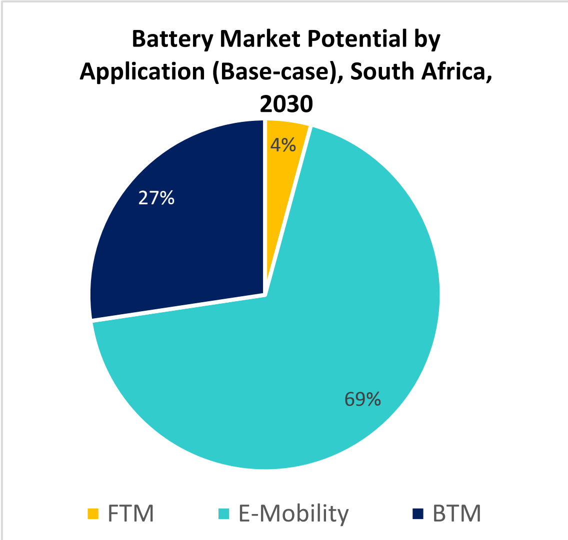
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Worst-case		450	1,760	1,300	2,900	1,800	1,800	2,300	3,300	4,100	5,700
Base-case	440	540	1,890	1,500	3,600	2,900	4,100	4,900	5,500	7,100	10,400
Best-case		680	4,370	3,000	5,400	4,100	5,200	7,300	8,200	11,100	17,000

Source: CES Analysis

Despite the spur in demand from the stationary storage segment, the requirement from this segment will only be around 31% of demand compared to mobile storage batteries needed in the e-mobility sector in the region by 2030. An EV policy aimed at faster adoption of electric transport has not been formulated in South Africa yet, however the rapid declines in battery prices and fast improving economics in this segment will drive the demand post-2027. In Figure 12**,** the South Africa battery market is split by segments. The market for front-of the-meter (FTM) and the electric vehicle segment, which is expected to grow from 1% in 2021 to 69% by 2030.

Figure 12: Battery Market Potential by Application, South Africa, 2021 and 2030.





Source: CES Analysis

In the Southern African countries, the battery demand stood at 170 MWh in 2020. This was predominantly for power backup applications in telecom, UPS, solar home lighting systems, and microgrids. The battery market is expected to grow to 1.5 GWh by 2030. The demand for grid-scale energy storage (FTM) is expected to accelerate post-2027, and EV adoption is likely to pick up by 2026.

3.1 South Africa Storage Policy Analysis

3.1.1 FTM storage market policy analysis

FTM storage market is driven by policies and targets set by the governments to support greenhouse gas (GHG) emission reductions by reducing dependence on polluting peak power plants etc. In South Africa, the government has set FTM storage targets to support RE power integration into the grid and to improve grid stability under the Integrated Resource Plan 2019.

South Africa: Integrated Resource Plan 2019[2]

South Africa's **National Development Program 2030** focuses on providing reliable and efficient energy service at competitive rates that is environmentally sustainable. For achieving this vision, the **Integrated Resource Plan (IRP)** document was promulgated in 2010 and the latest revision was finalized and ratified by the cabinet in October 2019. **According to the 2019 IRP, the renewable energy target of the country is set at 26 GW by 2030**. The total installed capacity is expected to reach around 80 GW and the renewable penetration in installed capacity is expected to be 31%.

Table 6: South Africa, Integrated Resource Plan 2019

	Coal	Coal Decommission	Nuclear	Hydro	Storage	PV	Wind	CSP	Gas & Diesel	Others (District, Cogen, etc.)
Current Base (IRP 2019)	37149		1860	2100	2912	1474	1980	300	3830	499
2019	2155	-2373					244	300		Allocation as per short term capacity and energy gap
2020	1433	-557				114	300			
2021	1433	-1403				300	818			
2022	711	-844			513	400, 1000	1600			
2023	750	-555				1000	1600			500
2024							1600		1000	500
2025						1000	1600			500
2026		-1219					1600			500
2027	750	-847					1600		2000	500
2028		-475				1000	1600			500
2029		-1694			1575	1000	1600			500
2030		-1050		2500		1000	1600			500
Total Inst. Capacity by 2030 (MW)	33364		1860	4600	5000	8288	17742	600		
% of Total Installed Capacity by 2030	43		2.36	5.84	6.35	10.52	22.53	0.76	8.1	
% Energy Contribution (% of MWh)	58.8		4.5	8.4	1.2	6.3	17.8	0.6	1.3	

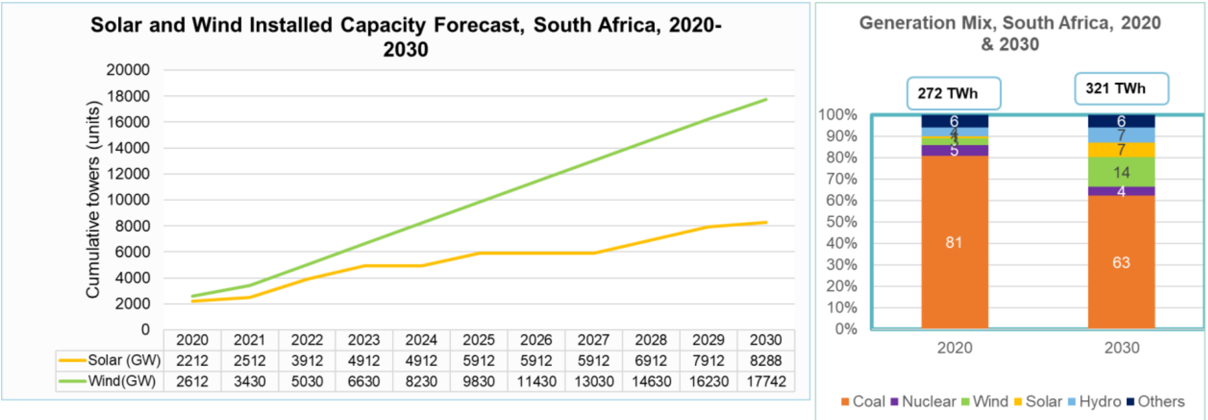
- Installed Capacity
- Committed/Under Construction
- Planned Coal Decommissioning
- New Additional Capacity
- Includes Capacity for Self-Use

Source: IRP 2019 document

[2] South Africa- Department of Energy, Integrated Resource Plan (2019)

The document mentions the allocation of 2 GW of energy storage on the grid-side for addition of renewables and grid support. This has already provided the market with a growth impetus in the form of several storage tenders in 2020 and 2021.

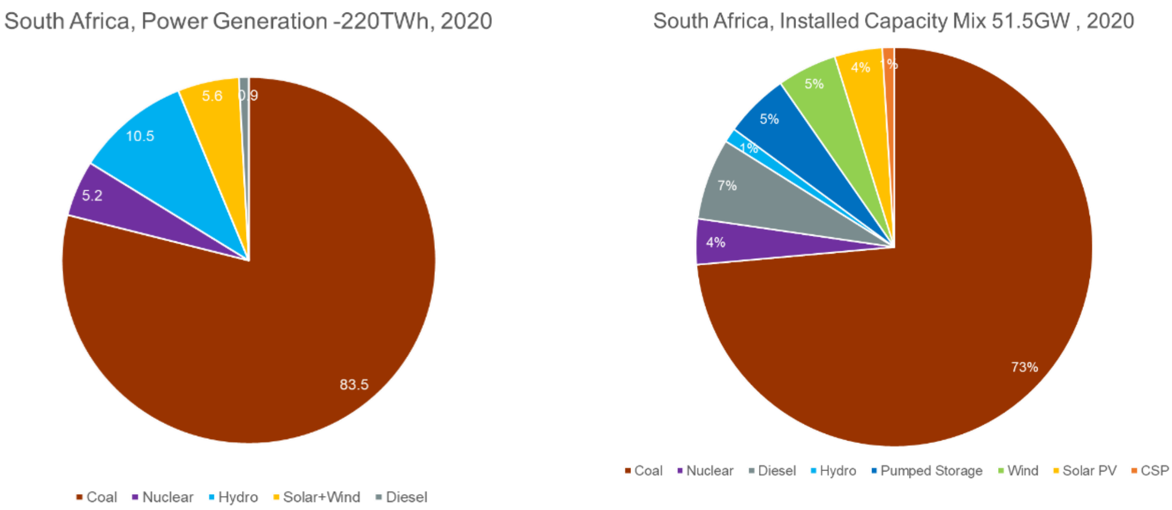
Figure 13: Renewable Energy Forecast, South Africa (IRP), 2020-2030



By 2030, renewable energy through intermittent sources of power especially solar and wind will account for nearly 31% of the installed capacity. To balance this intermittent power, there is a requirement for flexible resources on the grid such as gas, hydro, pumped hydro, and battery storage plants. Presently, there is 2.9 GW of pumped hydro storage in the country. **The IRP 2019 advocates an additional 2GW of storage by 2030**. The coal power capacity in the country stood at 37 GW in 2019; by 2030, 10 GW of coal power plants will be decommissioned as they reach their end-of-life stage. These plant decommissioning will also trigger a shortage in power generation capacity to meet future electricity demand.

Present Scenario: From the supply-side, in 2020[3], around 723 MW of coal, 415 MW of wind, and 558 MW of solar PV became operational in the country. The total installed capacity hit 51.5 GW and the total generation in 2020 was 220 TWh. However, annual electricity production in the country has been reducing since 2018, from 241 TWh in 2018 to 220TWh in 2021. This is due to scheduled maintenance and unscheduled outages in the grid which has led to reduced production of power.

Figure 14: Installed Generation Mix and Capacity Mix, South Africa, 2020.



[3] Eskom, CSIR- Annual Power Sector Statistics (2021)

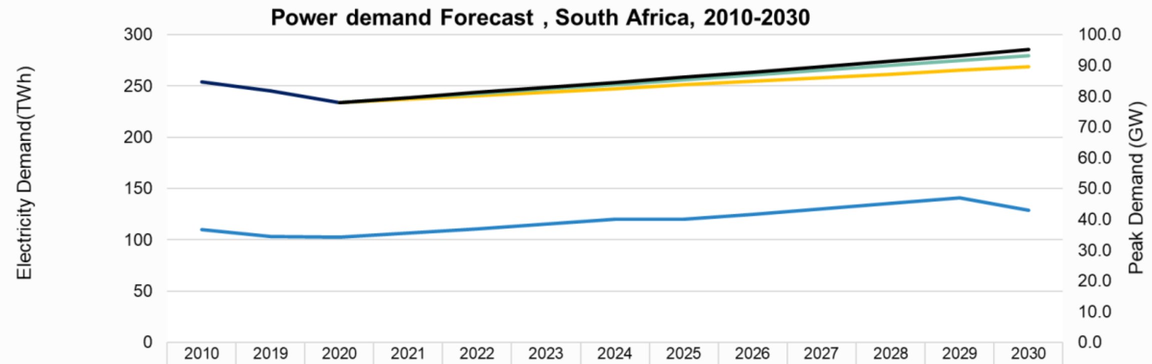
Source: Eskom

South Africa: Power System Demand Forecast 2030

From the demand side, from 2010 to 2020, the power demand in the country dropped by 0.4% y-o-y. IRP 2019 forecasts the power demand to grow in three scenarios as listed in Figure 15 below.

In the high scenario, the expected y-o-y growth is at 2%, the median scenario at 1.8%, and the low scenario at 1.4% till 2030.

Figure 15: Power Demand Forecast, South Africa 2010-2030.



	2010	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Low	254	245	234	237	241	244	247	251	254	258	262	265	269
Median			234	238	242	247	251	256	260	265	270	275	280
high			234	239	243	248	253	258	264	269	274	280	285
Peak demand GW	36.7	34.5	34.2	35.6	37.0	38.5	40.0	40.1	41.7	43.4	45.1	46.9	43.0

Source: CSIR, South Africa, Eskom

Risk Mitigation IPP Procurement Program (RM-IPPPP):

Currently, Eskom is facing challenges in maintaining supply-demand balancing. Around 870+hours of load shedding was recorded in 2020. The Risk Mitigation IPP Program was designed to solve this issue immediately. In March 2021, under the RM-IPPPP, 1845 MW was awarded to 8 bidders, and power purchase agreements (PPAs) for 20-years were signed with each of them. The technologies bid was a combination of LNG, solar+storage, wind+solar+storage, and LNG+solar. Out of 1845 MW of capacity awarded in Risk Mitigation tender, 428 MW was awarded to RE plus storage under 20 year PPA. The market for the FTM (front-of-the-meter) segment for stationary storage in South Africa is set for an early boom in addition to the targets established in the IRP-2019. The first such opportunity lies with the requirement for augmenting flexible assets to meet the mandate for the emergency power requirement.

The IRP mentions around 2 GW of storage to be built under the emergency power mandate. From this 2 GW total, 1.2 GW was to be procured from liquid natural gas (LNG) from Turkey through ships docked at a local South African port with built-in gas-fired generators on board. The future of this tender is unclear at present as there have been challenges with conducting the Environmental Impact Assessments' (EIA) including obtaining approvals and clearances. There is a strong likelihood that this current gap would be filled by substituting the LNG capacity with new renewable energy (RE) capacity paired with stationary storage solutions. These new market opportunities including changes in existing regulations and their impacts are detailed in the market potential section of this report.

Furthermore, for the FTM segment, the demand for large grid-scale energy storage in South Africa is evolving rapidly and is likely to go beyond 2 GW of grid-scale battery storage systems mentioned in the IRP targets for the period between 2020 and 2030. Thus, the grid-scale batteries would come into play as the RE penetration increases in the South African electricity grid through the REIPPP Program.

3.1.2 BTM storage market policy analysis

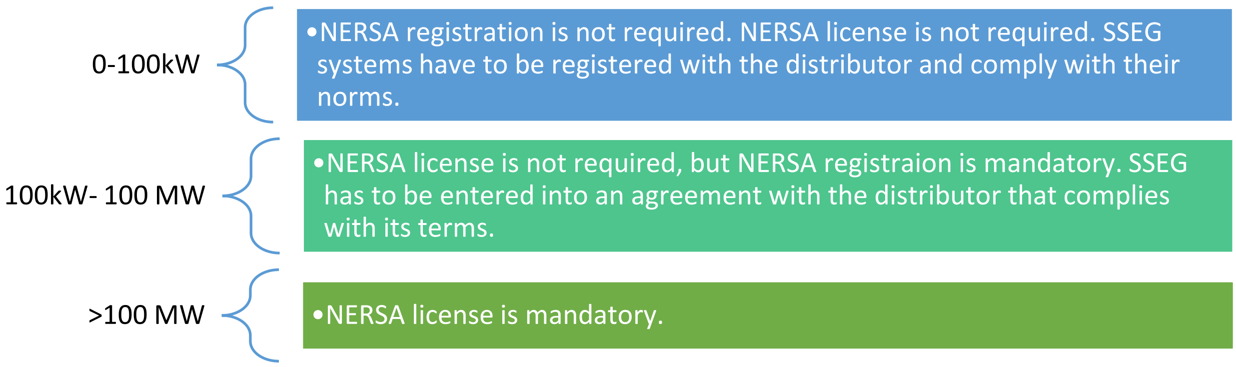
In South Africa, the BTM batteries are being installed by residential as well as commercial and industrial (C&I) customers as backup power. The consumers face 2–4-hours of daily load shedding which is driving demand for power backup systems such as UPS, solar-plus-battery, and diesel generation sets (DG sets). The policies driving the BTM market are aimed at increasing the distributed renewable energy generation in the country. For distributed generation, the Small-Scale Embedded Generation (SSEG) regulation and the Distributed Generation Target for 2030 are key policies that guide this market.

Distributed Generation Target 2030:

The IRP 2019 document highlights the role of renewable power within the 'distributed generation' category as given in Table 6 (last column). Under the category of 'distributed generation', the IRP 2019 has allocated a target addition of 500 MW annually between 2023 and 2030. The distributed generation accommodates 1MW to 10 MW of renewable power projects. Although, small-scale embedded generation of below 1 MW has not been included in this section, there exist a strong market with an installed capacity of around 700 MW in this segment.

Small Scale Embedded Generation: Licensing Exemption and Registration notice (June 2021)

The National Electricity Authority of South Africa (NERSA) has laid down conditions that specify SSEG license registration and exemptions.



Source: NERSA

Until April 2021, all SSEG above 1 MW required obtaining a NERSA license for grid integration. On August 12th, 2021, the Ministry of Mineral Resources and Energy released the exemption which raises registration threshold for self-generation facilities from 1 MW to 100 MW.

Impact of the new regulation: The regulation is expected to open the SSEG market extensively in the country, which is plagued with high electricity tariffs and load shedding of up to 4-hours daily. Based on an industry survey[4] by Meridian Economics to gauge the interest of the participants towards renewable generation, it was

[4] Meridian Economics: scoping interest in the South African distributed energy generation sector, Jan 2021

concluded that an additional 5000 MW of distributed generation (above the IRP target) is expected to be connected to the grid if the NERSA licensing cap is lifted even up to 50 MW.

Feed-In-Tariffs for Distributed Generation: National Electricity Regulator of South Africa **(NERSA)** has approved tariffs to customers feeding self-generated power into the municipal distribution network. As of June 2020, of the total 165 municipal distributors, 56 allow SSEG into their networks. Furthermore, NERSA has structured a legislative framework to facilitate SSEG rollouts at the municipal level. This system has been a notable driver for the distributed generation market growth in South Africa.

Rural Electrification policy: The rural electrification access rate in South Africa was 91% in 2020 and the target is to achieve a 100% access rate by 2030. Currently, Eskom (national utility) and the **DMRE** play a key role in the development and operation of mini grids in South Africa. With Eskom controlling more than 90% of the total electricity supply in South Africa, it has a major role in the development of rural electrification as well. The plan for rural electrification in the country is thus through grid expansion rather than the independent development of mini grids. Solar Home Systems (SHS), however, is the more popular choice for off-grid rural electrification, especially for household lighting.

The South African government launched the 'Off-grid Solar Home System Programme'[5] at the start of the 2010-2020 decade which aimed to electrify all formal households in the country by 2025. The objective of the SHS programme was to provide energy access to remote areas far from the national grid which is technically and/or economically difficult to electrify. This programme was revitalized in 2013. However, there have been no additional updates after 2013.

3.1.3 E-mobility market policy analysis

The **South African Automotive Masterplan (SAAM)** will be applicable in South Africa from 2021-2035 to support the domestic automotive industry. SAAM covers all types of vehicle segments and the South African component supplier industry. In addition to the above, SAAM also covers vehicle importers and distributors. As per the masterplan-

- SA's vehicle production (all drivetrains included), which is currently 0.69% is to be 1% of global output by 2035.
- Local content for vehicles assembled in South Africa is to be increased to 60%, from 38.7%.
- Incentives for EVs and hybrids are expected by this scheme. However, incentives are subject to approval by National Treasury only.
- South Africa is considering a special tariff regime to be established across all vehicle segments, including EVs. This can address the challenges that arise due to high import duties.

In line with SAAM, the **Department of Transport (DoT)** has developed a **Green Transport Strategy** (2018-2050). It aims to minimize the impact of transport on the environment by meeting current and future transport demands. Under this strategy, DoT will offer incentives for the manufacturing and sale of EVs for both the local and export markets. Furthermore, DoT will support research in EV batteries. Most importantly, the strategy states it will introduce technology to retrofit current ICE vehicles into electric vehicles (by

[5] GNESD Energy Access Knowledge Base: Off Grid SHS Program South Africa

replacing the engine and ancillary components with an electric motor, battery, controllers, etc suitable for an EV), by providing incentives related to the beneficiation of using local resources.

3.2 South Africa Storage Market Forecast

South Africa and Southern Africa battery markets are forecasted for the period 2021 to 2030. The forecast is covered under three scenarios namely: **best-case**, **base-case**, and **worst case**.

Base-case: For this scenario, each of the market sub-segments is studied for a historical 3–5-year period to understand the market growth trend. This growth trend is then corrected to accommodate the new policy or regulations adopted in the country to estimate the new growth trend during the forecast period. The FTM segment projection is based on the project pipeline, existing regulations, and targets set under the IRP-2019 document.

In the BTM and e-mobility segments, during the **short term (1st to 3rd year)** of the forecast period, the growth trend is based on factors such as historical trend, GDP growth, and the impact of new regulations driving the market.

For the **mid-term period (4th to 6th year)**, techno-commercial analysis is performed to analyze battery penetration in various applications such as telecom, solar PV + storage, e-mobility, etc.

In the **long-term period (7th to 10th year)**, the price drop expected in lithium-ion battery chemistry is higher, resulting in greater penetration in the BTM segment, and higher penetration of electric vehicles in the market.

Best-case: In this case, the market is forecasted to grow at a higher growth rate than the base case. The factors considered in this case are:

- Higher economic growth in the country as projected in the IRP-2019 document affects the overall C&I sector growth.
- Impact of existing and latest policies and regulations that drive the battery market.
- A faster price drop is expected for lithium-ion batteries resulting in higher penetration of batteries (than base case) in BTM segments, and high electric-vehicle penetration in the country.
- FTM market is not just restricted to the target set for storage in the IRP-2019 document, but other opportunities such as LNG replacement, the impact of RE-IPPPP 5 bid window amendment (detailed in **section 3.1.1**), etc.

Worst-case: An approach conservative than base-case is applied in this scenario, where a lower economic growth is forecasted (annual GDP growth of 1.33%) till 2030. Some of the assumptions chosen are:

- FTM storage is restricted to addition as per the IRP-2019 document.
- Lithium-ion battery price drop is expected to be conservative, which results in lower penetration of Li-ion batteries in the BTM segment.
- Lower penetration of electric vehicles in the country and across countries in Southern Africa region

The section also estimates the potential of Lithium-ion batteries in these markets. Section 3.3 is dedicated to the global battery market. It covers the advanced chemistry potential, globally, and the key battery raw material demand projections till 2030.

Cumulative Battery Potential in 2021-2030 (base-case) - 42 GWh (100%)

South Africa Market 2021-2030 - 38 GWh (90%)

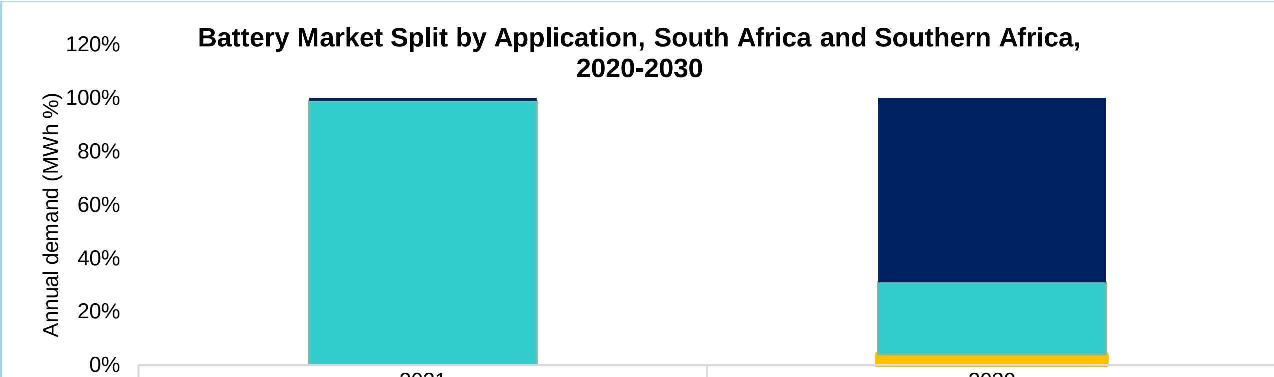
- E-mobility - local + exports - 42%
- BTM (34%)
- FTM (24%)

Southern Africa Market in 2021-2030 - 4 GWh (10%)

- BTM (65%)
- FTM (35%)

Figure 16 depicts the cumulative battery demand from 2021 to 2030 split between South Africa and Southern Africa. In South Africa, the potential of e-mobility batteries is highest at 42%.

Figure 16: Battery Market Split by Application, South Africa, and Southern Africa, 2021-2030.



	2021	2030
EV	1%	69%
BTM	99%	27%
FTM	0%	4%

Source: CES Analysis

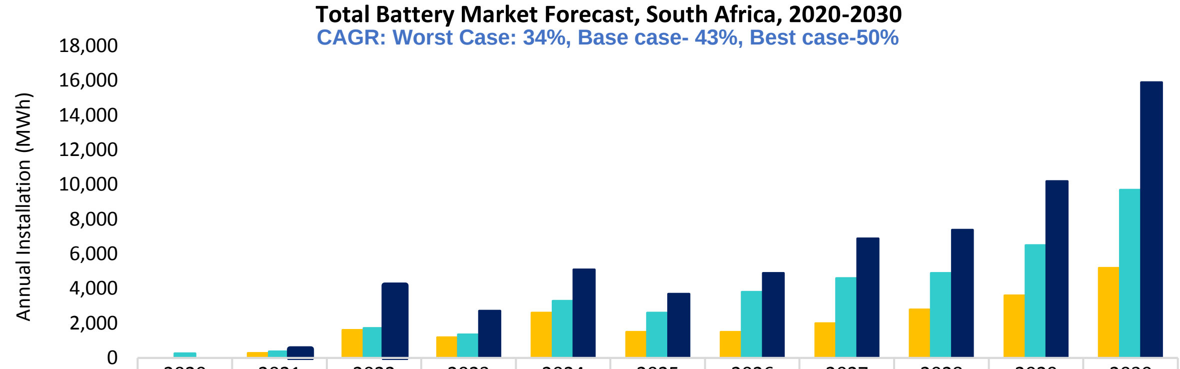
In the FTM segment, based on several storage tenders released and closed in 2021, the installations are expected to grow in 2022. As per IRP- 2019 document, the storage addition is expected to be 2 GW between 2021 and 2030. This addition is considered in all three forecast scenarios.

In 2020, the BTM segment contributed 270 MWh towards the total battery market; UPS and telecom applications were the major contributors. In June 2021, the Department of Mineral Resources and Energy (DMRE), announced the lifting of the licensing cap for SSEG allowing grid integration of renewable plants up to 100 MW (see section 2.4). The impact of this regulation on storage penetration in the embedded generation is expected to be significant. This trend is analyzed and included in the three forecast scenarios.

Other C&I sectors contributing to the battery market until 2030 are forecasted to grow as per the GDP rate projections provided in the IRP 2019. The impact of this is reflected in battery market sub-segments- telecom, UPS, embedded generation from C&I, and diesel optimization.

In the e-mobility segment, three EV penetration scenarios are considered for South Africa, in the absence of a concrete EV Target set by the government.

Figure 17: Total Battery Market Forecast in South Africa, 2020-2030.



	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Worst-Case		290	1,620	1,180	2,600	1,500	1,500	2,000	2,800	3,600	5,200
Base-Case	270	380	1,730	1,360	3,300	2,600	3,800	4,600	4,900	6,500	9,700
Best-Case		500	4,180	2,710	5,100	3,700	4,900	6,900	7,400	10,200	15,900

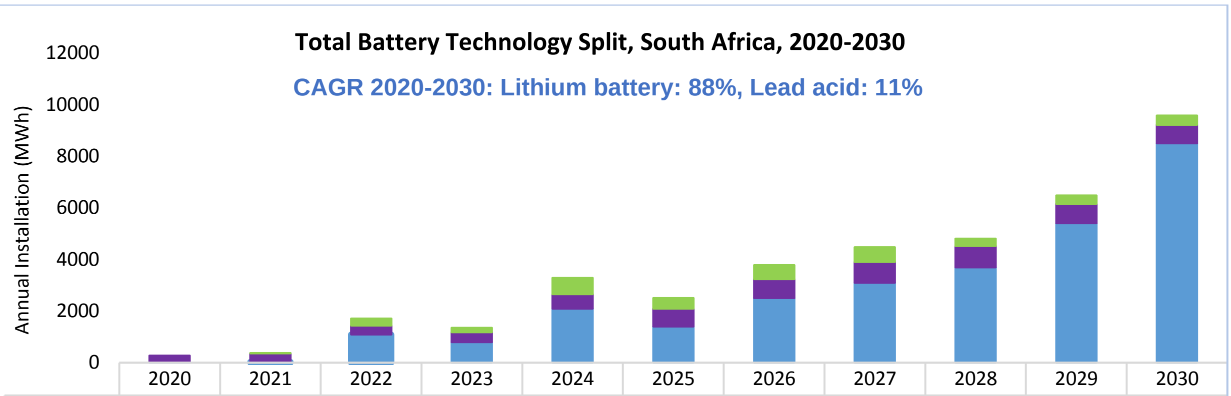
Source: CES Analysis

Technology Split: The South Africa battery technology split is covered Figure 18. In terms of the technology split, lead-acid chemistry drives the market during 2020 and 2021. The BTM segment predominantly uses the lead-acid type of batteries. Presently, the penetration of lithium-ion chemistry is <10% of the BTM segment. With the price of this chemistry dropping year-on-year, it is expected to meet cost parity with the lead-acid chemistry by 2025-26. Besides, the techno-commercial viability of the chemistry is proved for the BTM applications such as embedded generation, diesel optimization, and telecom towers. Due to these reasons, we expected lithium-ion penetration to hit up to 60% by 2030 in the BTM segment.

Lithium-ion (Li-ion): By 2022, the FTM segment will be driven by renewable integration and grid-side projects which are likely to push demand for advanced battery chemistries such as Lithium-ion batteries, flow batteries, etc. The lithium battery market is forecasted to grow at a Compound Annual Growth Rate (CAGR) of 88% during 2020-2030. Beyond 2025, however, the e-mobility segment (mobile storage) also kicks off and by 2030, the segment is expected to constitute nearly 70% of the Li-ion battery demand in South Africa. Throughout the report, the technology split is done for the base-case scenario, where business-as-usual is the focus.

Vanadium Redox Flow Battery (VRFB): This chemistry is expected to be installed in rural or remote microgrids, and for long-duration battery storage requirements in the FTM segment. When the penetration of variable renewable power (solar PV, wind, solar CSP) increases above 20% (of the installed capacity) in the power grid, the need for long-duration storage of 4-6 hours is essential to balance the grid. Hence, flow batteries and other long-duration battery chemistries are, therefore, expected to grow in the market in the future to up to 4% market share of total battery market by 2030.

Figure 18: Total Battery Technology Split, South Africa, 2020-2030.



	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Others	0	11	268	172	630	410	550	570	280	320	360
Lead Acid	260	330	350	390	550	700	730	800	830	760	720
LiB	15	30	1090	790	2100	1400	2500	3100	3700	5400	8500

Others include Vanadium redox flow battery and other long duration batteries.

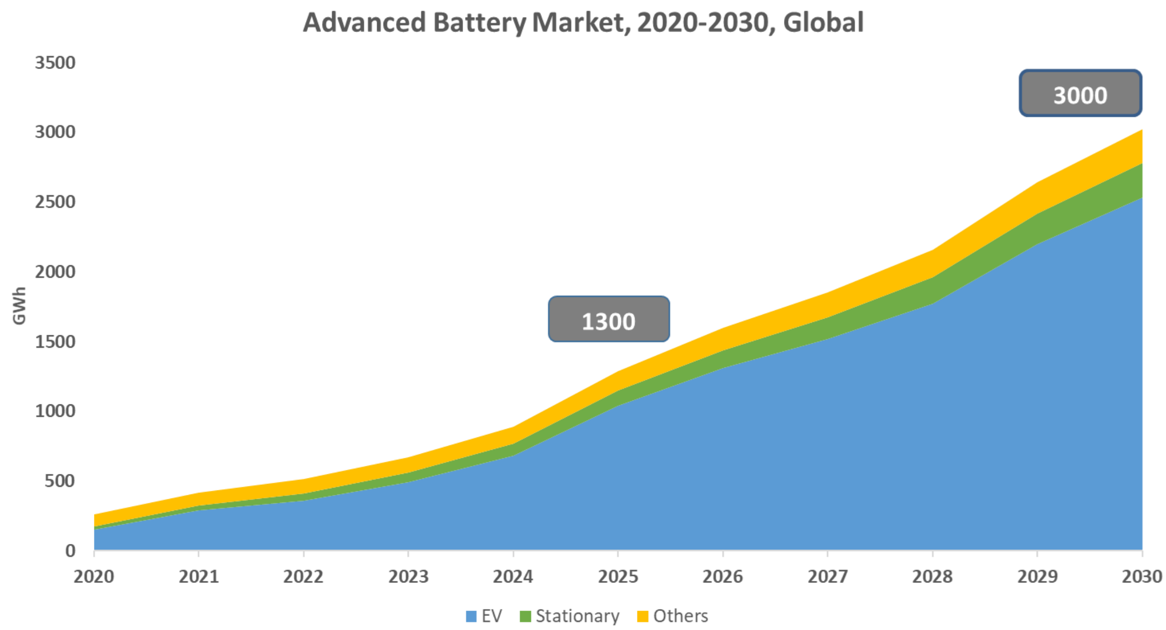
Source: CES Analysis

3.3 Global Total Battery Market

Global advancements in the battery market have got a push with a steady up-tick in demand for electric vehicles in various geographies. Drivers for advanced battery technologies have spurred demand for stationary storage in both FTM and BTM C&I applications like data centers, telecom towers, and rooftop PV. Combined demand for advanced battery technologies across the world surpassed 100 GWh in 2019 and was over 175 GWh in 2020 for EV and stationary storage applications. Considering applications like power tools, electronics, and other gadgets, demand for advanced batteries in 2020 would have surpassed 270 GWh. The global automobile market in 2020 witnessed over 3% EV penetration and the European electric car market witnessed 8% penetration. China and Europe are likely to be the early growth engines for the EV sector since most of the carmakers in these markets are eyeing close to 25% EV penetration by 2025. Apart from China and Europe, the encouraging Biden Climate Policy of 50% carbon emission reduction by 2030 (w.r.t 2005 levels) will also result in massive EV and ESS demand in the short term. As shown in

Figure 19, global demand for advanced batteries is likely to grow by a CAGR of 25% in the coming decade. The total market is likely to be at 1300 GWh by 2025 and 3000 GWh by 2030 based on CES analysis of global battery demand for advanced chemistries in 2021. The other applications in the following chart include power tools, electronic gadgets, etc.

Figure 19: Global Advanced Battery Market Forecast, 2020-2030.

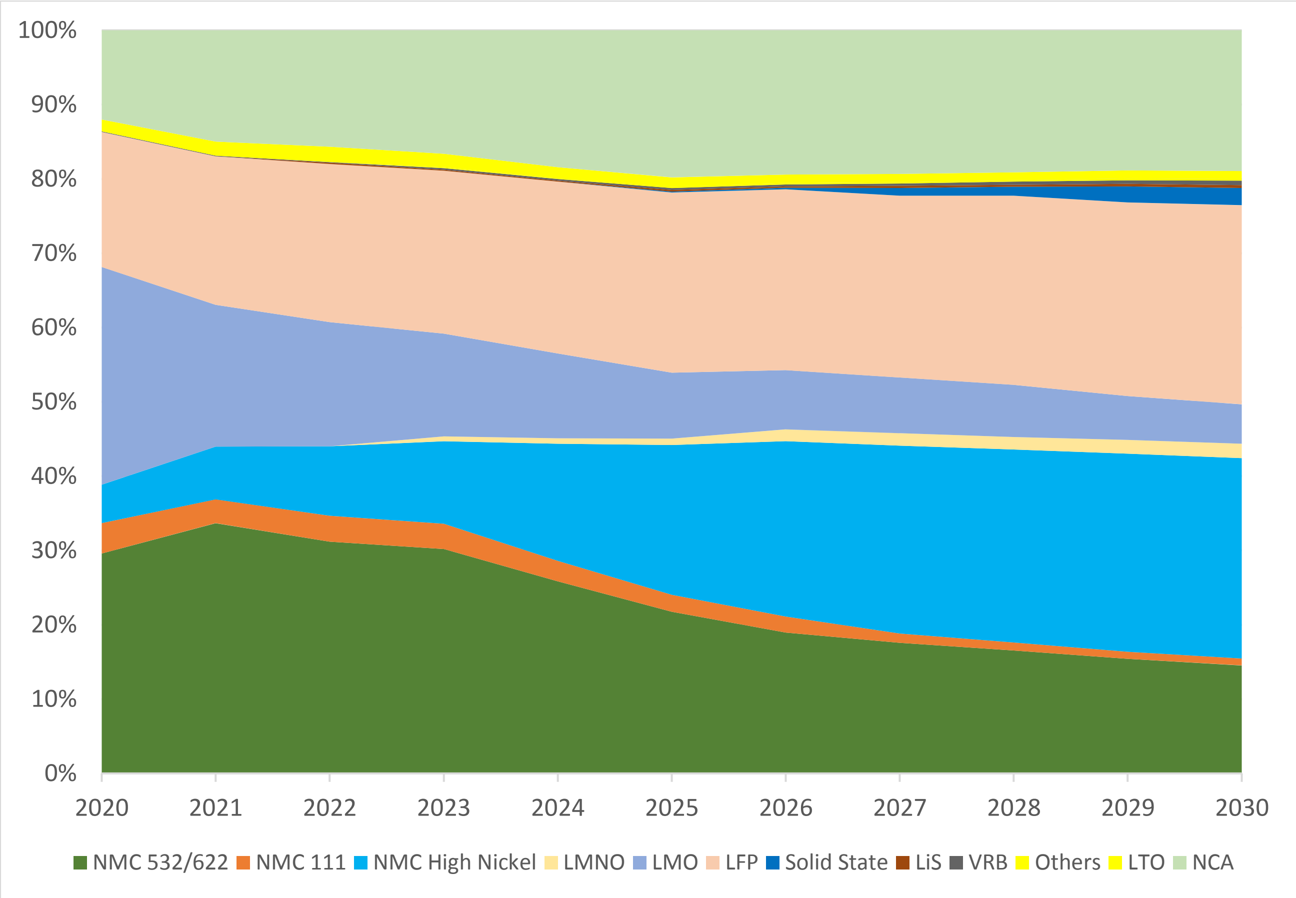


Source: CES Analysis, SNE Research, AB Bernstein

To support this market growth, there are announcements of over 4000 GWh of manufacturing capacity by 2030. Most of the plants would be set up in Asia, especially in China. However, with President Biden's *Make in America* and Europe's strategic push for localization of battery supply chains, over 1500 GWh of capacity is likely to come from Europe and North America, with almost a 60-40% split between the respective continents.

It will not be easy to predict the technology split for the batteries in the mid-term future. However, investments in cathode suppliers, cell manufacturers, and car OEMs have showcased that the market is moving towards batteries with high energy density and faster charging capabilities. For stationary applications, the market is moving towards higher cycle life and long-duration batteries as RE penetration in the grid increases. The technology split can be seen in Figure 20. Dominant technologies like NMC 532/622 and LFP might witness a decline after 4-5 years, but they are going to hold a solid market share in the foreseeable future.

Figure 20: Technology-wise Split of Advanced Battery Chemistry, 2020-2030.

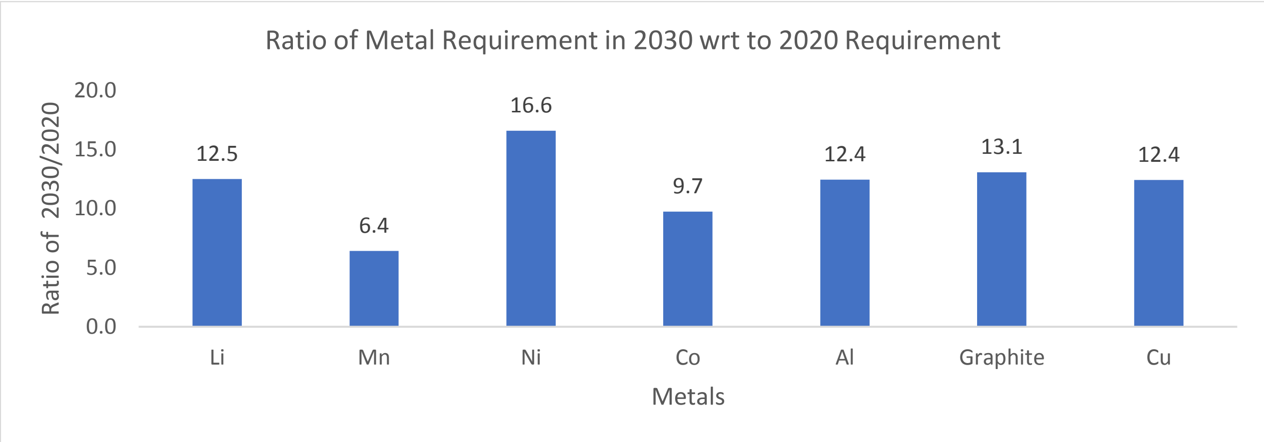


Source: CES Analysis

Global experts have indicated that for Lithium-Ion batteries, nickel-rich cathode chemistries (NMC and NCA and blends of both), combined with increased silicon content in the anode, will enable further energy density and cost improvements. In addition, the market consensus of moving to low cobalt chemistries will also result in these two Li-ion chemistries gaining a significant market share by 2030. The NCA Lithium-ion chemistry will continue to grow as its adoption by major EV manufacturers such as Tesla, BMW, and VW increases. However, the current mainstream technology, NMC 532/622 will continue to dominate the market before the high nickel chemistries begin to rule the market from 2024 to 2026. On the contrary, cobalt-rich chemistries such as LCO and NMC 111 will continue to lose their market share due to the high costs associated with cobalt.

Industry announcements suggests that next 5-10 years may see an increase in solid-state batteries with fully/semi-dry electrolyte chemistries gaining marginal market share although mass production of solid-state batteries for EVs will most likely not reach commercial-scale production until 2030. In addition, as innovative technologies such as Blade cell (BYD) and Cell to Pack (CATL) come to market, the share of LFP batteries (an alternate Li-ion battery chemistry) is expected to grow on account of being adopted by more passenger BEV, suggesting LFP would hold on to its market share as it will continue to dominate the e-bus market due to its low cost.

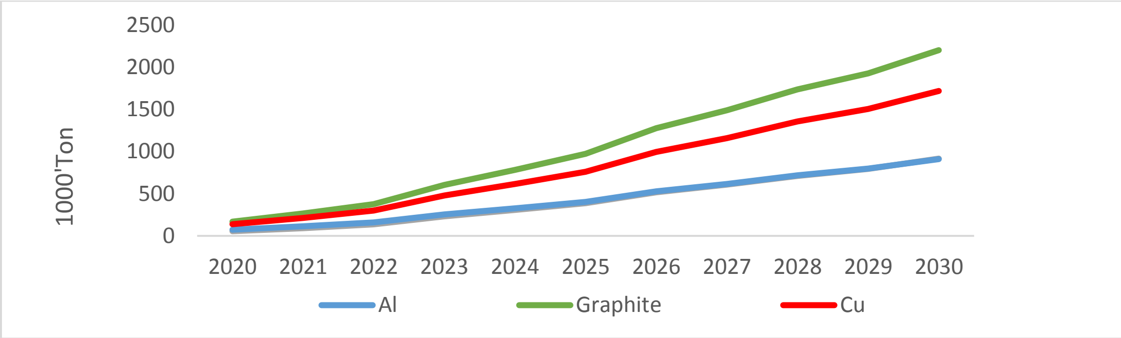
Further, chemistries such as LMO/LTO shall grow in the next 10 years owing to applications in low-priced BEV, PHEV, and HEVs. The Research and Development (R&D) efforts into the utilization of cheaper materials (high Mn NMC, Sulphur) for cathode materials should see a marginal increase in their market share over the next 10 years.The Li-ion battery market is expected to grow 12 times between 2020 and 2030. This will likely lead to higher demand for all the metals in different ratios. Of all these metals, the requirement for nickel is going to grow the fastest as seen in Figure 21**Error! Not a valid bookmark self-reference.** and the growth for cobalt (Co) would be slower as most of the higher energy density chemistries are moving to cathodes with higher nickel content at the expense of lower Co. The growth of demand for Manganese (Mn) will depend upon the uptake of the newer chemistries like LMNO and NMCA. **Error! Not a valid bookmark self-reference.**Figure 21: Ratio of Metal Requirement in Li-Ion Cell in 2030 w.r.t to the requirement in 2020.



Source: CES Analysis

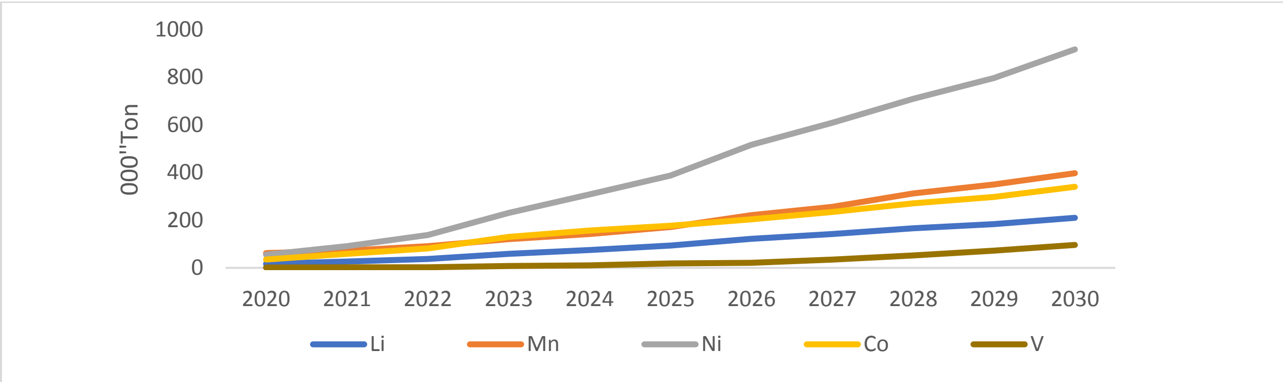
In absolute terms, as per CES analysis, the requirement for graphite, copper, and aluminum will be highest followed by other metals as shown in the figures that follow. Adoption of high nickel chemistries is the trend aimed at increasing energy density and shall result in a 16-17-fold increase in its demand as the Lithium-ion battery manufacturing sector steps away from its dependence on cobalt and the bottlenecks around its supply chain. As mentioned above, NCA chemistries are expected to hold a significant market share, especially in the EV market, and would result in a 13-fold increase in demand. Some of the future requirements for metals and precursors would also be done through recycled materials. The contribution of recycling materials after 2025 is likely to take the pressure off mining activities and the requirement for virgin metals and precursors might have slower growth than as shown in figures below.

Figure 22: Requirement of Different Metals for Advanced Chemistry Batteries I.



Source: CES Analysis

Figure 23: Requirement of different metals for advanced batteries II.



Source: CES Analysis

4. The Case for Battery Value Chain Development in South Africa

This chapter explores the positioning of South Africa with regards to the different value chain segments (up-stream, mid-stream, down-stream), and their relative strengths, weaknesses, opportunities, and threats (SWOT Analysis). As such, the chapter analyzes market opportunities and the potential to establish value chain segments in South Africa coupled with broad strategic guidance on policy, sector, regulatory, and investment support frameworks.

4.1 Value Chain Overview

This section provides a brief overview of the value chains for lithium-ion (LIB) and vanadium redox flow (VRF) batteries, which are the most important and relevant battery storage technologies for South Africa.

4.1.1 Global Players in Battery materials mining and processing

The global distribution of reserves and production of key battery materials is summarised in Table 7. It will be seen that in all cases, only a few countries hold the largest mineral reserves and account for the bulk of world production. African countries (highlighted in bold) feature strongly in cobalt (DRC), manganese (South Africa), bauxite (Guinea) and, to some extent, graphite (Mozambique), and vanadium (South Africa).

Table 7: Global reserves and production of battery minerals[6]

Minerals	World Reserves (metric tons)	World Production in 2020 (est.) (metric tons)	Location of Reserves and approximate percentage values by country per global reserves)	Countries with the highest Global Production in 2020 (metric tons)
Lithium (LCE)	21 million	82 000	- Chile (43%) - Australia (22%) - Argentina (9%) - China (7%)	- Australia (40,000) - Chile (18,000) - China (14,000) - Argentina (6,200)
Cobalt	7.1 million	140 000	- **DR Congo (51%)** - Australia (20%) - Cuba (7%) - Philippines (4%)	- **DR Congo (95,000)** - Russia (6,300) - Australia (5,700) - Philippines (4,700)
Nickel	94 million	2 200 000	- Indonesia (22%) - Australia (21%) - Brazil (17%) - Russia (7%)	- Indonesia (760,000) - Philippines (320,000) - Russia (270,000) - New Caledonia (220,000)
Manganese	1.3 billion	18 500 000	- **South Africa (23%)** - Ukraine (11%) - Brazil (9%) - Australia (7%)	- **South Africa (6,200,000)** - China (3,000,000) - Australia (2,900,000) - **Gabon (1,800,000)**

[6] In metric tons of ore unless otherwise indicated

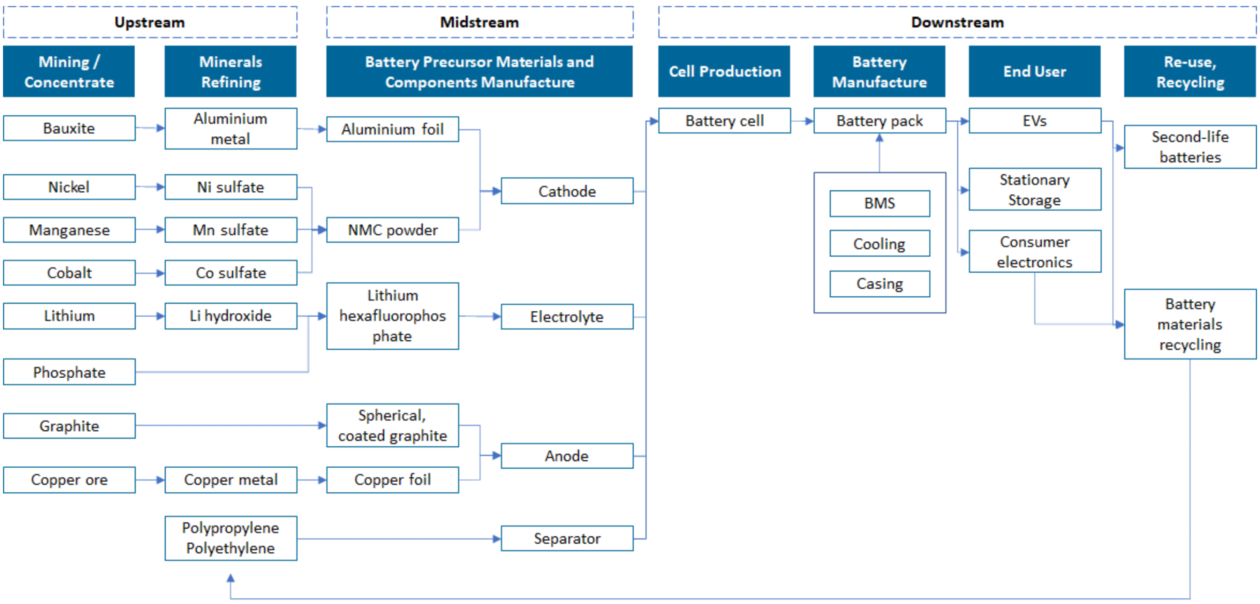
Graphite (natural)	320 million	1 200 000	- Turkey (28%) - China (23%) - Brazil (22%) - **Mozambique (8%)**	- China (650,000) - Brazil (95,000) - **Mozambique (47,000)** - India (34,000)
Bauxite	30 billion	371 000 000	- **Guinea (25%)** - Oceania (23%) - South America and Caribbean (21%)	- Australia (110,000,000) - **Guinea (82,000,000)** -
Vanadium (metric tons contained metal)	20 million	75 000	- China (46%) - Russia (26%) - **South Africa (18%)**	- China (60%) - Russia (17%) - **South Africa (7%)**

Source: LHA analysis

4.1.2 Lithium-Ion Battery

A generalised LIB value chain can be conveniently structured into up-stream, mid-stream, and down-stream activities (Figure 24). In this context, upstream activities include the mining and refining of battery minerals where the mining stage produces mineral concentrates while the minerals refining stage produces refined precursor materials to the required battery qualities and purities.

Figure 24: Generalised LIB value chain



Source: LHA

Lithium precursor materials include lithium carbonate and lithium hydroxide, which are extracted from lithium brines and from spodumene hard rock deposits. Lithium brines are found mainly in the salt flats of Chile, Argentina and China, while the most notable spodumene deposits occur in Australia, China and the USA. In Southern Africa, the largest spodumene reserves are located in Zimbabwe[7], while the Democratic Republic of Congo (DRC) also has significant deposits. These precursors come from either spodumene ore via hard rock

[7] Statista, 2021, https://www.statista.com/statistics/268790/countries-with-the-largest-lithium-reserves-worldwide/, accessed 23.3.2022.

mining, or from metallic brines stored in man-made ponds in the high deserts around the world, South America primarily. Generally, when brine is the source material, water has been pumped into the earth, usually in a very remote location, to create a brine that is captured in storage ponds. Over the course of 18-24 months, in ideal conditions, natural evaporation occurs, and the resulting material is Lithium Carbonate. The alternative to a brine operation is the hard rock mining of spodumene ore. Once the ore is mined, a concentrate is created where the lithium-infused spodumene is filtered and captured. The concentrate then goes to a chemical processing operation where the Lithium Hydroxide is produced. Generally, Lithium Carbonate is used as precursor for LFP and low nickel composition batteries. For high nickel composition chemistries, Lithium Hydroxide is the preferred precursor.

Source-wise, nearly 31% of the world's Lithium production comes from lithium brines in an Andes mountains' region encompassing parts of Chile (24%), Argentina (7%) and Bolivia. This area is often referred to as the "Lithium Triangle". And, Australia (46%) and China (16%), amongst the top 3 Lithium producers on the world, predominantly relies on hard-rock mines that produce spodumene concentrate.

Purified materials from metal ores are then beneficiated to be utilised in mid-stream activities to manufacture high-grade battery materials and components to be used in battery cells. This step is followed by downstream activities which include the production of battery cells and battery packs, end-use of batteries in various industry sectors, and finally recycling of battery materials.

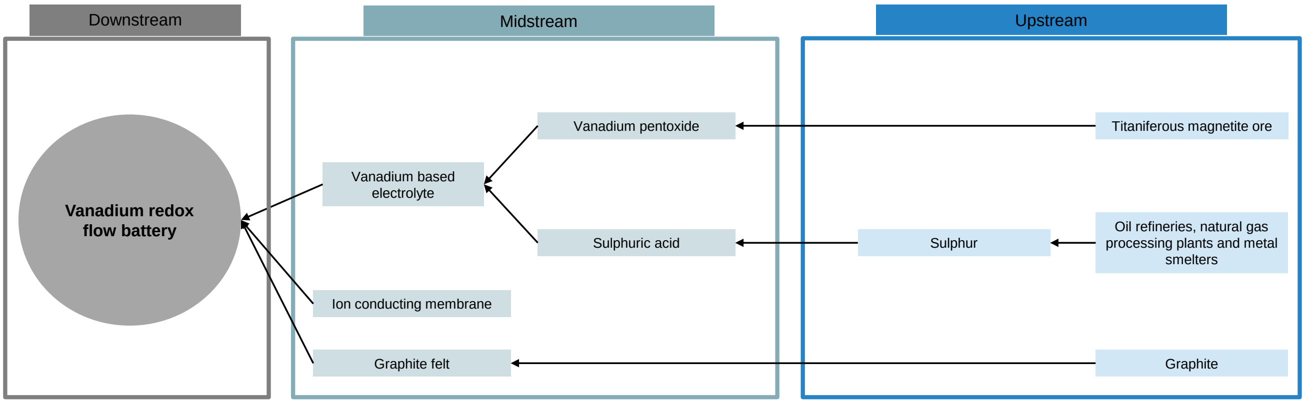
Although several techniques have been developed for the recycling of LIB, the industrial application of LIB recycling is in its infancy, largely due to the relatively small amount of materials being available for recycling. Nonetheless, recycling will become an important source of future battery materials for newer battery production, primarily due to environmental, social, and commercial reasons. Thus, this final stage in the battery production value chain will become critical with rapid growth in large-scale LIB applications across EVs (e-mobility) and stationary energy storage systems. Commercial scale recycling, capable of recovering 90 to 95% of battery materials, using hydrometallurgy is expected to be in place by 2023-24 in both Europe and the US.

4.1.3 Vanadium Redox Flow Battery

A simplified value chain for vanadium redox flow batteries (VRFB) is shown in

Figure 25. On the upstream side, primary vanadium is mined from titaniferous magnetite ore and typically extracted directly from the ore using the salt roast or roast-leach process. This involves multiple steps of crushing-milling-roasting-leaching- precipitation and calcination to produce only vanadium in the form of vanadium pentoxide (V_2O_5) flakes. Ore is finely crushed and milled to micron size, then roasted in a kiln with added sodium salt to form water-soluble sodium vanadate. It is then leached using water, and the pregnant solution is precipitated by adding ammonium chloride and forming ammonium metavanadate (AMV), which is further calcined to form high purity V_2O_5 material. Vanadium electrolyte is produced by dissolving high purity vanadium pentoxide in sulphuric acid. The purity and composition of the electrolyte are key in determining electrolyte performance. The construction of the electrochemical cell is similar to that of a fuel cell.

Figure 25: Value chain for vanadium redox flow batteries (VRFB).



Source: CES

4.2 Mining and Processing of Battery Materials in Southern Africa

The Southern African region is well endowed with most of the key battery minerals (Table 8). Clearly this could offer potential opportunities for the establishment of upstream activities and potential collaboration between African countries in the battery value chain.

Table 8: Battery mineral reserves and production in Southern Africa

Minerals	Country	Reserves (Metric tons)	Share of Global Reserves (%)	Production (metric tons)	Share of Global Production (%)
Copper	DRC	19 000 000	2%	1 020 000	5%
	Zambia	19 000 000	2%	712 000	4%
Cobalt (content)	DRC	3 600 000	51%	95 000	57%
	South Africa	50 000	<1%	2 300	2%
	Madagascar	120 000	2%	3800	3%
Graphite	Mozambique	25 000 000	8%	300	<1%
	Tanzania	18 000 000	6%	N/A	N/A
	Madagascar	1 600 000	<1%	9000	1%
Iron ore (content)	South Africa	770 000 000	1%	52 000 000	3%
Lithium	Zimbabwe	230 000	7%	40 000	2%

Manganese	South Africa	230 000 000	23%[8]	6 200 000	31%
	Gabon	61 000 000	8%	1 800 000	11%
Nickel (contained)	South Africa	3 700 000	4%	44 000	2%
	Zimbabwe	N/A	N/A	17 743	<1%
	Botswana	N/A	N/A	16 878	<1%
Vanadium	South Africa	3 500 000	18%	8 000	7%
Bauxite	Guinea	7 400 000 000	25%	82 400 000	22%

Source: LHA analysis

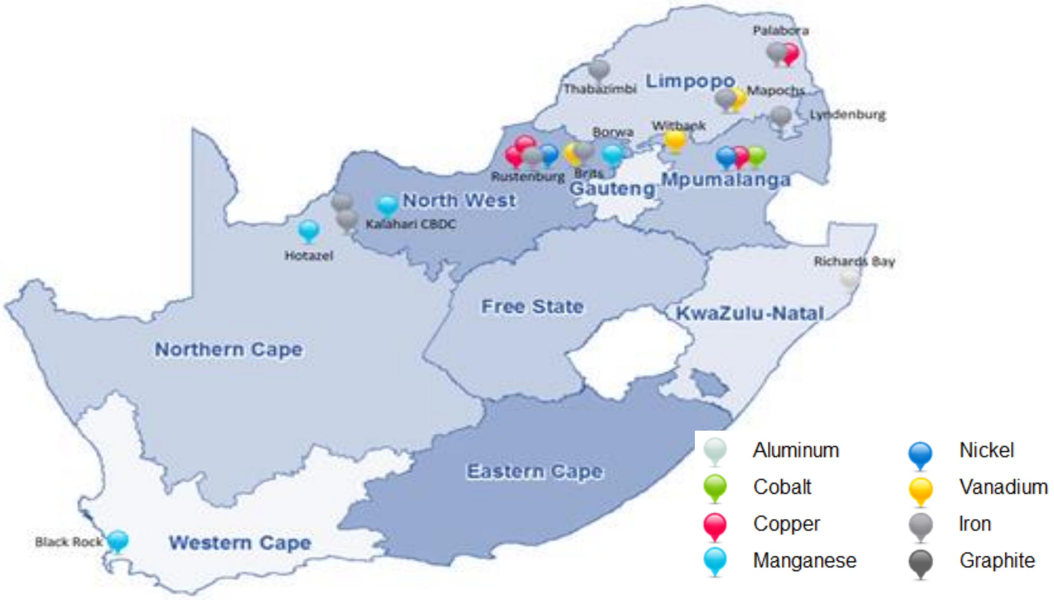
4.2.1 South Africa

The main battery materials available in South Africa are manganese and vanadium, while smaller amounts of nickel and cobalt are also extracted as by-products of Platinum Group Metal (PGM) mining (Figure 26). The major mining companies and their mineral production profiles are listed in

Table 9.

Figure 26: Mineral reserves map for South Africa.

[8] A resource is that amount of a geologic commodity that exists in both discovered and undiscovered deposits—by definition, then, a "best guess." Reserves are that subgroup of a resource that have been discovered, have a known size, and can be extracted at a profit. South Africa has ~75% of world manganese resources but about 23% of reserves.



Source: CES analysis

Table 9: Major mining companies for battery materials - South Africa

Company	Capacity (in kt)			
	Material	Mining	Smelting	Refining
South 32 ltd.	Aluminium	-	823	-
Nkomati Joint Venture	Cobalt	1.2	-	-
	Copper	10	-	-
	Nickel	21	-	-
Palabora Mining	Copper	65	110	140
	Iron	9000	-	-
AMPLATS	Copper	13	11	13
	Nickel	33	-	33
IMPLATS	Copper	7	7	7
	Nickel	6	-	16
Hotazel manganese mines	Manganese	4500	-	-
United Manganese of Kalahari	Manganese	4000	-	-
Assmang	Manganese	3800	-	-
	FeMn	16000	-	300
Tshipi e Ntle Manganese Mining	Manganese	3600	-	-
Evraz Highveld Steel and Vanadium	Vanadium	28.3	-	-
	Iron	2700	-	-
Bushveld Minerals	Vanadium	?		8
Glencore	Vanadium	10	-	-
	FeCr	-	-	400
Kumba Iron Ore	Iron	51700	-	-
Glencore and Merafe Resources	FeCr	-	-	1703

Source: CES analysis, USGS

It can be seen that manganese and vanadium is in plentiful supply, as is aluminium metal. In this regard, it should be noted that South Africa does not have any bauxite reserves (bauxite is refined into alumina, which is the raw material for producing aluminium). South Africa imports the alumina required in its aluminium smelter, primarily from Australia.

South Africa is also among the top 15 producers of both nickel and cobalt[9], although the volumes are small compared to other major global producers.

Most of the nickel, cobalt, and manganese over the years has been exported while the local sales are mainly consumed in the steel industry. There could thus be a potential opportunity for the local beneficiation of nickel and cobalt. The following paragraphs summarize the present scenario with regard to battery precursor materials production in South Africa.

Nickel

With regard to intermediate battery precursor materials (refined battery materials), South Africa does produce class 1 nickel and crude nickel sulphate. Thakadu Battery Materials has commissioned a battery-grade nickel sulphate plant, beneficiating crude nickel sulphate produced by Sibanye Stillwater (formerly Lonmin). Initial production is planned for 16,000 tpa by end 2021, ramping up to steady-state production of 25,000 tpa

[9] US Geological Survey, 2019.

thereafter. Sibanye Stillwater is exploring further opportunities in the battery materials space with specific interest in lithium, nickel, and copper.

Manganese

As noted in Table 8, South Africa has 70 – 80% of the global manganese resources or 20 – 30% of global manganese reserves. Most of the manganese from South Africa is exported as manganese ore or converted to ferromanganese for local and global use in the steel industry. However, Manganese Metal Company (MMC) is a long-standing producer of electrolytic manganese metal or EMM (99.9% manganese content), which is suitable for battery applications. Approximately 95% of MMC's production is exported of which about a third is supplied to battery materials manufacturers[10]. The production operation of MMC is highly energy intensive and is becoming increasingly costly due to rapidly rising electricity prices in South Africa. Hence, MMC is conducting a pre-feasibility study for the production of battery-grade high purity manganese sulphate monohydrate (HP-MnSO4 or HP-MSM) from manganese ore.

The only producer of electrolytic manganese dioxide in SA, DeltaEMD, has closed down, reportedly due to competition from China which led to the loss of the key USA market for DeltaEMD. The technology and some of the refining assets of DeltaEMD have been transferred to the University of Limpopo to preserve the know-how. The importance of manganese as a battery material will increase due to the increasing adoption of manganese-rich battery chemistries (NMC). Given South Africa's ample manganese reserves and the growing market for manganese as a battery material, the possibility of re-starting and upscaling the production of manganese NMC precursor materials based on the DeltaEMD operations and know-how should be explored urgently. This could potentially take the form of a public-private partnership (PPP) venture.

Lithium

South Africa has no significant lithium reserves and there are presently no processing plants for lithium precursors (LiCO3/LiOH). However, large lithium hard rock deposits (spodumene) are located in the DRC with smaller deposits in Zimbabwe and Namibia, hence South Africa could be well positioned to process spodumene concentrate from these countries to lithium sulphate. Key players in the DRC are also exploring the development of primary lithium-sulphate production facilities (e.g., AVZ Minerals' Manono lithium and tin project).

Cobalt

As noted above, South Africa produces refined cobalt and exports most of its production. Refined cobalt oxide/cobalt hydroxide/cobalt metal are considered primary materials for production of cobalt sulphate. The main cobalt producers in the region, ERG Africa and Glencore, are located in the DRC and their production is mainly exported as well. ERG Africa's Chambishi Metals central copper and Co refinery is located in Zambia.

Current Collectors

Hillside Aluminium (owned by Australia-based South32) produces primary aluminium metal using bauxite imported primarily from Australia, since South Africa does not have any bauxite reserves. Aluminium foil producer Hulamin is able to roll aluminium foil suitable for battery applications down to a thickness of

[10] MMC, private communication

approximately 7 microns. The company is actively considering the supply of foil to global Li-ion cathode / cell manufacturers.

Regarding copper foil for Li-ion battery anodes, local company Copalcor rolls copper foil down to approximately 50 microns. This is too thick for anodes and significant capital investment would be required to either upgrade rolling capability or to establish a continuous electroplating process for foil production, which would be a completely new technology for Copalcor.

Graphite

South Africa does not produce significant amounts of graphite but could refine natural graphite mined in Mozambique and Tanzania.

Vanadium

Vanadium is derived from three sources: co-production, primary production and secondary production. Co-production derived from iron ore processed for steel production remains the main source of vanadium, accounting for 72% of 2020 global supply. Primary production involves salt-roasting, water leaching, filtration, desalination and precipitation, and accounted for 18% of global supply in 2020. Finally, secondary production is the recovery of vanadium from fly ash, petroleum residues, alumina slag, and from the recycling of spent catalysts used in crude oil refining; it accounted for approximately 10% of global supply in 2020.

South Africa is the world's third-largest producer of vanadium with an annual production of approximately 8,000 tons, which accounts for about 7% of world production. South Africa's vanadium is derived from primary production and most of the production is exported. The two main producers are Bushveld Minerals, accounting for approximately 5,000 tpa, and Glencore which accounts for the balance of production.

4.2.2 Summary

The availability of battery materials within Southern Africa is summarised in

Table 10. It is important to note that most of the minerals mined and refined in countries north of South Africa are typically transported in trucks, for export into international markets through the Durban Sea port. This existing supply chain advantage could potentially provide an opportunity for establishing South Africa as a battery minerals processing hub for Class 1 nickel, lithium, and graphite, and possibly cobalt from imported raw materials, including manganese which is in plentiful supply in South Africa itself. Accessing the raw minerals will be a challenge, however, given the strong presence of Chinese and Australian firms in the mining/minerals processing value chain and established longer-term supply contracts, typically with Chinese battery material firms.

Table 10: Summary of battery materials sources in Southern Africa

Country	Mining	Refining
South Africa	Mn, V Ni, Co, Cu	Cu Ni, Co
Namibia	Cu Li	Cu
Zimbabwe	Ni, Li	Ni, Cu
Zambia	Cu Ni	Cu
Botswana	Cu, Ni	-
Tanzania	Cu Graphite	-
Mozambique	Ti Graphite	Al
Madagascar	Co, Ni, Graphite	Co, Ni

Source: CES and LHA analysis

4.3 Scope for Cell and Battery Manufacturing in South Africa

4.3.1 Cell Production

South Africa currently is not involved in commercial lithium-ion cell production. However, several companies are exploring the possibility of local cell production.

The **Megamillion Group** has established relationships with a Chinese cell manufacturer and has plans to be Africa's first large scale lithium-ion cell producer. The group ultimately plans to establish activities at every stage in the Li-ion battery value chain, from mining and refining through to battery recycling. However, the company is still engaged in sourcing funding for the establishment of a pilot plant.

Current progress against these plans includes the conclusion of a technology transfer agreement with an Asian technology provider; discussions with government representatives in various African countries (Zambia, Zimbabwe, Guinea, Ghana) for localization of battery-grade mineral beneficiation (although no agreements have been finalized); the development and commercialization of a 5 kW, 10 kWh energy storage system for household and commercial applications (less than 1,000 systems installed at the time of writing this report); and the development of a small-scale uninterrupted power system (UPS) for home and commercial use, which is to be commercialized with local banks.

Metair Investments is a group of local and international companies that manufacture, distribute, and retail automotive components and energy solutions to the automotive industry, telecoms, mining, and materials handling industries. A key strategic focus is growing the energy storage business and ensuring that Metair moves with the technological requirements needed to shift towards Li-ion technology and electric mobility. Metair has operations in South Africa, Turkey, and Romania and has developed intellectual property in cell production and battery assembly. Metair is already engaged in the manufacturing of Li-ion battery cells through its Romanian subsidiary Prime (35% shareholding). Prime is a technology-focused company that develops and manufactures cells and battery packs in Romania for automotive and industrial storage solutions.

In South Africa, Metair has collaborated with the University of Western Cape, which houses the only pilot Li-ion cell manufacturing facility in the country. Initiated in 2017, the R3 million, three-year collaborative program was aimed at piloting the manufacture of Li-ion cells, primarily for mining cap lamps used in the mining industry. In combination with its international LIB activities and well-established market linkages, Metair is well positioned to potentially localize Li-ion cell production in South Africa.

AutoX is one of South Africa's largest battery manufacturing companies and works closely with automotive OEMs in the supply of lead-acid batteries. The company has sponsored post-graduate students at Nelson Mandela University to conduct research in LIB manufacturing with the aim of promoting cell development and the manufacturing of cells for telecommunication, back-up storage, and forklift applications, specifically developed for the African market[11]. In the longer term, the company considers expanding into battery pack assembly as this is a comparatively easy process given the company's expertise in lead-acid battery manufacturing and assembly. The company announced that it has acquired new cathode technology intellectual property for LIBs, however, it was unable to disclose the cathode technology, although it did mention that the technology is not NMC[11].

It must be recognized, however, that lithium-ion cell production is a high-volume industry; the minimum viable size of a cell factory is approaching 10 GWh per annum. A local demand of this scale could be required to contemplate a cell plant (Gigafactory), and this would require the local manufacture of EVs including 2-Wheelers, 3-Wheelers, buses, cars and other commercial vehicles.

4.3.2 Battery Pack Assembly

As outlined in more detail in Section 2.1 in this report, several companies in South Africa are already engaged in Li-ion battery pack development and manufacture, for applications including UPS, residential and commercial renewable energy storage, industrial mobile machines (e.g., forklifts), refrigerated trucks and trailers, and replacements for lead-acid batteries. Notable companies involved are: Balancell, Mellowcabs, Maxwell and Sparks, BlueNova Energy and FreedomWon.

These companies all source their cells from China and source their battery pack materials either locally or internationally. The companies all design and develop other battery pack components in-house, i.e., battery management system (BMS), electronics firmware and software, wiring harnesses, and enclosures. This is considered to be a key capability and differentiator for the companies.

[11] Montmasson-Clair, G., Moshikaro L., Monaisa. L. (2021). Opportunities to Develop the Lithium-Ion Battery Value Chain in South Africa, Trade & Industrial Policy Strategies (TIPS).

It is notable that these companies are internationally competitive and are active in countries in Africa as well as Australia, the USA, and Europe. Clearly, this provides a platform from which to grow the non-EV battery pack industry in South Africa.

There are currently no EV battery pack manufacturing activities in South Africa, which is not surprising since the EV market is still in its infancy and what little local demand exists is met through vehicle imports.

One company, **EV Dynamics**, locally manufactures electric drivetrains for EVs and e-buses. The core offering is the conversion of internal combustion engine (ICE) vehicles into EVs at a significantly lower cost compared to commercially available EVs, with a focus on public transport such as e-buses and minibus e-taxis. The company assembles battery packs from LFP cells and battery management systems imported from China but is also engaged in the development of its own BMS. This is an important capability that could be scaled up further in South Africa and other African countries, and should form part of government policy and incentives in the e-mobility space.

South Africa has an established and sophisticated automotive industry comprising seven automotive OEMs and a wide variety of component and systems suppliers in four supplier parks (Tshwane Rosslyn, Gqeberha, Durban, and Tshwane Silverton (under development)). The industry is exclusively focused on the manufacture of ICE vehicles and highly dependent on vehicle exports (in 2019, 72.8% of the total local production was exported, mainly to European countries[12]). At the same time, demand for EVs remains low in South Africa - only 92 electric vehicles were sold in 2020, which represents less than 0.02% of the total vehicles sold. Reasons include affordability and the lack of charging infrastructure including the on-going grid power constraints.

In contrast, the penetration rate of new electric vehicles (EVs) is substantially higher in other key markets such as Europe, Asia, and the USA. By the year 2030, European countries aim to achieve a penetration rate of up to 40%, with this percentage to increase to 80% by the year 2040. The rapid shift to EVs in South Africa’s key export markets places great pressure on the local automotive industry to migrate towards local EV production in order to survive. The basic construction and assembly techniques of an EV are similar to an ICE vehicle; hence it should be possible to adapt existing local assembly lines with limited capital investment. The components industry will also need to adapt. In the case of EV batteries, pack is mostly an assembly process that should be viable and within the capabilities and expertise in the South African automotive industry.

4.3.3 Re-Use and Recycling of Battery

A number of companies in South Africa are involved in marketing second-life batteries on the local and regional market. LIBs used in industrial and EV applications (first life) can be refurbished and repurposed to be used in stationary applications. This second-life use is critical to extend the useful life of LIBs and the more efficient use of scarce battery material resources as market demand soars.

The company **Revov** sells both new and second-life, carry-case sized batteries into the residential and commercial/industrial markets for backup, UPS, and renewable energy storage systems. The cells for the second-life batteries are sourced from China and the batteries are marketed through wholesalers and Revov-approved installers in South Africa and neighboring countries.

Batteries that reach the end of their second lives need to be dismantled and recycled. China and South Korea dominate the LIB recycling market, due to their dominance in the LIB manufacturing value chain and proximity

[12] NAAMSA data

to large end-user markets. However, they primarily use the older pyro metallurgy technology which was more suited for the cobalt-dominant consumer electronics batteries. It also has a poor environmental footprint. Commercial scale recycling of large Li-ion batteries using hydrometallurgy is expected to be in place by 2023-24 in both Europe and the US. No LIB recycling facility exists in South Africa and the economic viability of such a facility will depend on the availability of sufficient volumes of end-of-life LIBs. However this capability could be developed by establishing recycling operation as an integral part office cell manufacturing facility to handle manufacturing scrap.

An important driver for local LIB recycling is the Extended Producer Responsibility (EPR) regulations published by the Department of Forestry, Fisheries and the Environment (DFFE) in November 2020 (in line with the National Environmental Management: Waste Act No. 59 of 2008). These require the establishment of Producer Responsibility Organizations (PRO), through which producers of, in this case batteries, need to provide a framework for ensuring the effective and efficient management of end-of-life products and to encourage and enable the implementation of circular economy initiatives. Large Li-ion batteries fall within the EPR regulations, while small-scale portable batteries will be addressed in separate regulations. The e-Waste Association of South Africa is exploring the establishment of a pilot recycling facility by 2022/23.

4.4 SWOT Analysis for the Battery Materials Value Chain in South Africa

A SWOT analysis for each value chain segment (up-stream, mid-stream, and down-stream) has been created to develop a synthesized view of the current environment in South Africa's value chain.

4.4.1 Mining

As a leading producer of key battery minerals, South Africa has numerous strengths that could be exploited to enable greater participation in this segment of the value chain. An overview of the mining SWOT analysis is presented below in Table 11. It is apparent that South Africa's strengths in the up-stream mining sector outweigh the weaknesses and that the country is well positioned to expand the mining of battery minerals.

Table 11: Mining SWOT analysis

Strengths	Weaknesses
• Rich history of mining expertise within the country • Mining infrastructure already in place • South Africa accounts for ~23% of world manganese ore reserves and produces 62% of the world's total manganese ore • SA accounts for 3.7% of world nickel reserves and produces class 1 nickel and crude Ni-sulphate. • SA produces refined cobalt • Large cobalt and copper mining operations in the DRC and Zambia, respectively, raw product is transported through SA's Durban port for export • Large deposits of high-quality graphite in south-eastern Africa, esp. Tanzania, Mozambique and Madagascar • Established graphite mining and some refining operations in Madagascar and Mozambique.	• SA has low-grade manganese ores (~35% Mn) while China has carbonate ores (~85 % Mn) • Nickel and cobalt are produced as by-products of Platinum Group Metals (PGM) mining, hence supply depends on PGM market • Nkomati, SA's only primary nickel mine, has been on care and maintenance since March 2021 • SA has no economically viable lithium reserves and no bauxite (aluminium) reserves • Most Class 1 nickel is exported to international markets due to the small scale of battery materials production and the absence of cell production in South Africa

• SA has the world's third largest vanadium reserves (~18%) after China and Russia • Existing vanadium mining and chemicals operations (Bushveld Minerals, Glencore), decoupled from the steel industry	• Tenuous legislative frameworks and increased BEE (Black Economic Empowerment) threshold requirements13
Opportunities	**Threats**
• Strong growth in NMC and LMO battery chemistries, especially for EVs • SA nickel reserves can support ~50 GWh NMC plant for 20 years[14] • Large Li hard rock deposits located in the DRC[15] with smaller deposits in Zimbabwe and Namibia • Numerous graphite development projects in the region • Rapid development of the grid-tied energy storage market is leading to an increased need for longer-duration energy storage, which fits the vanadium redox flow battery (VRFB) profile	• The only producer of electrolytic manganese dioxide (DeltaEMD) has closed down due to competition from China and DeltaEMD losing the critical USA market as a result. • Constrained electricity supply and rapidly rising electricity prices in SA coupled with lack of well-developed power infrastructure across regional countries within Southern Africa are hindering expansion of battery industry in SA and the Southern Africa Region • Lower cost production of Class 1 nickel from laterite ore by Chinese company in Indonesia. • Political instability (e.g., recent insurgent attacks in Northern Mozambique • Government involvement and legislation

4.4.2 Mineral Refining and Material Production

The African continent has been blessed with an abundance of minerals which can be used in numerous applications, included in this are the minerals required for the manufacturing of lithium-ion batteries. This offers South Africa an opportunity to access minerals that are not particularly abundant in the country, such as lithium, cobalt and graphite, for processing into battery grade materials. Table 12 illustrates the SWOT analysis related to the mineral refinement (up-stream) and precursor materials beneficiation/production (mid-stream) segments.

Table 12: Mineral Refining and Material Production SWOT analysis

Strengths	Weaknesses

[13] Leon, P., 2019. SOUTH AFRICA: MINING 2020.
[14] Calculated from typical NMC composition.
[15] Although an opportunity, the DRC could also be a supply risk, given the controversial mining practices.

• The Manganese Metal Company (MMC) already produces electrolytic manganese metal suitable for battery material production, and is exploring the production of battery grade manganese sulphate • Thakadu has recently started beneficiating crude nickel sulphate from local mining to battery grade Ni-sulphate • Emerging vertically integrated vanadium electrolyte producer (Bushveld Minerals/Energy) • IDC is engaged in several industrial development projects along the Li-ion and vanadium value chains • Expertise in minerals processing technologies. • South Africa's geographic location with easy access to the European Market to be a supplier of key battery materials across value-chain segments • Recent establishment of the African Continental Free Trade Area Agreement (AfCFTA) facilitating access to regional trade enabling the option to develop a Regional Hub within Africa including within the Southern African Development Community (SADC) region • Established aluminium smelters in South Africa and Mozambique • Hulamin can produce aluminium foil used as the current collector of the cathode • Local metallurgical processing expertise and R&D capability (e.g., Mintek, CSIR, universities)	• Constrained supply and rapidly rising cost of electricity has resulted in the closure of some processing activities (smelters) • Most of SA's electricity is derived from coal-fired power stations, a disadvantage since downstream players typically have stringent ESG compliance policies. • SA is located far from the major battery material and cell manufacturers. This can impact the viability of local beneficiation – e.g., cobalt-sulphate has a "shelf life" of about 4 months, which may render local beneficiation difficult or not economically/commercially viable • Lack of processing plants/know-how for lithium precursor (Li-carbonate/hydroxide) development • Limitations in financing/investing high up-front CAPEX costs to build a state-of-the-art battery processing plant in South Africa with cutting-edge technology • Limitations in attracting top-notch human capital with latest global battery industry expertise/intellectual capital/patents etc. • Limited R&D being allocated for the refining of key battery minerals and material production • No capability to roll copper foil to < 10 µm thicknesses required for anode foil production (although Copalcor can roll Cu foil down to 50 µm) • Lack of government support and incentives to scale-up battery industry
Opportunities	**Threats**
• SA has potential to become a refining hub in Southern Africa for nickel, cobalt, and copper, (existing refining capabilities) as well as lithium and spherical graphite. This could be further leveraged and expanded into cathode material production with the chemistry and composition (including LFP, adopted to market requirements. • Production of aluminium cathode foil for export. • Establishment of a copper foil plant for export (needs investment into new technology). • Production of high value electrolyte additives such as LiPF6	• SA is located far from the locations of the major battery material and cell manufacturers • Dominant players have already secured minerals supply agreements with Southern African countries (especially China), and mid-stream minerals beneficiation (processing of battery precursor materials) is done outside Africa • Constrained electricity supply and rapidly rising electricity prices slowing-down progress at scale • Key players in SADC countries are also exploring the development of battery grade material production (e.g., AVZ Minerals' Manono lithium and tin project in the DRC)

Key strengths include established and emerging battery materials producers (Manganese Metal Company, Thakadu, Bushveld Minerals/Bushveld Energy), with long-standing expertise in up-stream minerals refining, and the capability to produce Aluminium cathode foil. An important opportunity is the establishment of South Africa as a battery mineral refining hub for Southern Africa, but this depends on the ability to access raw materials from other countries and at competitive prices, like graphite from Tanzania and Mozambique, lithium from Zimbabwe, and cobalt from the DRC. Established supply agreements with Asian companies and China's strong position in the mining industry (China owns more than half of the mines in the DRC and exports the raw materials to China for processing) are significant hurdles in this regard. Other complications include existing vertically integrated producers that refine battery materials elsewhere (e.g., Syrah Resources refining graphite from Mozambique in the USA), and the ambitions by other mining-focused countries like Zimbabwe seeking to enter battery materials production space also need to be recognised.

Given the various constraints and interests in the various countries, a regional approach to localise battery minerals beneficiation may be appropriate. Trade agreements in the context of the Southern African Development Community (SADC) and AfCFTA should aid in the trade of battery minerals, but it is likely that bi- and multilateral negotiations will be required between South Africa and the relevant countries to explore and agree on an acceptable approach towards battery materials beneficiation.

At a project level, the Industrial Development Corporation (IDC) in South Africa is engaged in a number of industrial development projects along the Li-ion and vanadium battery value chains, and these efforts should continue to be supported.

Weaknesses include mainly a lack of technical know-how and experience on producing lithium hydroxide (or carbonate) and a lack of support infrastructure, as well as a lack of government support and incentives compared to countries/regions such as China and Europe. Key threats include the constrained nature and high cost of electricity as well as competition from other African countries and dominant Chinese producers.

In summary, South Africa has sufficient capabilities and strengths to become a refining hub in Southern Africa for nickel, cobalt (potentially), and copper (existing refining capabilities), as well as lithium and spherical graphite. The local production of NMC materials for the global market (outside China) could also be explored, although this will be more challenging and will require strong technical and raw materials supply partnerships.

4.4.3 Cell Production

Table 13 summarises the SWOT analysis for this Cell Production (down-stream) segment of the value chain.

Table 13: Cell Production SWOT analysis

Strengths	Weaknesses
• Private companies are actively researching cell production. • Metair has established cell production in Romania and could provide a platform to begin production into South Africa. • Sustained R&D initiatives through private companies sponsoring post graduate students. • AutoX and Megamillion have announced cell production plans. • Pilot research battery cell facility located at the University of the Western Cape. • Emerging vertically integrated vanadium redox flow battery value chain.	• No past experience or expertise in commercial-scale LIB cell production. • Highly complex stage which requires specialized technology. • Limited ownership of intellectual property. • Large scale and large capital investment required for developing a local Gigafactory. • No specific supporting government strategies or support measures currently in place and will require significant time and additional resources. • No local production of EV's at scale or other mechanisms for sustainable demand
Opportunities	**Threats**
• Potential for high local demand if local OEMs switch production from ICE vehicles to EVs. • High potential for manufacturing and assembling of vanadium redox flow electrode stacks.	• China, South Korea, and Japan currently dominate global cell production. • China particularly dominates cell production for EV applications. • Asian countries have well established value chains with many partnerships with key mineral producing countries within and outside of Africa. • Lack of support from South African automotive industry for local cell production. • Localization of cell production in export markets.

There are no commercial cell production capabilities in South Africa including anywhere else within the African region at present. A key obstacle is the high-volume nature of cell manufacturing which requires enormous scale to be viable; the typical minimum economic scale for a Gigafactories is 5 – 10 GWh per annum[16]. Moreover, the production technology for high-quality cells, particularly for EV applications, is complex and requires very high capex investments. Global cell production is dominated by China, South Korea, and Japan, with large Gigafactories also emerging rapidly in the USA and Europe, typically linked to leading global automotive OEMs (e.g., Tesla, VW, BMW, Ford, etc).

If automotive OEMs in South Africa switch local production to EVs, which will be necessary in the medium to longer term, especially if the industry is to survive, then this would create a local demand for EV battery cell production, which in turn could provide the impetus for establishing a large-scale local cell manufacturing facility. However, the potential economic viability of such a facility remains to be confirmed. A further complication is the fact that a local cell plant would need to produce cells for multiple manufacturers.

[16] CES analysis

4.4.4 Battery Pack Assembly

The SWOT analysis for battery pack assembly is shown in Table 14.

Table 14: Battery Pack Assembly SWOT analysis

Strengths	Weaknesses
• Numerous private companies in South Africa are involved in battery pack assembly. • Companies have own Intellectual Property for Battery Management Systems (BMS) & Software. • Access to abundant labour would enable a more labour-intensive and flexible assembly philosophy. • Small but established track record for export of battery packs to demanding markets (USA, Australia, Europe). • Assembly can be achieved notwithstanding small SA market. • Established know-how in automotive manufacturing (systems, processes, automation) that can be leveraged for pack manufacture. • Emerging integrated vanadium battery materials producer (Bushveld Energy).	• Difficulty in accessing financing limits the relatively small battery manufacturers to scale production and exports. • No current local demand for battery packs for electric vehicles. • Small automotive market (local and exports) even if local OEMs switch to EV production. • Lack of local battery pack testing and certification facilities.
Opportunities	**Threats**
• Rapid growth in energy storage demand due to energy transition and electromobility • Expansion of SA battery pack manufacturing industry for industrial applications and stationary energy storage systems for local and export markets. • Automotive manufacturing is regarded as a strategic industry by the South African government, and the APDP will most likely be amended to increase support for local EV manufacturing value chains. • Local manufacture of Vanadium Redox Flow Batteries (VRFBs) for long-term stationary storage.	• Inability or unwillingness of automotive OEMs to invest in EV production in South Africa could result in the decline of the industry. • Lack of effective government policies and incentive structures to adapt fast enough to global changes and developments in energy storage and electric mobility.

South Africa is already engaged in battery pack development and manufacture for industrial and stationary energy storage applications. Although the companies are still quite small, all have developed proprietary know-how in the form of pack designs, battery management systems (BMS), and software. The manufacture of battery packs for EVs is a timely opportunity, especially if local automotive OEMs switch production from ICE to EVs. The investments required for a large-scale battery assembly plant are substantially lower than for a cell plant, and existing automotive manufacturing expertise could be leveraged for such a plant.

4.5 Opportunity Analysis

Based on the research and analysis described in the previous sections, this section focuses on a summary analysis of the potential opportunity for South Africa. The analysis is outlined in two parts, firstly, the identification of the most appropriate and viable opportunities within the battery value chain(s) and, secondly, a quantification of the opportunity which analyses the value addition throughout the value chain, the potential scale of the opportunities, as well as key investment requirements (focusing on battery cell plants).

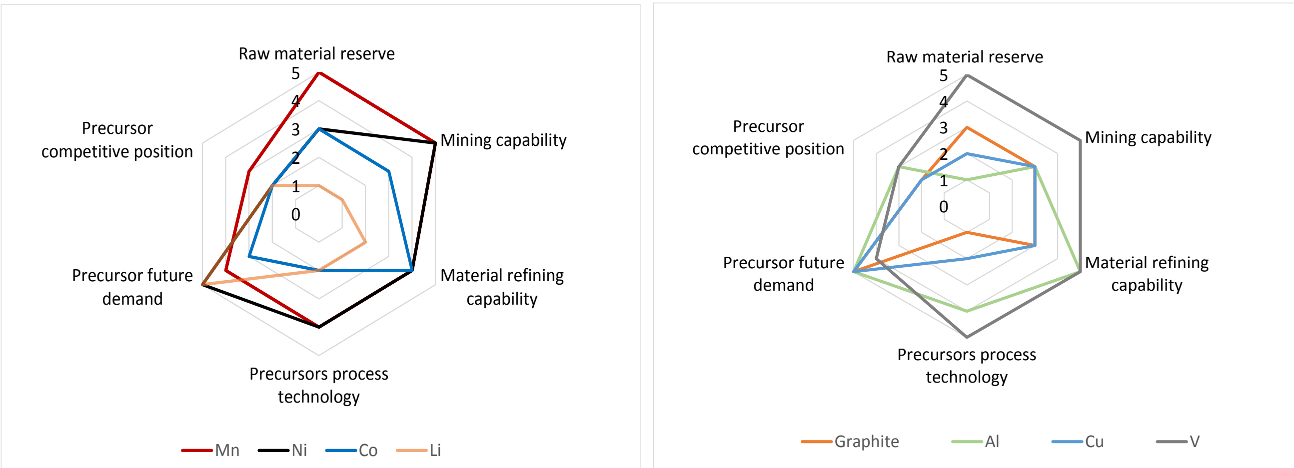
4.5.1 Opportunity Identification

The key drivers for the identification of opportunities are:

- South Africa's strength in mineral reserves and processing position
- Potential for regional integration through processing of imported minerals
- Localization and import substitution

From the SWOT analyses, South Africa's positioning in the mining, refining, and battery material precursor production was rated in terms of raw material (mineral) reserves, mining capability, battery minerals refining capability, battery precursor (production) process technology capability , precursors future demand, and precursor competitive position. Figure 27 illustrates the outcome for the different battery materials grouped into two categories as Category 1: Mn, Ni, Co, Li and Category 2: Graphite, Al, Cu, V.

Figure 27: South Africa's Position in Mining, Refining, and Precursor Production



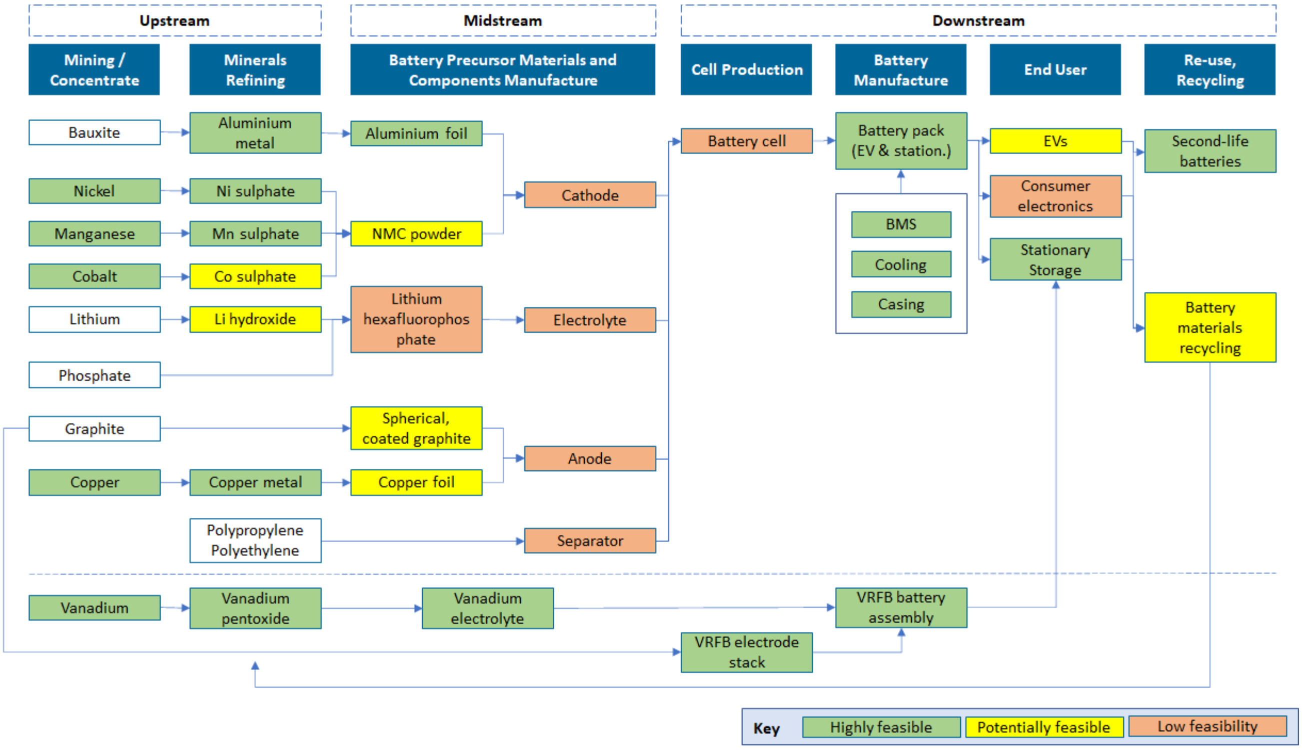
Source: CES and LHA analysis

It will be seen that vanadium and manganese are rated highly in all segments except precursor competitive position. This is related to South Africa's emerging position relative to established precursor producers in China and other countries. Nickel and Aluminium ranks are moderate, whereas lithium ranks low due to the lack of reserves in South Africa and a lack of refining and precursor process capabilities. Nevertheless, as discussed earlier, the production of lithium precursors in South Africa could be a proposition, if lithium raw material can be sourced in sufficient quantities and at competitive prices from Zimbabwe. There is potential for graphite, copper, and cobalt battery material production in South Africa, but in all three cases new process technology will need to be acquired.

Combining the above view with the previous analyses regarding further downstream value chain stages, the value chain opportunities and their assessed high-level feasibility for South Africa are summarized in Figure

28. In this case, the green elements of the value chain are considered to be feasible for South Africa. These include areas where South Africa has strengths in mineral reserves as well as mineral processing.

Figure 28: Battery value chain opportunities and feasibility for South Africa



Source: LHA analysis

Stages highlighted in yellow are considered to be potentially feasible but depend on the successful sourcing of battery raw materials from other countries, as in the case of Co-sulphate and Li-hydroxide/lithium carbonate as well as NMC material where South Africa could have an opportunity to play a role in terms of regional integration of the battery value chain. The localization of EV production is clearly a strategic issue to retain the competitiveness of the local automotive industry in the longer term. This will require appropriate government policy and incentive support, e.g., through a suitably modified Automotive Production and Development Programme (APDP).

Copper foil production requires investments into new technology while battery materials recycling depends on the availability of sufficient quantities of end-of-life batteries, which will most likely only be the case around or after 2030, bearing in mind that larger stationary and EV batteries should have a life of 10 years or more.

The activities highlighted in orange are considered to have low feasibility at present, and their potential viability needs to be analyzed in more depth. It is clear that cell manufacture and hence potential cathode and anode manufacture would depend critically on the localization of EV production, and even then, the scale may be sub-economic.

4.5.2 Opportunity Quantification

The estimated local production potential along the battery value chain is provided in Table 15.

Upstream Activities – Mining and Minerals Refining

The biggest opportunity in upstream mining activities lies in the existing manganese and vanadium mining industries. To satisfy the future demand for local production of battery energy storage, the production of manganese ore in the country will need to increase by 330,000 tons by 2030, leading to an additional production revenue of R620 million in 2021 constant prices. In 2019, 17,002 kilotons of manganese ore were produced in South Africa, of which 95% was exported[17]. The additional production of manganese ore would represent an increase of 1.9% on the existing production to supply the local battery mineral demand as well as export opportunities. Vanadium sulphate battery material is produced from vanadium pentoxide, and it is estimated that local production could reach 18,000 tpa by 2030.

Table 15: Estimated Production Potential for Local Use and Export in Pre-identified Battery Value Chain Stages

Opportunity	Estimated production volume pa – near term	Future estimate given market growth potential up to 2030	Production revenue pa for 2030 potential (2021 prices, R/USD = 13.5)
Mining and Mineral Refining activities (Upstream)			**R11 780 m**
Mining of manganese ore	100 000 tons	330 000 tons	R620 m
Nickel sulphate (low grade)	-	-	-
Mining of aluminium ore	-	-	-
Mining of vanadium ore (pentoxide)	9 000 tons	18 000 tons	R4 470 m
100-300 µm graphite flake	-	-	-
Manganese sulphate	30 000 tons	100 000 tons	R860 m
Nickel sulphate	25 000 tons	80 000 tons	R5 830 m
Precursor Materials Beneficiation and Manufacturing activities (Midstream)			**R8 345 m**
Lithium hydroxide / carbonate	-	20 000 tpa	R 2 430 m
NMC cathode material	-	10 000 tpa	R 2 835 m
Aluminium foil	1 000 tons	5 000 tons	R1 000 m
Vanadium electrolyte	8 ML	16 ML	R1 230 m
Spherical graphite	-	20 000 tons	R850 m
Manufacturing and Assembly activities (Downstream)			**R 23 530 m**

[17] Department of Mineral Resources, 2021.

Opportunity	Estimated production volume pa – near term	Future estimate given market growth potential up to 2030	Production revenue pa for 2030 potential (2021 prices, R/USD = 13.5)
Li-ion cell manufacturing	-	5 000 MWh	R6 750 m
Li-ion battery assembling for stationary applications	840 MWh	1 740 MWh	R3 990 m
Li-ion battery assembly for EV	200 MWh	6 500 MWh	R12 020 m
VRX battery for stationary applications	2 MWh	260 MWh	R770 m
Recycling: Vanadium, Al and Copper	-	Low	-
TOTAL			**R 43 655 m**

Source: LHA analysis

The production of nickel sulphate presents the largest opportunity in the midstream mineral refining (processing) stage. As outlined in Table 23, nickel sulphate production for the local and global lithium-ion precursor market is estimated to reach 80,000 tpa by 2030, with a value of R5,830 in 2021 prices. Furthermore, there are good value adding opportunities in the production of manganese sulphate precursor material (100 000 tpa and R860 million).

South Africa lacks reserves of bauxite (for aluminium production) and graphite, hence there are no upstream mining opportunities within the country. However, as discussed previously, significant graphite deposits are located in Mozambique and Tanzania, as well as in Namibia, hence there may be possibilities for local (investment) companies to become involved in graphite mining in those countries. Nickel production is associated with Platinum Group Metals (PGM) mining and hence constrained by PGM demand. Increased demand for nickel for battery chemicals production should be covered from multi-sourcing from several PGM mines, as well as from neighbouring countries such as Zimbabwe and Botswana.

Midstream Activities – Battery Precursor Materials Beneficiation and Components Manufacturing

The largest opportunities in the midstream value chain segment lies in the production of lithium hydroxide (derived from Spodumene in hard rock) and/or lithium carbonate (derived from Brines in salt flats) and NMC cathode material. The spodumene concentrate would be imported from Zimbabwe for processing in South Africa while the NMC production would rely on local manganese and nickel precursors and cobalt-sulphate produced locally from concentrate imported from the DRC. These opportunities are currently being explored by the IDC.

The next largest opportunities by value are vanadium electrolyte production (16 MLpa and R1,230 million) and aluminium foil for LIB cathodes (5,000 tpa and R1,00 million). In total, the potential midstream opportunities are estimated at R8,345 million per annum by 2030 (2021 prices).

Downstream Activities – Cell and Battery Pack Production

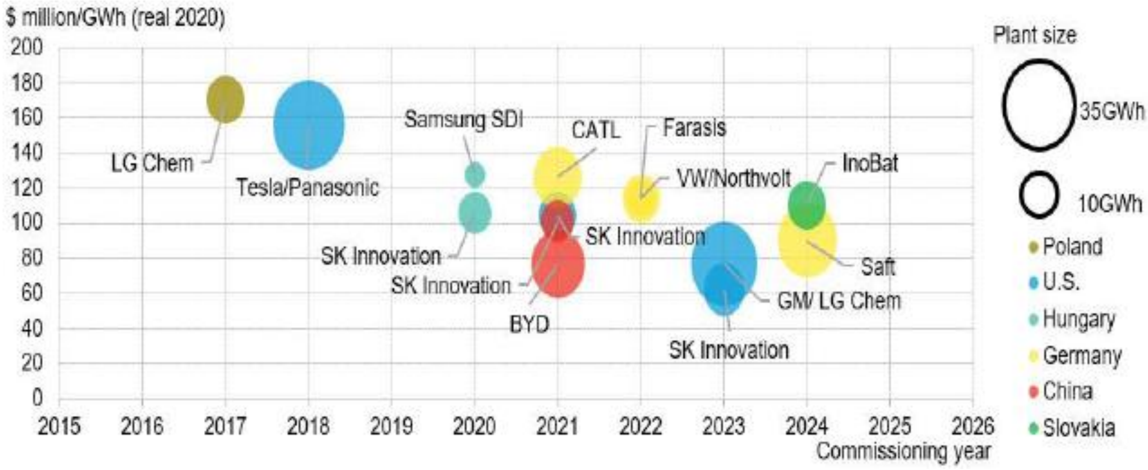
The market assessment task undertaken as part of the study projected the annual demand for energy storage batteries to range between 5,200 MWh and 15,900 MWh in South Africa by 2030, depending on the scenario. In the base case scenario, the estimated demand by 2030 is 9,700 MWh. Considering the substantial investment requirements and the dependence on local cell production on the scale of local EV production, it is estimated that some 5,000 MWh of Li-ion cell production could be localized, mostly for EV applications, and a further 260 MWh of vanadium redox flow battery production for stationary applications. It should be noted that 5 GWh li-ion cell capacity is about half the current economic size of a Gigafactory, which again emphasizes that localization of cell production will most likely require a strategic choice on the part of the government to facilitate the localization of cell production and anchor the EV value chain in South Africa.

The largest localisation opportunities in downstream activities lie in the establishment of lithium-ion battery assembly activities for both electric vehicles and stationary storage that could create an additional R16,010 million worth of revenue in 2021 prices. The establishment of a 5 GWh Li-ion battery cell plant could generate R6,750 million worth of revenue per annum. It should be noted that this is not additional to the revenue generated from battery pack assembly, but rather avoid the leakage of this revenue due to importation of cells for battery packs. Finally, opportunities related to VRFB battery manufacture for stationary applications is estimated at 260 MWh per annum, representing R770 million worth of revenue.

Investment Requirements – Cell versus Battery Plants

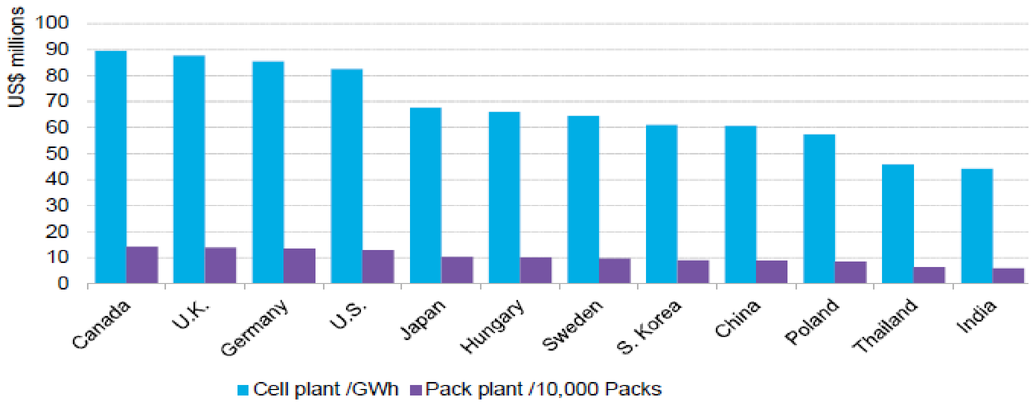
The establishment of gigafactories for LIB cell manufacturing is a costly endeavour, even though there is a decreasing trend in costs as shown in Figure 29. For smaller plants, such as a 5 GWh plant that might be of interest in South Africa, investment costs are around USD 80 – 100 million per GWh. However, the investment requirements appear to be significantly lower in Eastern Europe and Asia, which range from USD 45 – 60 million per GWh (Figure 30).

Figure 29: Capital Investment Requirements for LIB Gigafactories[18]



[18] Source: BNEF, 2020, Dataset on Electric Vehicle Outlook 2020 – Data
Note: It is not always clear if a facility will manufacture cells, or cells and packs.

Figure 30: Capital investment cost for LIB cell and pack plants (2020)[19]



A battery pack manufacturing facility is 5 – 6 times less expensive than a LIB cell manufacturing plant. It is also important to note that the required investments are significantly lower in China and India (USD 7 – 9 million) than in Western countries such as the USA and Germany (USD 10 – 15 million)[19].

4.5.3 Strategic Considerations for Sector Support and Investment

Value Chain Attractiveness Analysis

The GE-McKinsey Matrix is a multifactorial portfolio analysis tool that was originally developed as a corporate strategy tool aimed at supporting companies in making decisions on whether to invest or not in certain business ventures or company business units. This concept of the matrix has been adapted and applied to the relevant battery storage value chain segments.

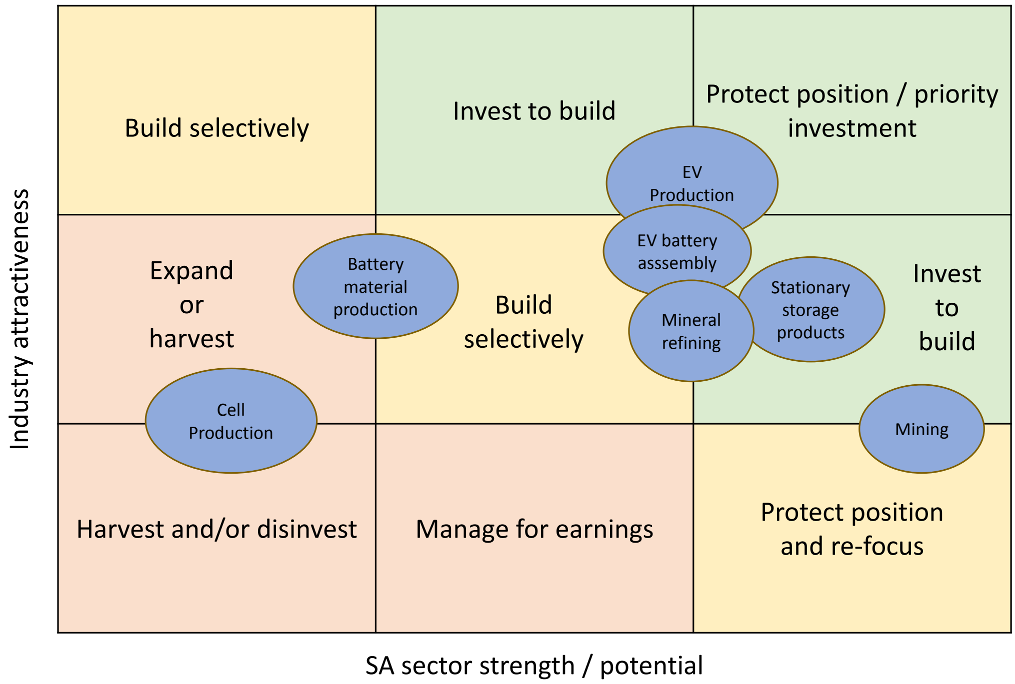
The Y-axis of the matrix represents the value chain stage attractiveness, which equates to how easy or difficult it will be for a value chain segment to realize profits in the market based on relevant criteria. Usually, a value chain segment becomes more attractive if it is more profitable. The X-axis represents the relevant value chain stage strengths/potential within South Africa, and it refers to the sustainable competitive advantage a value chain may have or could develop. By evaluating the attractiveness and the relative strengths/potential of each segment in the value chain, the position of each segment could be plotted on the GE McKinsey matrix.

The attractiveness matrix consists of nine different boxes with nine different scenarios and corresponding strategic actions. The boxes in the matrix are used to determine where to invest, where to hold a position, and where to harvest or divest.

Eight criteria were used to create the market attractiveness assessment. Four criteria were assigned to evaluate the attractiveness of the different value chain segments: value addition, the potential market growth, barriers to entry, and the global competition in the segment. Four additional criteria were considered for evaluating South Africa's value chain segment strength/potential: South Africa's past experience in the value chain segment, ease of implementation, South Africa's competitive position/potential, and the current infrastructure relevant to the value chain segment. Weighted scores were assigned to each criterion for each value chain segment to assess its relative attractiveness and strength/potential. The resulting value chain segment attractiveness matrix is shown in Figure 31.

[19] BNEF (2020), Dataset on Electric Vehicle Output 2020 – Data. Based on cell plants of 10 GWh per annum manufacturing capacity and packs plant of 50,000 packs per annum manufacturing capacity

Figure 31: Attractiveness matrix and South Africa's positioning for battery value chain stages



South Africa clearly has great strengths in the mining stage of the upstream value chain; however, it is rated as comparatively unattractive, mainly because of the limited additionality and the level of increased revenues that can be achieved. Value added segments such as mineral refining, and the assembly of battery packs for both EV and stationary applications are rated as more attractive, given their potential for much higher value addition coupled with South Africa's good expertise and capability to enter these value chain segments.

Although EV production is not strictly a battery value chain segment, it is included due to its importance for the establishment of EV battery pack assembly and, possibly, LIB cell production. EV production is rated as highly attractive, mainly because it is a strategic industry in South Africa that not only contributes directly to the local economy, but also because it can catalyze new technology in the country through numerous value-add spin-offs in the automotive manufacturing value chain. South Africa also has many strengths in this value chain stage, due to the existing automotive industry know-how and infrastructure that could be leveraged for EV production. EV battery pack assembly is rated as attractive and due to its relative ease of implementation, comparatively low investment requirements, and the ability to leverage existing automotive production technology expertise, this stage is also rated as having high potential in South Africa. Of course, EV battery pack assembly depends on local production of EVs, this value chain segment would otherwise not be viable.

Battery precursor material production is rated as reasonably attractive based on its position on the matrix and moderated by the highly technical nature and strong position of a limited number of existing material manufacturers in this stage. Also, South Africa has few strengths in this area, and would be dependent on own technology development (expensive and time-consuming) or on accessing technology through partnership(s).

Finally, cell production is rated as comparatively unattractive. This is due to the large economies-of-scale and massive investments that are required, fierce global competition in this area with dominant positions currently held by China, South Korea, and Japan. Also, anecdotal evidence from stakeholder interviews suggests that many cell producers struggle to achieve a return on capital. This may be one reason why automotive OEMs increasingly look towards integrating cell manufacture in their manufacturing plants, for margin capture as well as quality control and technology ownership reasons.

Moreover, LIB cell plants are usually heavily subsidized by governments, and not only in China. For example, five US states competed for the first Tesla Gigafactory in Nevada, offering tax incentives, cash grants, and other incentives. Nevada's incentive package for Tesla, included a USD 195 million tax credit, 1,000 acres free land, no sales tax for 20 years, and no property tax for 10 years. Chapter 6 provides further details on support programmes and case studies employed by key countries to support and facilitate the establishment of local battery value chains and EV manufacturing industries.

4.6 Mapping of Tax & Duty Structures in Battery Value Chain

There is an ordinary import duty of 15% in South Africa on automotive lead-acid starter batteries (the kind used to start piston engines). This was implemented in 2015 because of a loss in market share by local producers to imports and declining production capacity utilization.

However, there are no duties and taxes applicable to batteries outside of automotive batteries in SA (see the table below).

Table 16: Tax Duty Structure for Batteries, South Africa, 2020

Heading	Article	Rate of Duty					
		General	EU	EFTA	SADC	MERCOSUR	AfCFTA
85072000	Lead-acid	Free	Free	Free	Free	Free	Free
85073000	Nickel-cadmium	Free	Free	Free	Free	Free	Free
85074000	Nickel-iron	Free	Free	Free	Free	Free	Free
85075000	Nickel-metal-hydride	Free	Free	Free	Free	Free	Free
85076000	Lithium-iron	Free	Free	Free	Free	Free	Free
85078000	Other	Free	Free	Free	Free	Free	Free

Source: South Africa Revenue Service (SARS)

Battery manufacturers in South Africa noted that:

- A possible future local industry in the battery value chain would need some form of protection from imports.
- Capabilities related to customs, excise responsibilities at country entry points are deficient, and controls over imports are almost impossible. The battery manufacturers have approached the government to offer assistance in the training of customs officers, to improve border controls. However, the government has not responded to this offer to date.
- In many cases, South Africa is only a conduit for the supply of batteries to SADC countries and this needs attention in the design and implementation of import barriers.

Also, for trade within the **SACU (The Southern African Customs Union)** and **SADC regions** and with South Africa, no customs duties apply to batteries of any type.

The International Trade Administration Commission (ITAC) administers the import and export control measures for South Africa.

For the import of used and second-hand goods, an import permit is required. This would typically be relevant for battery waste and scrap, and where recycling of batteries is becoming an issue in larger global markets and hence to control possible dumping in other countries including South Africa.

Given that the EV battery market represents the largest proportion of the estimated potential by 2030, the recently published **Auto Green Paper**[20] on the advancement of **New Energy Vehicles (NEVs)** in South Africa is an important step. Regarding tax and duty structures, the paper advocates that the duty rebate mechanism for the auto sector needs to be monitored and balanced to ensure that assembly and localization objectives (including those for batteries) are delivered in a way that neither is adversely impacted by overweighing the other. The auto sector is also calling for a reduction of the ad valorem tax on EVs and EV components such as battery packs to stimulate the market for EVs and promote electric mobility.

4.7 Review of Fiscal Budgeting, Accounting, Procurement Rules Governing Battery Industry

The South Africa budget of 2020 does not overtly specify funding for the renewable energy industry and by extension the battery value chain and manufacturing industry. Funding for large projects is most likely to be available through the newly established **R100 billion Infrastructure Fund**. However, in the State of the Nation address held on February 11, 2020, the president specifically mentioned the rapid expansion of energy generation capacity as one of four priority interventions. Inter alia, this would include the easing of licensing requirements for the new embedded generation to unlock an estimated additional 5 000 MW of capacity.

Subsequently, in April 2021, **Schedule 2** of the **Electricity Regulation Act, 2006** was amended to increase the threshold for embedded generation from 1 MW to 100 MW. This should positively impact both the further development of the RE and energy storage industry.

Additionally, Eskom announced a tender in 2021 for 80 MW/320 MWh of battery storage and many of the larger metropolitan councils (e.g., Cape Town 300 MW) are considering their own generation capacity.

Furthermore, on public reforms and regulatory interventions, the **National Energy Regulator of South Africa (NERSA)** reportedly has applications for power projects over 2000 MW from the industry. In particular, the mining industry is leading the way and the **Minerals Council of South Africa** reports a project pipeline of above 900 MW. Some notable RE projects by mining companies are listed below.

Table 17: Renewable Energy projects, South Africa, 2020

Company	Project Size
Sibanye-Stillwater	200 MW
Anglo American	75 MW
Gold Fields	40 MW
Vendanta	200 MW
Orion Minerals	38 MW
Bushveld Energy	3.5 MW
Exxaro	3 MW

[20] Department of Trade, Industry and Competition

Harmony	30 MW
Pan African Resources	10 MW
Sasol/Air Liquide	900 MW

4.8 Review of Different Market Mechanisms and Public & Private Incentive Structures

We consider below the most prominent market mechanisms that would provide impetus to the development of the battery market and support battery value chains. It is evident that the battery value chain can, and should, leverage off the considerable base and groundwork that has already been established in the successful establishment of the renewable energy industry in South Africa.

4.8.1 Supportive Policy Framework and Regulations

There is no clear policy on energy storage, and this has been identified as one of the reasons for the relative lack of development of this sector. The implementation of suitable supportive policies and regulations would elevate energy storage development to the priority list of national programs and thereby bring consistency to the energy storage market to accelerate its development.

Nevertheless, ***at the national and industry level***, both the latest **Integrated Resource Plan (IRP2019)** and the **Automotive Master Plan 2035** serve as important instruments that promote storage at the utility-scale level and in e-mobility respectively. The **Automotive Master Plan** requires an amendment, and the automotive manufacturers recently called on the government for making those changes, so that production is better aligned with export market requirements by 2030.

The **Auto Green Paper** referenced earlier also mentions various policy options that can be considered, particularly beneficiation policies to incentivize the use of regional raw materials, especially those used in EV manufacturing value chains. Support mechanisms, for example, could also include the expansion of charging infrastructure in the domestic market to incentivize the use of EVs.

At the local government level, efforts to entrench small-scale embedded generation (SSEG) are important, in terms of registration, compliance, training, and certification including tariffs. Currently, no entity is permitted to operate any power generation facility larger than 1 MW without a license from the NERSA. The recent announcement by the government, confirming the increase of the licensing limit to 100 MW will stimulate substantial private investment into SSEG, which in turn, should have a stimulating effect on battery storage.

Other initiatives by the government such as localization and designation of products for local use as well as targeted import control measures to protect local industries are already in place and should equally apply to the battery value chain.

The emerging local Li-ion battery manufacturers noted that there is a lack of local testing and certification facilities for Li-ion batteries. This means that there is also a lack of protection for the industry and consumers from sub-standard technologies, both through imports and local assembly. Urgent action is required by the **Department of Industry and Competition (DTIC)** and entities such as the **National Regulator for Compulsory Specifications (NRCS)** and the **South African Bureau of Standards** (**SABS)** to put relevant standards and testing capabilities in place.

An important policy mechanism is the **Special Economic Zone (SEZ)** instrument of the DTIC. Established in 2007, the purpose of the SEZ is to:

- Expand the strategic industrialization focus to cover diverse regional development needs and context;
- Provide a clear, predictable, and systematic planning framework for the development of a wider array of SEZs to support industrial policy objectives, the Industrial Policy Action Plan (IPAP) and the New Growth Path (NGP);
- Clarify and strengthen governance arrangements, expand the range and quality of support measures beyond the provision of infrastructure; and
- Provide a framework for a predictable financing framework to enable long-term planning.

SEZs are geographically designated areas of a country set aside for targeted economic activities, supported through special arrangements (such as laws) and systems that are often different from those that apply in the rest of the country. SEZs could be sector-specific or multi-product-focused. The following categories of SEZs have been defined as per the SEZ Act No. 16 of 2014:

- **Industrial Development Zone** – These SEZs are purpose-built industrial estates that leverage domestic and foreign fixed direct investment in value-added and export-oriented manufacturing industries and services.
- **Free Port** – These SEZs are duty-free areas adjacent to a port of entry where imported goods may be unloaded for value-adding activities within the SEZ for storage, repackaging, or processing, subject to customs import procedures.
- **Free Trade Zone** – These SEZs are duty-free areas offering storage and distribution facilities for value-adding activities within the Special Economic Zone for subsequent export.
- **Sector Development Zone** - These SEZs are focused on the development of a specific sector or industry through the facilitation of general or specific industrial infrastructure, incentives, technical and business services primarily for the export market.

SEZs could play an important part in the development of local battery value chains in South Africa. For example, the vanadium electrolyte plant of Bushveld Energy is being established in the Coega SEZ in the Eastern Cape, located at the port of Coega. It is potentially advantageous to locate additional battery value chain activities, such as VRFB battery manufacture, in the same SEZ. Similarly, an **automotive battery value chain** could also be located in an automotive-focused SEZ, such as the Silverton Automotive Supplier Park in Pretoria. Alternatively, an **advanced battery supplier park** could be established at an SEZ like Coega, fostering the **co-location** of various value chain activities such as **battery cell imports, battery pack assembly, manufacture of enclosures and harnesses,** and **software development**. With time, even the local manufacture of battery material precursors could be contemplated in such a supplier park. The co-location of value chain activities would benefit from logistics efficiencies, duty-free areas for local value addition for subsequent export, incentives, and technical and business services.

4.8.2 Finance and Business Support

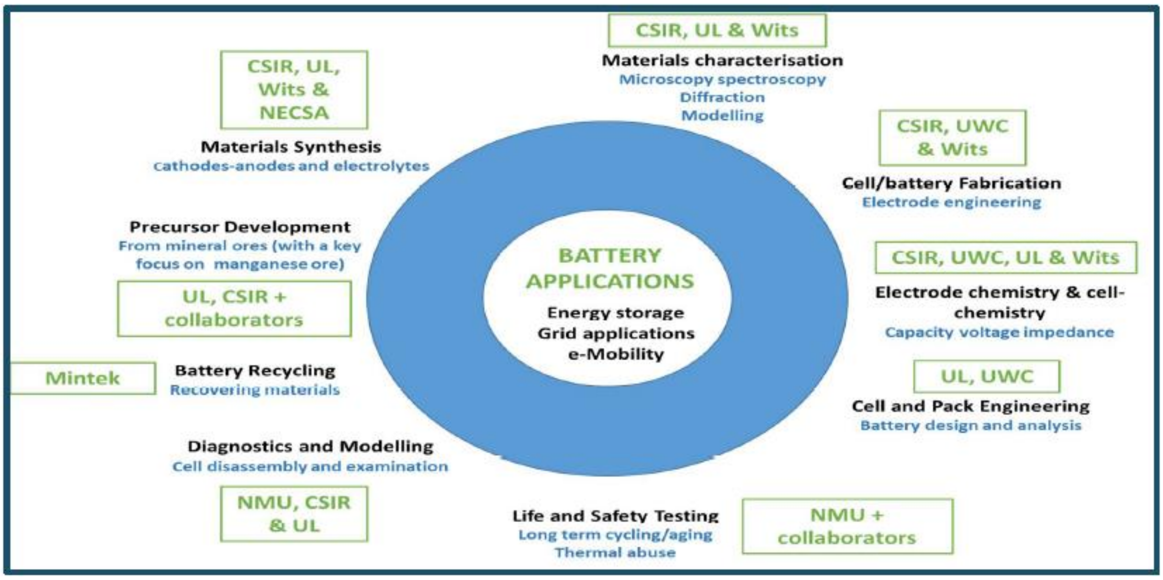
There are already a plethora of actors, stakeholders, and finance sources/mechanisms that support the green economy. These include international and local development finance institutions such as IDC, World Bank**,** commercial banks such as Nedbank, HSBC, private equity players such as Actis, as well as sovereign funds, enterprise development programs, and venture capital companies. There exists sufficient funding, but they await a promising business case and policy certainty for long-term market visibility for such financiers and equity investors to proceed with speed.

4.8.3 Research and Development

Various research and testing programs often in collaborative structures, aimed at developing local capabilities in the battery value chain exist. This has been formalized in a consortium comprising research organizations, universities, and other institutions under the auspices of **South Africa's Research, Development, and Innovation (RDI) programme**.

This Energy Storage Research, Development and Innovation (RDI) Consortium (Figure 32) was established by the Department of Science and Innovation (DSI) for the purpose of developing cell components through the beneficiation of raw materials available in South Africa. Members of the consortium include the University of Limpopo (UL), University of the Witwatersrand (Wits), Council for Scientific and Industrial Research (CSIR),

Figure 32: Structure of South Africa Energy Storage Research, Development and Innovation (RDI) Consortium



Source: TIPS report, 2020

South African Nuclear Energy Corporation (NECSA) electrode materials development, UWC Energy Storage Innovation Lab (whose activities include cell assembly and validation) and the uYilo e-Mobility Programme (uYilo) hosted at Nelson Mandela University (NMU), whose activities include the testing and validation of cells, modules, and battery packs.

The CSIR, Hulamin, NECSA, and Sasol have the facilities and capability to make cell components for lithium-ion batteries. However, there is currently no market in SADC for them to adapt and upscale their processes to make lithium-ion battery-related components on a commercial basis.

4.8.4 Certification and Training

Like in the case of the finance market, a significant number of institutions exist in South Africa which provide training and certification services for the renewable energy industry. The **South African Renewable Energy Technology Centre (SARETEC)** was the first national centre to be established, but others soon followed such as the Solar Training Centre at Northwest University and many private companies (e.g., Green Solar Academy, SUNCYbernetics Solar Training Centre). The services provided include installation training, system assessments, and PV GreenCard accreditation. All of these would ideally be suited to provide similar services for the battery value chain. Several universities, including Stellenbosch University and the NMU offer postgraduate studies in renewable energy and energy storage topics.

The potential for international partnerships to develop and provide relevant training and education should also be explored. One particularly suitable potential partner would be the Future Battery Industries Cooperative Research Centre (FBICRC) in Australia. The framework conditions in Australia relating to the energy storage value chain are broadly similar to those in South Africa and hence the experience of the FBICRC should be particularly relevant to South Africa. Education and training initiatives at FBICRC include:

Higher degree research (HDR) and undergraduate students

- A variety of scholarships and top-ups are offered to research students with a target of facilitating a total of 40 HDR's across the FBICRC research programs.
- Potential partnerships between South African universities and FBICRC including, for example, student exchanges could be explored.

Vocational Skills

- A national training analysis will be done by the FBICRC's vocational training partner, to help understand future workforce capability needs and skills requirements.
- The outcome of this analysis could help inform the South African vocational training needs, to be delivered through the local vocational training colleges.

Entrepreneurship and adoption

- This includes augmenting existing incubator, accelerator, and entrepreneurship programs.
- Several universities in South Africa have established entrepreneurship and incubator programmes, which could be leveraged for the local energy storage sector in partnership with FBICRC in Australia.

Professional Development

- This includes short courses and executive education for industry, typically delivered through partnerships with training providers and universities.
- Short courses and executive education are well-established education offerings at South African universities. Through partnering with the likes of the FBICRC and global energy storage industry players, these should be expanded to include energy storage topics including hands-on training.

4.8.5 Environmental Measures

The anticipated increase in use of energy storage systems will create a need for the effective recycling of batteries. All hazardous e-waste including batteries will be banned from being landfilled during 2021, and thus an effective waste management scheme is required, including the establishment of suitable recycling facilities. Alternatives to recycling, such as repurposing the second-life use of EV batteries for residential use aimed at mitigating power outages should also be considered.

The Energy Storage RDI Consortium has initiated activities towards lithium-ion battery recycling. Mintek is conducting electronic waste research that includes the recovery of valuable metals from lithium-ion batteries and the preparation of a business case to establish a lithium-ion battery recycling facility in South Africa.[21] uYilo (at NMU), the Energy Waste Association of South Africa, and Mintek are exploring the value chain of e-waste management for lithium-ion batteries.

4.8.6 Innovative Business Models

It is likely that, due to high initial capital costs, the rapid introduction of energy storage systems in decentralized renewable energy installations (e.g., SSEG) could be compromised. This would require innovative ownership business models for batteries, such as **leasing of batteries** also known as the **Battery-as-a-Service (BaaS) model**, or in the case of VRFBs, **leasing of the electrolyte**. Such leasing models could lower the barriers to market entry, aid applications (such as telecom tower batteries), thereby stimulating the replacement of end-of-life lead-acid batteries with advanced battery chemistries to expedite the faster market transition to more optimal battery solutions.

4.9 Assessment of Drivers and Bottlenecks for Creation of Battery Value Chain

The key drivers and inhibitors for the creation of a local battery value chain were assessed based on the foregoing analysis and discussions with energy storage industry stakeholders. Although policies and support mechanisms are important, the prevailing IPP procurement practices currently contain important inhibitors and could be significantly improved to de-risk and support the development of battery value chain segments in South Africa.

Key Positive Drivers:

- **C&I sectors are increasingly focused on electricity cost reductions and energy security**, due to rapid increases in electricity prices and load shedding. This is resulting in rapid increases in the adoption of renewable energy in mining, commercial, and industrial applications.
- Substantial **reductions in the cost of renewables and energy storage technologies**, especially batteries, are driving the adoption of (stationary and mobile) energy storage project applications.
- Availability of **ample battery mineral resources** and increasing activities in the industry in battery minerals beneficiation and, at the other end of the value chain, design and manufacture of battery packs. Additionally, components like battery management systems, inverters, and power electronics.
- **Explicit inclusion of 2,000 MW of energy storage capacity addition allocations in the IRP2019.** This allocation is expected to be increased in subsequent IRP iterations, which is also something the energy storage industry is lobbying for, through the **South African Energy Storage Association (SAESA)**.
- **Dispatchability requirements for energy storage in IPP tenders** [e.g., the recent risk mitigation IPPP Program (RMIPPPP)] require longer energy storage durations of 4 – 10 hours and strongly support market growth.
- Recent relaxations in South Africa's **Electricity Regulations on New Generation Capacity** legislation now allow municipalities, large industry, and commercial consumers to establish own electricity generation or purchase electricity from independent power producers (IPPs) rather than from Eskom, who has up to now been the sole off-taker of power from IPPs. These **efforts to increasingly achieve**

[21] Government of South Africa, Department of Mineral Resources and Energy, "Shareholder Performance Agreement 2020/21 Entered Into By and Between the Mintek Board", https://static.pmg.org.za/Mintek_Compact_2020_16042020.pdf

self-sufficiency in electricity supply are positive for co-located battery storage and ripe for private sector investments.

- Substantial **capacity and capabilities in developing RE projects** through the new Bid-Window 5 of the REIPPP Program that can be leveraged to include energy storage. Thus, the implementation of Bid-Window 5 can be highly beneficial and critical to South Africa's adoption utility-scale solar pv + storage systems that could ultimately bring economies of scale to the stationary battery storage industry.

Key Inhibitors:

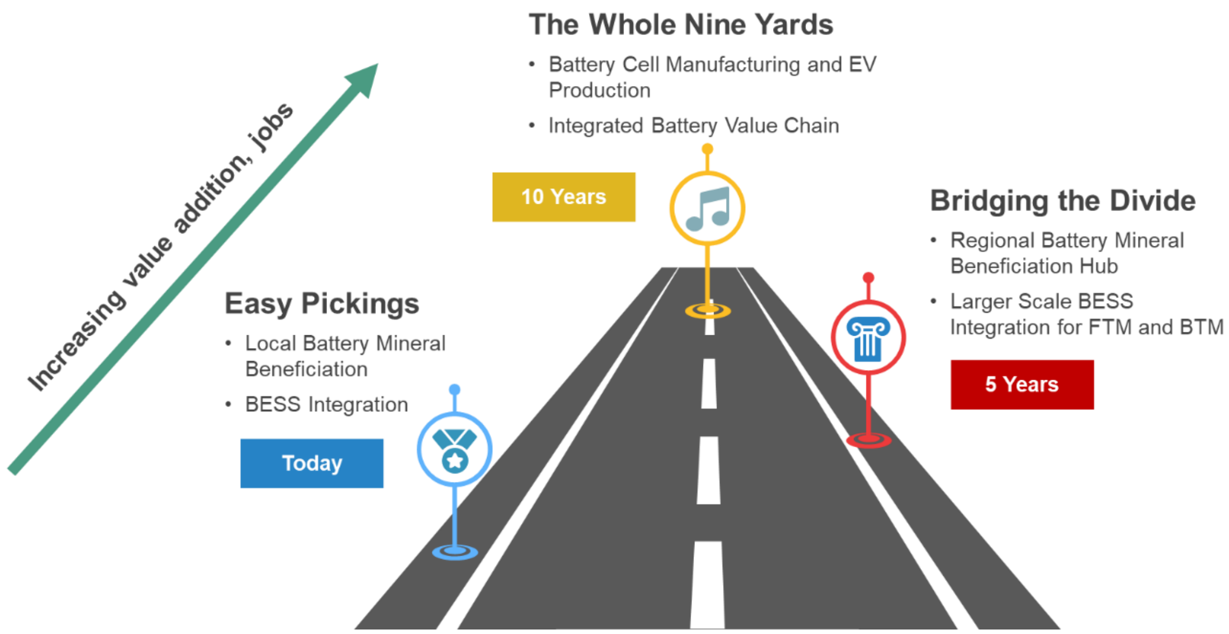
- The **IRP2019** foresees the addition of 0.5 MW of FTM energy storage in 2022 and the addition of a further 1.5 MW only 7 years later, in 2029. This **staggered timing of energy storage additions** is **not conducive to stimulating a battery storage industry**. However, battery storage industry players that were engaged in the present study indicated their expectation that subsequent iterations of the IRP would most likely include even more storage at shorter time intervals.
- The **IRP2019 only makes provision for energy storage power capacity targets (in MW)** and does **not include** any planned targets for **energy storage** (MWh). Since the size of battery and hence the size of the potential industry opportunity is substantially determined by the required energy storage capacity, future iterations of the IRP should specify both power capacity (MW) and energy (MWh) capacity targets.
- The **project delivery timescales** specified in IPP tenders are typically 18 months or less. This **does not allow potential bidders sufficient time for investments in and ramp-up of local manufacturing capabilities** to meet the project delivery timescales and hence inhibits investments. Longer delivery lead times would de-risk such investments and support the development of local battery value chain elements.
- **Minimum local content thresholds specified in tenders are typically too low and restrict** the potential for local manufacturers and value addition to the civil construction and electrical/grid connection equipment.
- **Prescriptive allocations for particular storage technologies**, informed by previous projects, preclude the development and localization of alternative technologies. The easing of such restrictions and/or the incorporation of technology-specific allocations should be considered.
- **Lack of standards for storage batteries in SA** allows import of sub-standard and uncertified products to be the detriment of the market (reputational damage of the technology) and local manufacturers.
- **Lack of local testing and certification facilities** hampers certification of local products and market opportunities. New partnerships with global industry players should be considered within this space.
- Key skills, especially **firmware and software engineers are hard to find and expensive** due to competition for these skills from other sectors locally. Lack of government and private sector incentives schemes/structures will be needed to attract skilled labor force and high-quality intellectual capital in order to accelerate the battery industry scale-up in South Africa.
- **Power electronics developers and integrators are scarce**.
- Recent research conducted by **Intellidex** for **Business Unity South Africa (BUSA)** and **Business Leadership South Africa (BLSA)** noted that there is a great degree of goodwill within the business fraternity towards sustainable localization but, equally there is **considerable skepticism on current**

localization policy[22]. It was recommended that localization should not be a fundamental policy goal, but rather a second order policy aim only where there is analysis that cheaper and quality imported goods do not create a more positive jobs outcome along the value chain. Policies should be transparent and consistent (policy predictability), with clear endpoints and a roadmap towards a more competitive local industry).

[22] Intellidex, 21 May 2021. Localisation: What is Realistic?

5. Developmental Scenarios

A SWOT analysis for each segment in the lithium-ion value chain was created to develop a synthesized view of the current environment for South Africa's battery value chain. Subsequently, the results from the SWOT analysis pertaining to specific value chain segments that were most attractive for South Africa were consolidated to formulate three developmental scenarios, based on their ease of implementation and implementation timeline. Together, these three scenarios, not only provide development options but also a roadmap towards the development of an integrated battery value chain in South Africa.



A brief on the roadmap of each stage is described in the following sections.

5.1 Easy Pickings

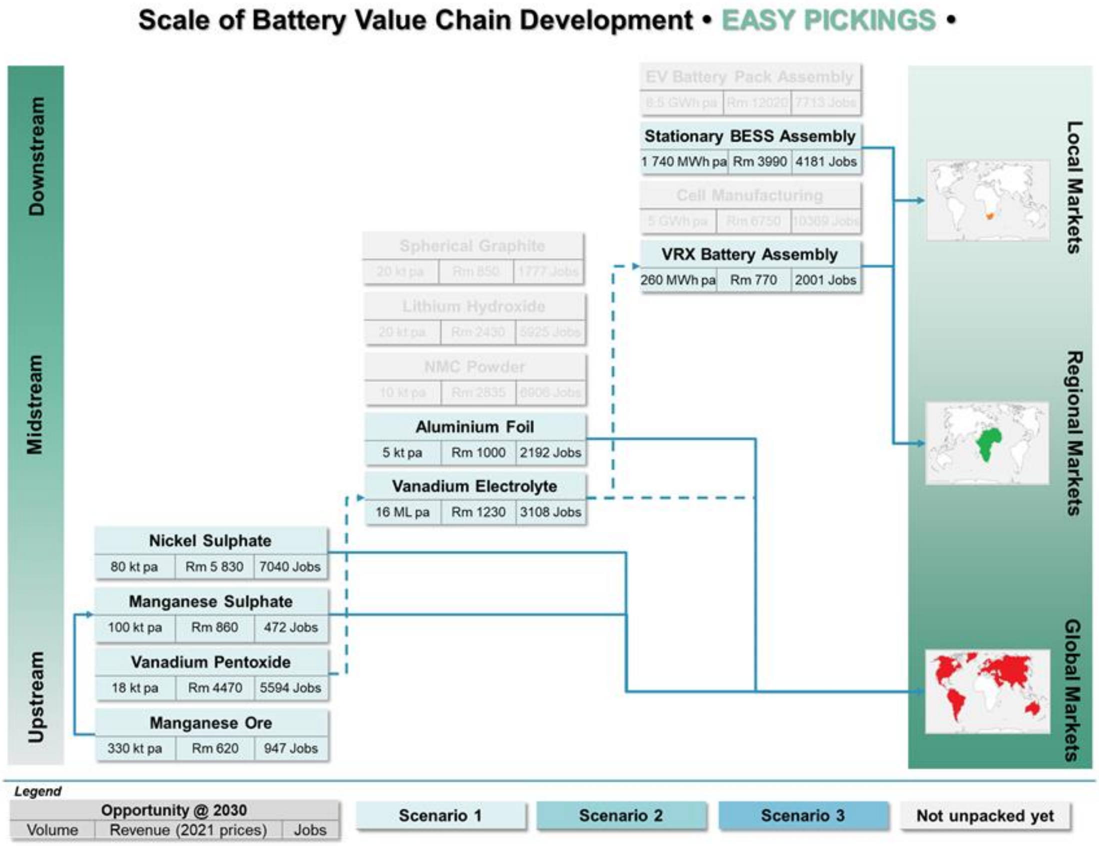
5.1.1 The Outline

This scenario builds on South Africa's strengths in mining, local battery material beneficiation, and battery energy storage systems integration to expand South Africa's participation in the global and local battery value chain. As summarised in Figure 33, this involves the expansion and initiation of up-stream and mid-stream manufacturing activities for the following battery grade materials, for global markets (mostly outside China):

- Manganese Sulphate
- Nickel Sulphate
- Vanadium pentoxide
- Vanadium electrolyte
- Aluminium foil for cathode current collectors.

On the down-stream side of the value chain, the focus would be on the development of the nascent lithium-ion BESS manufacturing industry in South Africa, to expand its scale and export reach. Moreover, the development of a local manufacturing capability for vanadium redox flow batteries (VRFB) is contemplated.

Figure 33: Scope and Scale of Battery Value Chain Development – EASY PICKINGS



This scenario builds on South Africa's existing strengths in battery minerals reserves, minerals and materials beneficiation, and BESS development, manufacturing and integration. These key strengths are summarised below.

Battery Minerals and Materials

1. Rich history of mining and minerals refining expertise, substantial industrial infrastructure in place.
2. South Africa accounts for about 23% of world Manganese ore reserves (and about 70% of global manganese or resources), and 62% of world's total Manganese ore production.
3. The country has 3.7% of world Nickel reserves and already produces class 1 nickel and crude Nickel Sulphate.
4. Local firm Manganese Metal Company (MMC) is a long-standing producer (since 1974) of electrolytic manganese metal (EMM), which is suitable for battery applications, operating the world's largest refinery of 99.9% (selenium-free) EMM. MMC is planning to diversify into the production of battery grade manganese sulphate for the global market.
5. Another local firm, Thakadu Battery Materials has recently started beneficiating crude Nickel Sulphate from local mining to battery grade Ni-Sulphate. The new Nickel Sulphate refinery uses proprietary process technology to purify crude Nickel Sulphate extracted from Platinum Group Metal (PGM) concentrate that would otherwise be sold as a lower value product. Targeting production of 16,000

tpa in 2021 with ramp up to steady state production of 25,000 tpa, Thakadu will refine crude nickel sulphate feed from its long-term supply agreement with Sibanye-Stillwater and other supplemental feed sources.

6. South Africa has the world's third largest vanadium reserves (18%) after China and Russia and is the third largest producer of Vanadium with about 8,200 tpa or 7% of the world production in 2020. South Africa's Vanadium is derived from primary production from Glencore and Bushveld Minerals.
7. Bushveld Energy is an emerging vertically integrated vanadium electrolyte producer with an electrolyte manufacturing facility under construction in the SEZ at Coega. Commissioning of the plant is planned for the second half of 2022.
8. Established Aluminium smelters in South Africa and Mozambique, notably Hillside Aluminium and Mozal, producing high grade aluminium metal for export markets (combined production capacity ~1.45 million tons per annum).
9. Local firm Hulamin, based in Pietermaritzburg, specialises in rolled Aluminium products and has the technical capability to produce Aluminium foil used as the current collector of the cathode.

Battery Energy Storage Systems (BESS)

1. Several private companies are already involved in battery pack development and assembly for stationary and selected mobility applications.
2. The companies source their battery cells from Asia, typically China, but design and develop their own battery management systems, software and power electronics, for which they own intellectual property. There is an established supply network for components, casings, electronics, and wiring for local manufacturing and assembly.
3. The companies have a small but established track record for export of battery packs to demanding markets (USA, Australia, Europe).
4. Bushveld Energy has already installed one vanadium redox flow battery at Eskom for testing and demonstration purposes. The company is actively exploring the local manufacture of VRFB for long-duration stationary energy storage applications in South Africa and the Southern African region.

5.1.2 Impact on GDP and Job Creation

To summarise, the **EASY PICKINGS scenario** is estimated to have a direct positive impact on GDP of about R6.5 billion per annum while the impact on employment is estimated at around 2,500 direct and 23,000 indirect jobs (Table 18). These numbers represent the sum of the estimated revenues and jobs associated with the various value chain stages shown in Figure 33 above.

Table 18: Impact on GDP and Jobs - EASY PICKINGS

EASY PICKINGS

Contribution to GDP		Contribution to jobs
R18 770 ml	Direct	2 455
	Indirect	23 080
R18 770 ml	**TOTAL**	**25 535**

5.2 Bridging the Divide

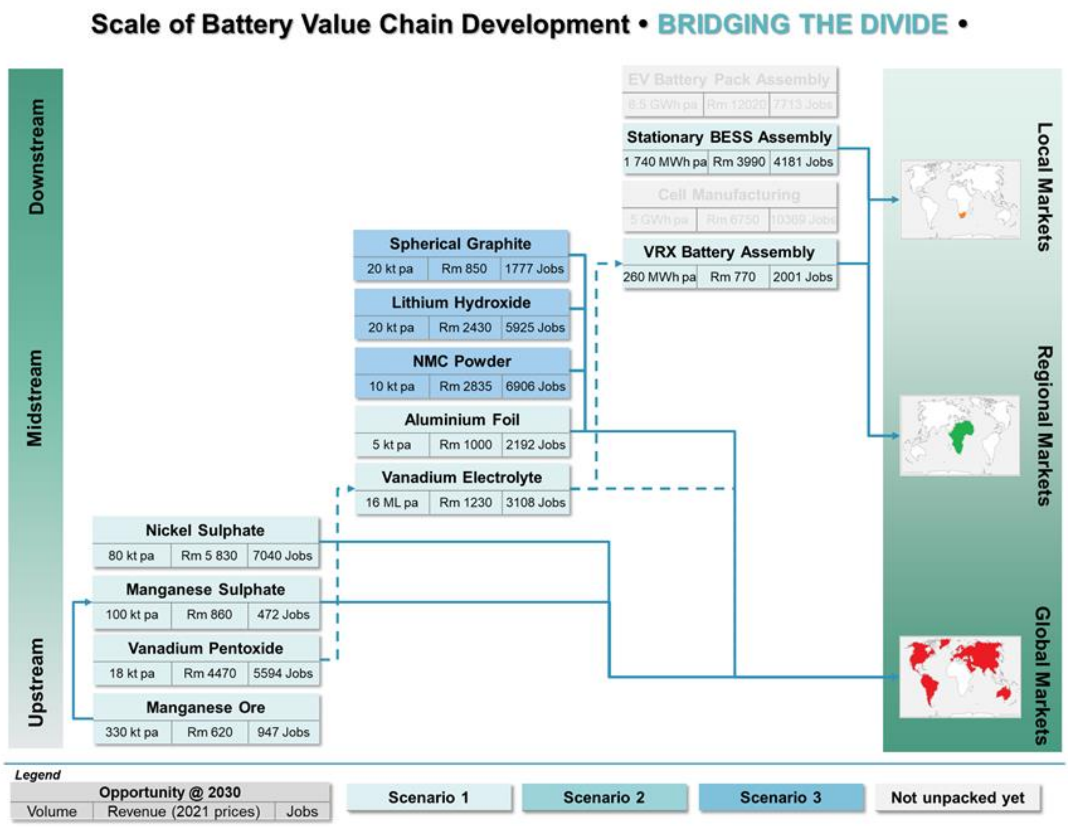
5.2.1 The Outline

This scenario focuses on the moderately achievable goals (over a 5-year period) on the journey towards stronger battery value participation. Considering the moderate implementation efforts and longer gestation periods, this roadmap proposes to build on the strengths of **Southern Africa**, in battery minerals and materials beneficiation, and BESS manufacturing. In particular, the development of a Regional Battery Mineral Beneficiation Hub in South Africa and larger scale BESS integration for FTM and BTM applications are envisaged.

As summarised in Figure 34 below, this involves the expansion and initiation of up-stream and mid-stream manufacturing activities to include the following battery materials, for global markets (mostly outside China):

- Lithium hydroxide (and/or carbonate)
- NCM cathode material (powder).

Figure 34: Scope and scale of Battery Value Chain Development - BRIDGING THE DIVIDE



As noted previously, the production of lithium hydroxide/carbonate would rely on imported spodumene concentrate from Zimbabwe for processing in South Africa while the NMC production would rely on local manganese and nickel precursors and cobalt-sulphate produced locally from concentrate imported from the DRC. Both these opportunities are currently being explored by the IDC.

On the down-stream side of the value chain, the focus would be on the continued development and expansion of the BESS manufacturing industry in South Africa, both LIB and VRFB.

The key strengths of the Southern African region which underpin this scenario are summarised below.

Battery Minerals and Materials

1. South Africa's favorable geographic location relative to key battery minerals – cobalt (DRC), lithium and nickel (Zimbabwe), copper (Zambia), graphite (Mozambique, Tanzania)
2. Storage technologies are seen boosting demand for four key battery metals - copper, nickel, cobalt and lithium, as countries across the globe step up their climate change mitigation ambitions. A resulting surge in prices for these minerals would bring boom times to some economies that are the biggest exporters, and the Southern African region stands to reap this benefit over time.
3. Trade agreements: In February 2019, South Africa deposited its instruments of ratification after parliament ratified the African Continental Free Trade Agreement (AfCFTA). When fully functional, the AfCFTA is expected to boast a total combined continental GDP of US$2.1 trillion for a total population of 1.3 billion people, with an African GDP growth between 1-3% and employment growth of 1.2%; this would see Africa as the 3rd largest market after China and India. South Africa has also led and entered into a duty-free Southern African Customs Union (SACU) through the Free Trade Agreement under the 14-membered Southern African Development Community (SADC) region. While most Intra-African trade comes from the SADC; the AfCFTA provides South Africa with an opportunity to realize a unified and diversified African market, free of trade barriers on a grander stage along with better coordination from the African Union (AU).
4. South Africa has potential to become a refining hub in Southern Africa for:
   - Nickel, Cobalt and Copper (existing refining capabilities), and Lithium and spherical Graphite
   - NMC / NCA active cathode material

   There is demonstrable expertise in Nickel and Cobalt refining, although still at a relatively small scale. Currently, most of the battery materials beneficiation is done outside Africa. However, a number of Southern African countries are actively exploring local beneficiation opportunities (e.g., Zimbabwe, Mozambique) and this could open the door for regional integration of a battery value chain.
5. Industrial Development Corporation (IDC) is currently assessing several industrial development projects along the Li-ion and Vanadium value chains.

Battery Energy Storage Systems (BESS)

1. In the medium term (over the next 5 years), South Africa is expected to show rapid growth in energy storage demand due to an accelerating transformation of the energy system to include more renewables and developing demand in the EV sector.
2. Additionally, there is a lot of scope for expansion of the South African battery pack manufacturing segment for export markets. Local battery company BlueNova Energy, has achieved significant milestones in the energy sector with its exports of intelligent Energy Storage System (iESS) and battery packs to Namibia, Botswana, and Mozambique. FreedomWon offers LIB packs targeted at storage applications and utility vehicles primarily across Southern and Western Africa, but also with a focus on Europe, Australia, and New Zealand. Durban-based battery manufacturer Maxwell and Spark, designs and assembles batteries and associated mobile systems and exports to Australia and is looking

at other export opportunities (Europe, North America). Bushveld Energy aims to be involved in the whole vanadium value chain and expand its operations to include VRFB manufacturing using locally sourced components.

5.2.2 Impact on GDP and Job Creation

To summarise, the **BRIDGING THE GAP scenario** is estimated to have a direct positive impact on GDP of about R24.9 billion per annum while the impact on employment is estimated to be around 3,200 direct and 37,000 indirect jobs (Table 19). It should be noted that these are cumulative numbers, i.e., this scenario incorporates the Easy Pickings scenario.

Table 19: Impact on GDP and Jobs – BRIDGING THE DIVIDE

BRIDGING THE DIVIDE

Contribution to GDP		Contribution to jobs
R24 885 ml	Direct	3 195
	Indirect	36 948
R24 885 ml	**TOTAL**	**40 143**

5.3 The Whole Nine Yards

5.3.1 The Outline

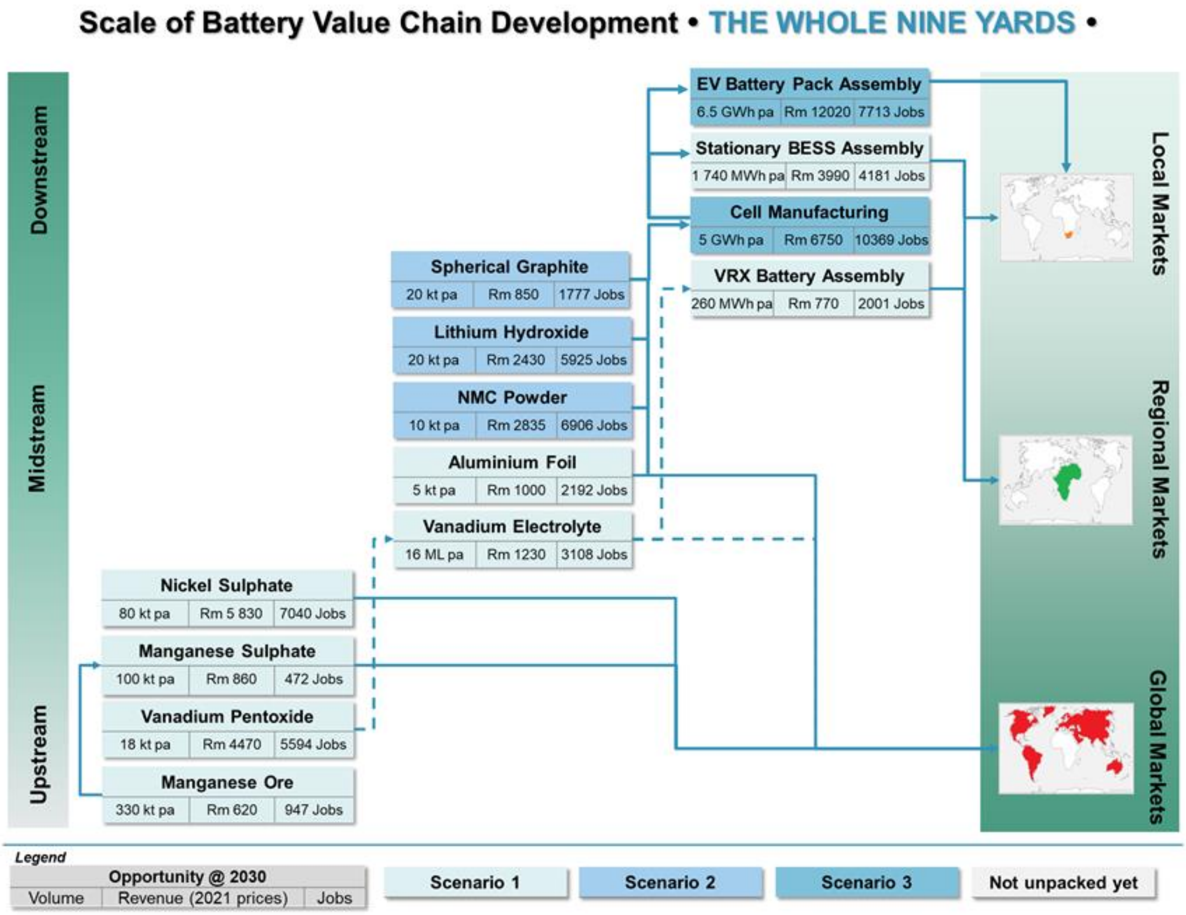
This scenario focuses on the long-term goals (over a 10-year period) on the journey towards stronger battery value chain participation. Considering significant implementation efforts and long gestation periods, this roadmap proposes to build an integrated battery value chain with scale (Figure 35), which involves the establishment of EV battery pack assembly operations as well as LIB cell production in South Africa.

The key driver for this scenario is the strategic importance of the existing automotive industry. As the largest manufacturing sector in the country's economy, a substantial 18.7% of value-addition within the domestic manufacturing output (in 2020) was derived from vehicle and automotive component manufacturing activity, continuing to position the industry and its broader value chain as a key player within South Africa's manufacturing and industrial landscape. More than 60% of local production is exported, of which, more than 70% of the exports go to Europe. Under the South African Automotive Masterplan 2021-2035, few key development objectives have been identified - grow South African vehicle production to 1% of global output and increase local content in South African assembled vehicles to up to 60%. Also, the South African automotive manufacturers have exclusively produced Internal Combustion Engine (ICE) powered vehicles for the past few decades. This demand is expected to decrease significantly by 2030 as key export markets in Europe and the USA rapidly migrate to electric vehicles.

This poses a very serious threat to the South African automotive industry, whose traditional strength is in the production of ICE vehicles. Hence, there is a strategic imperative of pivoting towards local EV production.

While local demand for EVs is expected to remain subdued in the foreseeable future due to affordability and charging infrastructure constraints, the opportunity exists to fast-track the migration of local vehicle production for export of EVs, leveraging existing automotive manufacturing expertise and manufacturing infrastructure, as well as leveraging existing automotive policies and incentives (with relevant amendments) to support such a transition. This should be pursued as a matter of priority and urgency.

Figure 35: Scope and scale of Battery Value Chain Development - THE WHOLE NINE YARDS



There is currently no commercial production of battery cells in South Africa, but some recent development could offer opportunities for moving in this direction. Local company Metair is an established manufacturer and supplier of components and batteries to local automotive manufacturers and the aftermarket. Through its Romanian subsidiary Rombat, Metair is active in the LIB space and has developed intellectual property at multiple levels:

- Manufacturing: developed its own modular, multi-level manufacturing line, which can be set up for about €15 million (compared to €30-€35 million traditionally)
- Chemistry: works on separators as well as the electrolyte
- Cells: develops cells, from LFP to NMC, particularly for low-temperature LIB (-30 ˚C to -35˚C)
- Subcomponent: develops machine and the electronic controls (BMS)

Compared to other local players, Metair is a key components supplier with a global footprint, thus the company has the advantage of existing relationships and partnerships with leading OEMs in the global automotive value chain.

AutoX and Megamillion have also announced their plans to build their own battery manufacturing facilities for manufacturing LIB cells. However, these are at a very early stage of development.

Given the structure of the EV industry globally, it is highly likely that a successful establishment of local LIB cell manufacturing would require South Africa to attract at least one leading cell manufacturer (e.g., CATL, LG Chem, etc.) to establish a local manufacturing facility, linked to one or more automotive OEMs.

5.3.2 Impact on GDP and Job Creation

To summarise, the **WHOLE NINE YARDS scenario** is estimated to have a direct positive impact on GDP of about R43.6 billion per annum while the impact on employment is estimated at around 4,100 direct and 54,100 indirect jobs (Table 20). It should be noted that these are cumulative numbers, i.e., this scenario incorporates both the **EASY PICKINGS** and the **BRIDGING THE DIVIDE scenarios**.

Table 20: Impact on GDP and Jobs – THE WHOLE NINE YARDS

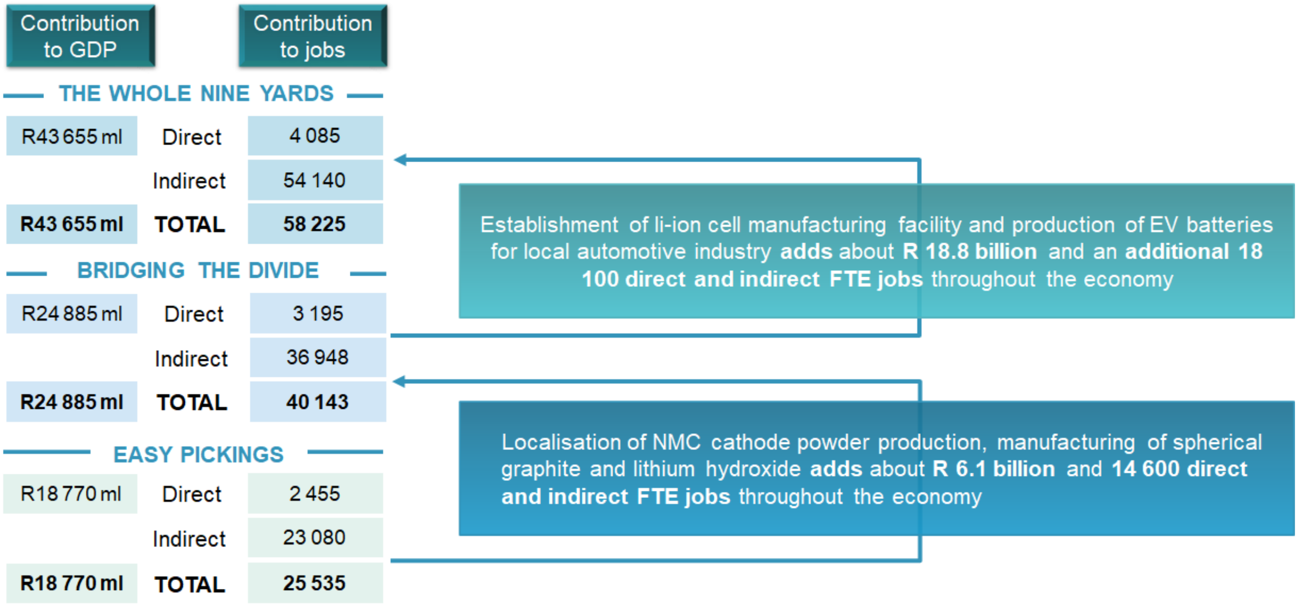
THE WHOLE NINE YARDS

Contribution to GDP		Contribution to jobs
R43 655 ml	Direct	4 085
	Indirect	54 140
R43 655 ml	**TOTAL**	**58 225**

5.4 Scenario Impact Comparison

It is clear that the impact on GDP and job creation increases significantly from the lowest to the most ambitious scenario. As summarised in Figure 36, the **EASY PICKINGS scenario** is already estimated to lead to positive impact on GDP and job creation of R 18.8 billion and 25,500 direct and indirect jobs, respectively.

Figure 36: Impact on GDP and Jobs in South Africa through Battery Value Chain scenarios



The establishment of the local production of spherical graphite, lithium hydroxide and/or carbonate as well as NCM cathode powder in the BRIDGING THE DIVIDE scenario has the potential of adding a further R 6.1 billion and 14,600 direct and indirect jobs. Finally, in the FULL NINE YARDS scenario, the establishment of battery value chains at scale could add a further R 18.8 billion to GDP and an additional 18,100 direct and indirect jobs.

It was noted earlier that leading countries and regions such as China, the USA, and Europe are utilising substantial government policies and support programmes to foster the adoption of EVs and renewable energy to grow demand for BESS as well as attract private investments into local battery manufacturing to foster the development of local scientific and technological expertise. Examples and case studies of global support programmes for development of battery value chains, Giga Factories, and EV adoption are discussed in the following chapter. Recommendations are made in Chapter 7 on the use of government policy and other support measures in South Africa, which could facilitate the development of the scenario roadmap discussed above.

6. Global Case Studies

This section of the report elaborates a set of global case studies that the South African battery industry and the government may refer to while making policy decisions. These case studies includes analysis of the development and policies in battery value chain in other countries. These countries have already progressed or are planning to progress to increase their participation in the battery value chain:

Table 21: List of Case Studies

SR NO	*CASE STUDIES*
1.	*Western Australia: Future Battery Industry Strategy*
2.	*Indonesia: Nickel Ore Ban and Consortium Creation for Smelting and Processing of Nickel Ore*
3.	*Global and Regional: EV and Charging Infrastructure Roadmap: Adoption Targets till 2030*
4.	*Indonesia: Engaging Global Companies for Localisation of EV and Cell Manufacturing*
5.	*India and Thailand: Cell Manufacturing Subsidy Programs*

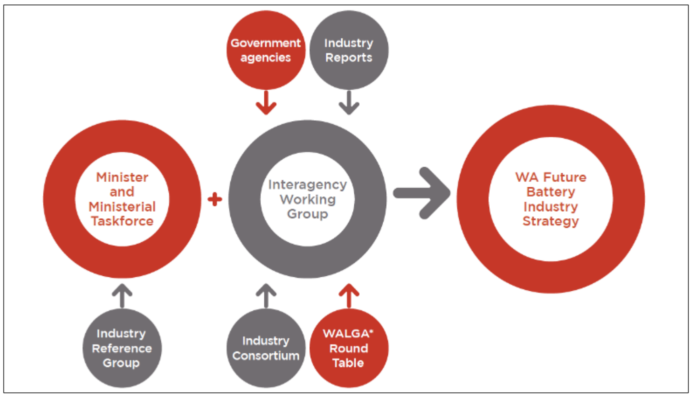
6.1 Western Australia: Future Battery Industry Strategy

Future Battery Industry Strategy developed by Western Australian Government in 2019 is an effort in this direction to make Western Australia a central player in the global battery manufacturing supply chain. To achieve this, a well-informed framework is prepared that builds on the existing expertise of mining and mineral processing.

As mentioned in the Western Australia's Future Battery Industry Strategy document, battery related mineral export from WA (Western Australia) constitute one third of Australia's exports and 4% of total global supply, making it an important player in the upper stream of the battery supply chain. Ideal future pathway is increasing the local value addition in the further stages of supply chain. As an initial step, supply chain is divided into different stages and maximum possible local value addition is quantified for each stage to avoid misplaced focus. Multiple supply chain stages thus identified possesses different level of technological maturity and infrastructure in place requiring different types of supporting policies in varying quantum. An optimum distribution of projects across various stages taking note of differences in type and quantity of required support, four action themes are identified.

WA Government has formed a Ministerial taskforce with an industry reference group. This taskforce continuously guided the interagency working group formed out of industry consortium and various government agencies. With an input from industry reports and round table discussion, WA future battery industry strategy was formulated.

Figure 37: WA Taskforce and process for creation of Future Battery Value Chain Strategy



Source: WA Future Battery Industry Strategy document

WA Government will deliver its vision by focusing on 5 objectives. Following are the objectives that have been documented in the strategy report:

1) Western Australia to be recognized as leading producer of battery minerals and materials, technology
2) Improve the competitiveness of WA's future battery minerals and materials industry
3) Expand the range of the future battery minerals extracted and processed in WA
4) Increase the scale of processing, manufacturing and service activities across the breadth of the value chain in WA
5) Increase R&D focused on battery materials and minerals, associated technology

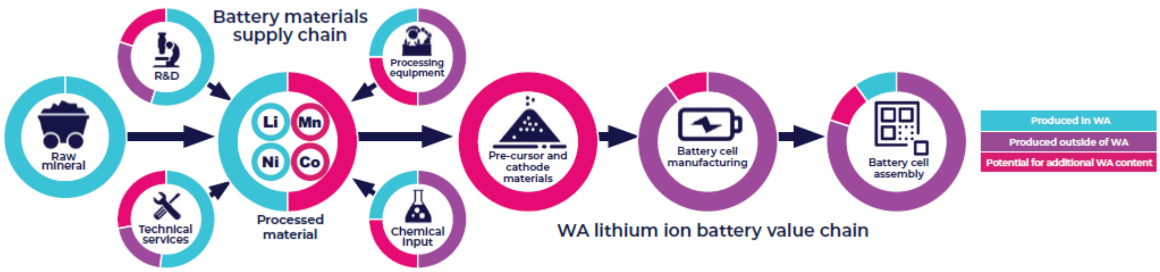
Each objective is achieved by 4 cross-cutting action themes identified for the purpose of optimum distribution of supportive policies and projects:

1) **Attract Investment:** WA Government to undertake various initiatives and activities to make WA an attractive destination for international investors looking for opportunities in battery manufacturing
2) **Project Facilitation:** WA Government to facilitate projects by providing investment ready industrial land, reliable access to energy and water, single point entry and priority status for project approvals, export infrastructure and access to state funding
3) **Research and technology sector development:** WA Government will support research projects related to future battery manufacturing. For this purpose, research centre called FBI-CRC had been established in 2019 with an initial funding of $6 million from WA Government
4) **Adoption of battery technology:** WA Government plans to adopt battery technology for various applications to create a strong demand from domestic market that can act as a catalyst for growing battery mineral and material industry. Government envisages to achieve this by identifying innovative battery applications like grid connected battery storage in remote areas, Electric vehicles etc.

All these individual action themes, either individually or combined, will create different pathways to achieve the 5 identified objectives.

With the five objectives as the guiding principles, and based on the existing mining expertise, WA Government had identified the level of opportunities available at different stages of battery supply chain as shown in Figure 38.

Figure 38: Opportunities for WA in global battery value chain



Source: Strategy Update Western Australia's Future Battery and Critical Minerals Industries (November 2020 – November 2022)

Raw mineral extraction involves the fullest value adding potential with Lithium and Nickel being extracted using the full potential for value addition. Manganese and Cobalt extraction have potential for more local value addition. WA Government identified manufacturing of pre-cursor and cathode materials as the stage that has highest potential for local value addition. It hopes raw material process to produce pre-cursor and cathode materials can act as a step towards further downstream value addition

Other than Western Australia, other battery mineral mining countries like Argentina and Chile have not yet defined a clear battery value chain strategy.

Key Takeaway: To layout a national vision in the mineral beneficiation and battery raw material manufacturing plan can be the first logical step for South Africa. Only limitations of such strategy documentations are that they don't emphasis on plans of making processing more commercially viable in their particular geographies.

The South Africa government along with such strategy documents can plan certain incentives to attract more companies. This can be approached by restricting export of ores to an extent or by providing export credits.

6.2 Indonesia: Nickel Ore Ban and Consortium for Smelting & Processing of Nickel Ore

Indonesia supplied around 30% of global Nickel production for the year 2021. In line with the ever-increasing global demand for this battery material, the Indonesian Government plans to expand the capacity of its mining and minerals processing industry further. Additionally, the Indonesian Government introduced a ban on export of its Nickel ore in 2019 and this ban became effective from 2020. This ban is expected to achieve the following goals:

- Preserve its Nickel ore for rapidly growing domestic nickel smelting and nickel pig iron industry
- Boost the processing of low-grade nickel ore that can support the EV battery manufacturing and other nickel value added product industries

In 2014, a similar ban on nickel ore export was imposed in Indonesia that resulted in a major Chinese stainless steel manufacturer, Tsingshan, to invest locally in downstream nickel processing and nickel pig iron (NPI) manufacturing. NPI is a raw material used by steel industry. Indonesia's NPI production grew from zero in 2014 to 500,000 tons by 2020.

This time the ban is expected to create investments opportunities in downstream activities linked to battery value chain. To process the ban induced nickel ore that is posed to accumulate in the domestic market, the Government plans to expand the capacity of its nickel smelting industry and a State holding company called Indonesia Battery Corporation (IBC) is kept in charge. IBC is formed out of four State Enterprises operating in oil exploration (PERTAMINA), mining (MIND ID), Nickel & Gold mining (ANTAM) and Electricity (PLN).

As on date, South Korean multi-national corporation LG had committed an investment of $ 10 billion in activities spanning the entire supply chain from mining to precursor manufacturing in Indonesia. Smelting capacity is expected to increase with addition of eight projects with a combined capacity of 450,000 tonnes of Nickel and 150,000 tonnes of Cobalt. By 2028, Indonesia is expected to supply 60% of world's nickel compared to today's 30%.

Key Takeaway: South Africa can impose such restrictions on ore exports to boost local mineral beneficiation and processing. Through the African Continental Free Trade Agreement (AfCFTA), South Africa can call for such measures at regional level. When fully functional, the AfCFTA is expected to boast a total combined continental GDP of US$2.1 trillion to benefit and a total population of 1.3 billion people, with an African GDP growth estimated between 1-3% and employment growth of 1.2%; this would position Africa as the 3rd largest market after China and India. South Africa has also led and entered into a duty free Southern African Customs Union (SACU) and the Free Trade Agreement in the 14-membered Southern African Development Community (SADC) region. While most Intra-African trade comes from the SADC; the AfCFTA provides South Africa with an opportunity to realise a unified and diversified African market free of trade barriers on a grander stage with better coordination from the African Union.

To compete on this front with economies like China and India, through AfCTA, South Africa must look at the regional integration plan for battery value chains in order front to attract more investments. As such, local projects and manufacturing industries may allow processed battery materials coming from AfCTA region as part of the local content. There can be a single window facility created for clean tech investors to set up processing plants at suitable locations for mined material available in the neighbouring countries.

6.3 Global and Regional: EV and Charging Infrastructure Roadmap: Adoption Targets till 2030

The penetration of EVs in markets like Europe and China have crossed double digit percentages and it is very likely that the global EV sales trend, sooner or later, will impact the South African automobile market. As per analysis done in the report, the South Africa automobile market is lagging behind these markets by about a decade. Even if the market keeps lagging in 2030 by a similar time frame, the demand for Li ion batteries in the country would hit close to 8 GWh. Over 80% of this demand is likely to be generated by electric mobility demand. This demand in 2030 and beyond can potentially support Giga Factories. And these factories can drive local processing businesses alongside catering to the global demand. It is very important for the South African government to have a clear vision on growth of EVs in the country. It will not only support the development of the local battery value chain, but also enable higher use of electricity (via renewables) while savings the country on their oil import bill. These benefits can be targeted in incentivising the development of EVs and EV charging infrastructure, including EV tariffs that can spur market demand. Presently, several PHEV and HEV models are available in South Africa. Although battery prices are falling every year, thereby making EVs affordable for the consumers, several government measures like tax exemptions/rebates for purchasing EVs, reduction in VAT, road tax waivers, and investment in public EV charging are strongly needed.

Initially, as the price of both EVs and batteries were significantly high, earlier subsidy programs around electric vehicles were very costly for national and state governments across the world. However, in 2015, the Chinese government under China's New Electric Vehicle (NEV) subsidy program was subsidising the price of BEVs by $5,000-8,600 and in 2020, the price subsidy by the national government was in the range of $2,500-3,500. This subsidy scheme is likely to be reduced by up to 30% in 2022.

In Europe, the EV market is another such example where high subsidies are provided to support BEV sales. Germany, with a target of 1 million EVs on road in 2020, extended its subsidy program of providing up to $10,000 in benefits on new EV purchases. This scheme is likely to continue till 2025.

Furthermore, subsidy programs in other countries like India also offer lower subsidies per electric vehicle. For example, India introduced the FAME 2 (Faster Adoption and Manufacturing of Electric Vehicles in India) Scheme with an outlay of approximately $2 billion, for a period of 3 years, commencing from 1st April 2019, which is now extended by another two years. Out of total budgetary support, about 86 percent of funding has been allocated for Demand Incentive, so as to create demand for Electric Vehicles in the country (x number of EVs) as shown in Table 22. In addition, creation of Charging Infrastructure will also be supported under the Scheme.

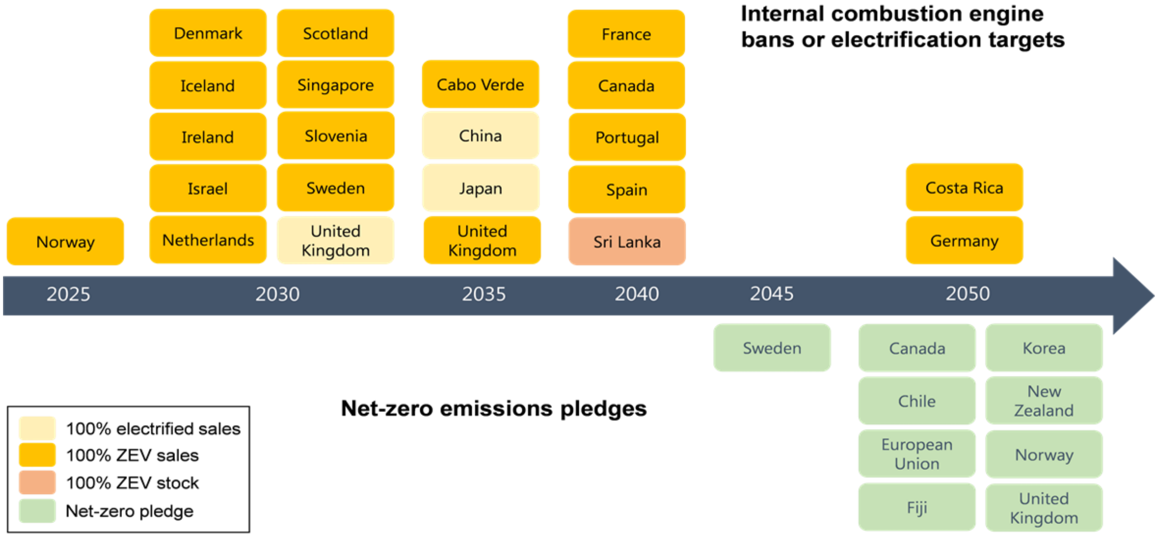
Table 22: Budget Outlay of FAME 2 Scheme

Category	Subsidy per vehicle* ($)	Total Fund Support ($m)
e 2W	500	267
e 3W	670	333
e 4W	2000	700
4W Strong Hybrid Vehicle	170	3
e-Bus	67000	473
Charging Infra		133
TOTAL		$~2 billion

* Calculated from INR per kWh subsidy mentioned in FAME 2 document (Source: CES analysis)

South Africa can analyse these schemes for its own automobile sales and infrastructure growth plan. The government would also need to devise a vision for vehicle penetration as done by many countries as shown in Figure 39.

Figure 39: Vehicle Electrification Targets Timeline (Source: IEA Report 2021)



Key Takeaway: South Africa can draw inspiration from some of these countries which have taken steps in the right direction of opening up their national EV markets. As such, some simple policy measures that can be adopted by the South African government are as follows:

i. Setting targets for EV penetration/sales for the next ten years
ii. Incentivizing local EV and EV component manufacturing
iii. Implementing Tax breaks/benefits for customers buying electric vehicles

Many nations in the region like Uganda and Rwanda have already taken small steps in the right direction to open up their national market for electric mobility as outlined below:

6.3.1. Uganda

As mentioned in **National Resistance Movement (NRM) Manifesto** 2021 – 2026, published in November 2020, the government of Uganda will invest $110 million in local vehicle manufacturing, in which EVs will also be included. The Government of Uganda has invested to incorporate a vehicle company called Kiira Motors, which has developed electric cars and electric buses in technology collaboration with China.

The NRM (National Resistance Movement) government has secured a World Manufacturers' Identifier for manufactured vehicles from the International Society of Automotive Engineers (SAE). This implies that vehicles assembled in Uganda can now be uniquely identified in the international market, paving the way for the export of vehicles made domestically in Uganda.

6.3.2. Rwanda

Rwanda has announced different incentives for the uptake of electric vehicles in the country. These incentives comprise of lower electric vehicle charging tariffs and lower tax rates on EVs. The electricity tariffs for charging stations will be priced at the industrial tariff level. The EV charging tariff will be fixed at Rwf 94 per kWh (0.093

USD per kWh). The energy costs for electric vehicle owners will be further reduced, as they will also be incentivized through an off-peak charging tariff from 11:00 p.m. to 08:00 a.m.

The Rwandan government during a cabinet meeting in April 2021 also decide to provide tax incentives on the import of electric vehicles and their parts as mentioned in the table below.

Table 23: Tax Incentives for EVs in Rwanda

	ICE Vehicle	Electric Vehicle
VAT	18%	NIL
Excise Duty	5-15%	NIL
Import Duty	25%	NIL
Withholding Tax on Spare Parts	5%	NIL

Source: Ministry of Trade, Rwanda

Rwanda too, like Uganda, has taken steps to encourage local manufacturing of EV components as it plans to provide tax holidays and an attractive Corporate Income Tax set at 15% for local assembling of EVs. This incentive is likely to encourage companies like Ampersand and Volkswagen Rwanda to not only sell EVs in the market but also make them locally.

Key Takeaway: The incentives proposed by the Government of Rwanda can become the cornerstone of electric mobility policies for the Southern African region. South Africa government can weigh the benefits of lower tax on EVs and can also consider a favourable electricity tariff structure for EVs to drive their growth.

6.3.3. Kenya

Kenya is one of the first countries in the region to set the target of 5% EVs on road by 2025. The first policy change in the direction to help EV sales has been the reduction of import duty from 20% to 10% on EVs. However, the Kenyan government needs to formulate policies for promoting indigenous assembling of electric vehicles and components, to achieve their stated target by 2025. This would necessitate Kenya having 160,000+ electric vehicles by 2025 against the 300 reported in 2020.

6.4 Indonesia: Engaging Global Companies for Localisation of EV and Cell Manufacturing

Like South Africa, Indonesia is blessed with abundant mineral resources for manufacturing of Li-ion batteries including infrastructure to further process the extracted resources as well as having a developed automobile industry that exports automobiles and spare parts to more than 100 countries. Indonesia plans to build upon these advantages to develop an end-to-end supply chain presence. It envisages to do this by entering into joint partnerships with world renowned companies and benefit from the transfer of technology and know-how. However, there are environmental concerns from downstream participants regarding ability of Indonesia to produce nickel without significant ecological impact. Hence, it will be important for mineral rich countries to address such issues while scaling up mining and processing operations.

As the total cost of ownership of electric vehicles is not competitive w.r.t. ICE technology, the export of EVs to foreign markets can be a short-term solution before EVs become competitive in the domestic market for Indonesia. Nonetheless, the Indonesian Government had recognised the convergence of electricity, transport, and mining sectors in the economy. In this context, Indonesia has also integrated the national electricity company PT PLN as one of the four members of the holding company IBC (Indonesia Battery Corporation) responsible for local battery value chain development.

On a smaller scale, the Nobel Peace Prize laureate, Abiy Ahmed Ali, the Prime Minister of Ethiopia, under his greening campaign has set manufacturing of electric vehicles as an important target in Ethiopia. His request to Hyundai Motors led to the company locally assembling its first EV in Ethiopia in 2020 through one of its dealerships. It is understood that the electric vehicle assembling plant set up by Marathon Motors (a Hyundai dealership) can ramp up to 10,000 cars per year with local and regional demand coming in place.

Key Takeaway: South Africa is one of the significant auto manufacturing hubs in the world with close to 1% manufacturing share. The country already boasts the local presence of automobile giants like Toyota, Volkswagen, Daimler, Nissan, Ford, and many others. Moreover, local manufacturers are trying to roll out e-cars. In addition, Toyota has announced an investment of $291 million in its local operations and has assigned $160 million to produce new passenger-car models in Durban.

Most of these auto giants export significant share of cars and other vehicles to the Middle East and the European market from South Africa. As global EV sales are picking up, many of these companies are transitioning in a big way towards NEV (New Energy Vehicles) and considering certain percentage of EV productions at all the global plants. The South African government should plan with these global giants to start EV manufacturing in the country and provide them with suitable infrastructure and provide auto-ancillary companies some incentives to add EV component manufacturing capabilities. With commitments from these auto companies, South Africa would be in position to take a holistic look at the local battery supply chain and also target cell manufacturing in the country.

6.5 India and Thailand: Cell Manufacturing Subsidy Programs

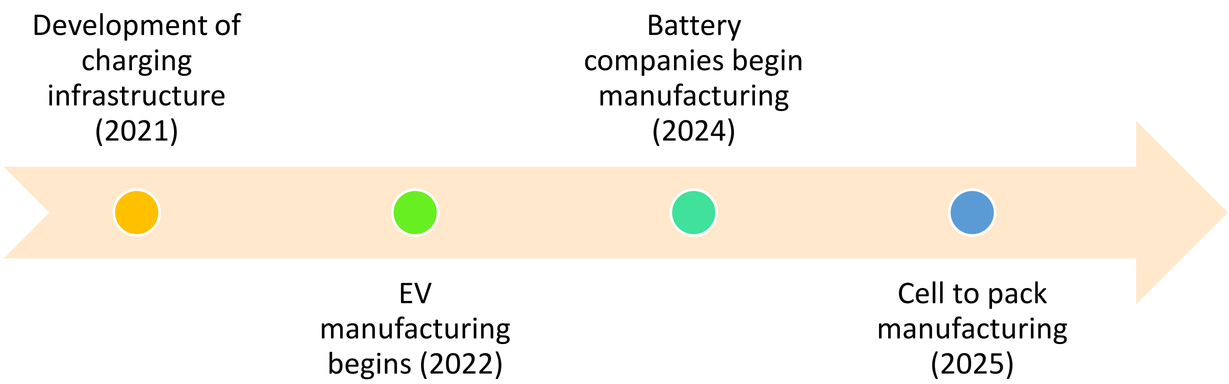
China, Europe, and the US are marching ahead compared to the rest of the world in terms of advanced battery manufacturing capacity, especially in Li-ion cell manufacturing capacity. It is estimated that between China, Europe, and the US, there would be close to 1000 GWh of cell manufacturing by 2025. South Africa can take inspiration from these countries for starting its own cell manufacturing program but practically it will be difficult for South Africa to attain the scale of expansion and their budget outlay around this sector. Hence in this report, countries like Thailand and India are studied in terms of schemes for supporting battery cell manufacturing indicating 50 GWh and 20 GWh respectively as shown in **Error! Reference source not found.**. As per the market projections for 2030 and beyond for South Africa, it can target 20-25 GWh of Giga Factories by 2030. ACC (Advanced Chemistry Cell) PLI (Production Linked Incentive) schemes of the Indian government is a good reference for South Africa as the scheme deals with subsidies in the form of a “production linked subsidy of up to 20% of cell price or $30 per kWh”, whichever is lower. Under this scheme both local and international companies can bid for 5 to 20 GWh of capacities and they need to commit to 60% indigenous value addition in three years from production. Such schemes not only provide impetus for local cell manufacturing but also promotes creation of battery value chains in the country.

Table 24: Support Programmes in India and Thailand for supporting Battery Manufacturing (CES Analysis)

	India	Thailand
Program	Advanced Chemistry Cell (ACC) Production Linked Incentive (PLI) Programme	Thailand Board of Investment (BOI) EV and components manufacturing package
Budget Outlay	$ 2.5 Bn	$ 1.1 Bn
Production Target	50 GWh by 2028	30% EV by 2030, estimated 20 GWh by 2025
Incentive Support	Sales linked subsidy of upto 20% of cell price for 5 years of production. Program requires local manufacturer to capture 60% of local value addition in first 5 years	3 years tax holiday, 8 years corporate tax exemption and 90% reduction in import duty on key raw materials to encourage cell and pack manufacturing The BOI approved the reinstatement of the International Procurement Office (IPO) category with the aim to strengthen Thailand's position as the regional business and investment hub.
Other Support	Apart from the ACC PLI, several state governments are also providing capital subsidy in tune of 10-25% and tax and duty exemptions on electricity tariffs/	IPO businesses will get import duty exemptions on machinery and raw materials for use in production for exports, as part of the policy to promote the development of the country's supply chain.

Indonesia, on the other hand, to cater to the expected increase in demand from the automobile industry, created Indonesia Battery Corporation (IBC) with mandate to sign partnerships with various international players for indigenous battery manufacturing. IBC is comprised of four state owned enterprises, each with a different mandate. One of the IBC shareholders, PT Pertamina, an Indonesian Oil & Natural gas company is tasked with construction and operations of precursor plants, cathode plants, battery cells & battery pack plants, and battery recycling plants. Inclusion of an oil & gas company to be in-charge of developing battery precursors, cathodes, and a battery manufacturing plant ensures avoidance of job losses in this sector. A strategy roadmap is created accordingly as shown in Figure 40.

Figure 40: Strategy Roadmap for creation of integrated battery value chain in Indonesia



As per the strategy roadmap, the Government of Indonesia has already signed MOUs with CATL and LG group and is optimistic about their domestic battery manufacturing capacity reaching 140 GWh and becoming a key supplier to the EU, the US, and the Asia Pacific.

Thailand is targeting 30% EV penetration by 2030 and aims to support the EV and component industry by extending tax rebates and holidays to cell manufacturing and other industries. Energy Absolute and GPSC are two Thai companies which have already announced ambitions to build Giga Factories in the country.

Key Takeaway: With the scale of more than 25 GWh of cell manufacturing as a target by 2035, such programmes would cost South Africa around $1 billion, which will help the local industry to compete with geographies like Thailand, India, Europe, and others. The Government of South Africa can support such programmes with savings achieved through reduction in oil import bills with higher EV penetration and also with the support of institutes like the African Development Bank and the World Bank.

7. Project Relevance from a Policy Perspective

South Africa has one of the most industrialized, technologically advanced and diversified economies in Africa and is the second largest economy in Africa (African Development Bank , 2020). Prior to the COVID-19 Pandemic, South Africa was the second most competitive economy in the sub-Saharan Africa in terms of the Global Competitiveness Index (GCI) with a well-developed financial system and specifically equity, insurance, and credit markets (WEF, 2019).

In the past decades, however, the economy of the nation has been struggling to achieve the 5% growth rate that was articulated in the **National Development Plan (NDP) 2030** to be required to reduce the unemployment to 6% by 2030 and in doing so increase the number of employed from 13 million in 2010 to 24 million in 2030. In the last decade, the economy experienced two periods of recessions – first in 2015 linked to the electricity crises and second in 2020 linked to the onset of COVID-19 pandemic. The COVID-19 pandemic has highlighted the structural problems and the extreme vulnerability of the country's economy and as stated by President Cyril Ramaphosa in his closing remarks to the ANC NEC Lekgotla "the extent of poverty and deprivation in our society in much starker than ever before". Indeed, the latest Quarterly Labour Force Survey released by Statistics South Africa suggests the country's unemployment rate increased to 34.4% in the second quarter of 2021 (Statistics South Africa, 2021b), taking it further away from the 2030 vision.

Recognising the need to revitalise and reenergise the country's economy, government released **Re-Imagined Industrial Strategy** in 2019. Industrialisation, investment and infrastructure, innovation, integration, and inclusion have been identified as five key engines to restart the economy and facilitate its speedy recovery and sustainable growth (the dtic, 2019). Improvement of the industrial performance was seen to be enabled through the formulation of master plans for various sectors, including the Energy Renewables and Gas and Mining, Minerals, and Beneficiation.

The Re-Imagined Industrial Strategy recognised the potential opportunities that are linked to, among others, the manganese and vanadium reserves that South Africa is endowed with. The strategy made a specific reference to the development of a local battery manufacturing industry to support utility-scale and automotive energy storage. This opportunity was also echoed in the Strategy's interventions preliminary identified for the Renewable Energy and Gas sector, which called for the development of "domestic capability to manufacture new green technologies including batteries for autos and the grid…" (the dtic, 2019).

In 2020, which showed South Africa's extreme vulnerability to exogenous shocks such as COVID-19 pandemic, the government has released a new plan aimed to outline the path to economic recovery. **The South African Economic Reconstruction and Recovery Plan (ERRP)** encompasses a wide range of priority interventions, which focus on stimulating the socio-economic development to bring it back on course to achieve the targets set out in the NDP. Among these interventions is the re-industrialisation of the economy through localisation, which is envisaged to include among others mineral beneficiation. In this context, the ERRP targets building of minerals value chains that are linked to the strategic minerals.

The potential that the development of minerals value chains has also been recognised by the Department of Mineral Resources and Energy (DMRE) in its **Strategic Plan for 2020-2025**. The focus on energy storage by the DMRE, however, is not only linked to the potential opportunities that the associated value chain development can bring in terms of job creation and employment but also the role energy storage can play in successfully managing the deployment of renewables in the country and supporting Just Energy Transition (JET).

In his closing remarks on 6 September 2021 at ANC NEC Lekgotla, President Cyril Ramaphosa reiterated the dual benefits that transitioning to a low-carbon economy can bring. While furthering the country's environmental protection objectives, the inclusion and growth of battery storage among others green technologies is envisaged to also to assist in job creation.

8. Recommendations

This section summarises recommendations regarding a potential development path for a South African battery value chain, and possible policy and support measures that could be applied to support such a battery industry development.

8.1 Battery Value Chain Development Ambitions and Pathway

Based on the findings outlined in the previous sections of this report, it is concluded that South Africa is well positioned to participate in the global battery value chains through the local mining, refining, and beneficiation of battery minerals. The country has a particularly favourable position in manganese, vanadium, nickel (to some extent), and also produces aluminium foil. These are all important battery minerals/materials. Other important minerals are located in other African countries (lithium in Zimbabwe, graphite in Mozambique and Tanzania, cobalt in the DRC, and copper in Zambia), which could offer a source of raw material for local beneficiation.

South Africa is also host to a well-developed and sophisticated automotive industry, with well-developed supply chains, organised in automotive supplier parks, which is an important contributor to the South African economy and employment. Automotive vehicle and component exports, mainly to Europe and the USA, account for close to 60% of local production. These markets are rapidly shifting towards e-mobility, hence it is imperative that the South African automotive industry also pivots towards the local production of electric vehicles and components. This, in turn, would also be the key lever that could stimulate the establishment of battery system components manufacture and assembly, including cells.

This report has identified **three development scenarios** for a local battery value chain (Section 5):

i.	Easy Pickings:	Local battery mineral refining and beneficiation, BESS manufacture and integration
ii.	Bridging the Divide:	Regional battery mineral beneficiation hub Larger-scale BESS production for FTM and BTM applications
iii.	The Whole Nine Yards:	EV battery production (components and assembly) Battery cell production Integrated battery value chain

These scenarios can be seen as stages on the pathway towards the development of an integrated battery value chain in South Africa which, given the country's position in battery minerals and the strategic nature of the local automotive industry, should be South Africa's stated policy ambition (see Recommendation 1). The following sections provide further recommendation on enabling policy support measures to support this vision.

Recommendations 1

Strategic intent

i. Support the growth of the nascent battery minerals refining and battery pack manufacturing industry in South Africa (1 – 2 years)
ii. Support the expansion of local battery mineral refining/beneficiation to include lithium, graphite and cobalt from other African countries (regional battery mineral beneficiation hub) (3 - 5 years)
iii. Target the development of an integrated value chain including EV battery and battery cell production as a 10-year policy ambition.

8.2 Policy and Support Measures

A key role of government would be to increase the focus of industrial policy on the development of the local battery value chain. Local EV production would of course be a key focus area, but other opportunities along the value chain such as minerals and battery materials production and the manufacture of stationary and industrial energy storage systems should also be prioritized.

The recent Intellidex[23] study on localization analyzed the success or otherwise of past industrial policies in South Africa, as well as a number of international case studies. Based on these analyses and the experience with the successful automotive (APDP) and renewable energy (REIPPP) policies, the following components of industrial policy should be prioritized in future: clear policy design, coordination and trust between public and private sectors, ensuring sufficient capacity in public sector monitoring (e.g. sector desk in relevant government department), careful design of programmes and incentives. Moreover, both the successful policies (APDP and REIPPP) focused on domestic production and value chain integration, rather than only one subsector or segment in the value chain. Overarching recommendations that can be derived from these lessons for the battery value chain development are summarised in the text box below.

Recommendations 2

Overarching recommendations for battery value chain policy

i. Send clear, positive policy signals for the development of the local battery value chain.
ii. Focus on maximising domestic production across the whole battery value chain.
iii. Develop mutual trust and coordination by extensive engagements between public and private sector as part of the design of programmes and incentives.
iv. Consider establishing a directorate in the DTIC for the establishment of a battery value chain in South Africa. This should work closely with relevant other directorates such as automotive.

[23] Intellidex, 21 May 2021. Localisation: What is Realistic?

8.2.1 Easy Pickings

Numerous companies in South Africa are already engaged in the mining and refining of battery minerals, as well as the development and manufacture of battery packs, as outlined in Sections 4.2 and 4.3. Government focus here should be on supporting the growth of these sectors by creating an enabling environment for private investment and reducing the factors that hinder growth.

Although most battery minerals can be found in South Africa and Southern Africa, mineral beneficiation in South Africa has actually been in decline for numerous years. A key contributing factor is the **constrained electricity supply and rapidly rising electricity costs**. Furthermore, most of the electricity is derived from coal-fired power stations, which is a substantial disadvantage since downstream players such as automotive OEMs have increasing pressures and targets regarding environmental, social and governance responsibilities. Interventions are required to increase the proportion of renewables in the energy mix and decarbonize the electricity grid. The recent increase in the licensing threshold for embedded generation from 1MW to 100MW is a substantial positive step, which will allow companies to generate their own electricity from renewables or purchase from independent power producers.

A **mineral beneficiation policy** could be introduced, such as an export tax, to improve the competitiveness of the industry. However, this is typically only viable for minerals where South Africa has a dominant global market position, such as manganese.

Access to finance is a significant factor limiting the growth of companies, particularly in the case of SMEs. Funding is required for the development and commercialization of new products, establishment and expansion of manufacturing facilities, working capital, and product warranties (especially for battery manufacturers). Numerous institutions and funding mechanisms exist, such as the IDC, Small Enterprise Development Agency, Small Enterprise Financing Agency, the DTIC (Black Industrialists Programme and Manufacturing Competitiveness Development Programme), and commercial banks. However, reducing the administrative burdens and timescales associated with securing funding and improving access to competitive debt and equity financing would substantially enhance the development and growth of the industry.

Development finance in the form of grants, loans at concessional rates and private investment should also be **leveraged** from international and local pools of finance, for example the Green Fund, Development Bank of Southern Africa, and the World Bank. An example of this is the recent announcement of a 700 million Euro (US$ 773 m) funding package for South Africa from Germany, which is primarily intended to contribute towards decarbonizing and stabilizing South Africa's electricity supply. It is intended to user this funding to mobilise a total of R130 billion (US$ 8.86 bn) together with the World Bank and private investors to promote developing renewable energy sources in the country.

Battery manufacturers noted that the local **battery testing and certification capabilities** need to be substantially improved. The USA and European export markets require testing and certification for battery performance, reliability and safety, which according to the battery manufacturers can cost up to R3 million. The cost of establishing such a facility has been estimated at R10 million [24](US$ 681 k). The existing facilities at the Nelson Mandela University could provide a suitable platform for such a facility, while certification services could be provided through collaboration with private laboratories such as Bureau Veritas or TUV Rheinland.

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[24] Montmasson-Clair, G.; 2021. Opportunities to Develop the Lithium-Ion Battery Value Chain in South Africa, TIPS.

A summary of the proposed policy measures is provided in the text box below.

Recommendations 3

Easy Pickings – Minerals Refining and Battery Manufacture

i. Facilitate an increase in the proportion of renewables in the South African energy mix to improve access to green energy (Integrated Resource Plan, green funding)
ii. Consider the introduction of a beneficiation policy for battery minerals (could take the form of an export tax).
iii. Facilitate access to finance through streamlining and accelerating application processes at financing institutions and leveraging international green funding (e.g. World Bank).
iv. Establish a competitive battery testing and certification facility in South Africa.

8.2.2 Bridging the Divide

This value chain development stage essentially builds on the previous stage (Easy Pickings) by expanding the local battery minerals beneficiation to other battery materials that could be imported from other African countries (lithium, cobalt, graphite, copper), and the production of battery cathode active material (e.g. NMC). The focus would be on export markets, excluding China. A second focus would be on increasing the scale of local battery manufacturing and to include large stationary battery energy storage systems (BESS).

The potential opportunity to develop a regional battery minerals beneficiation hub in South Africa is predicated on an ability to source the battery minerals at a competitive price. This is likely to be complex and difficult, due to existing supply agreements for these minerals and the strong presence of Chinese companies in the mining industries in countries like the DRC. Also, some of the countries have their own ambitions to establish local beneficiation capabilities. However, one possible avenue would be to establish a joint venture with an existing international battery materials supplier (possibly Chinese) and in this way secure access to raw materials (this is being explored by the IDC). Regarding the role of government, it is recommended that the possibility of **regional collaboration** should be explored in **bilateral trade discussions** between South Africa and the relevant countries, notably Zimbabwe, Tanzania, Mozambique, and the DRC.

Increasing local and regional demand for batteries would greatly improve the growth potential of the local battery manufacturing industry. This is particularly relevant for stationary battery storage systems (BESS). It is likely that with an increase in the proportion of renewables both on the grid and in the form of embedded generation, the requirement for dispatchable electricity and the need for energy storage will increase. A key policy instrument to stimulate the local battery industry is the specification of increasing local content for battery storage in public sector renewable energy tenders at national, provincial and municipal level. This would include independent power producer (IPP) tenders as well as other public sector tenders from state entities (e.g. Eskom for energy storage). It is important in this regard to provide a longer delivery time in future tenders or a longer-term future view of energy storage demand, to afford the local industry to build up required manufacturing capacity. This would mean issuing tenders earlier (at least 12 months earlier) and hence would require better future long-term planning of the energy system. Another imperative is to plan for the construction of a significant baseline amount of renewables per annum over at least 15 – 20 years, to provide a consistent baseline demand and better planning and investment certainty for the local industry.

A summary of the additional policy recommendations for the Bridging the Divide development stage is provided in the text box below.

Recommendations 4

Bridging the Divide – Regional Minerals Beneficiation Hub, larger-scale BESS production

i. Explore bilateral trade discussions with African countries that possess battery mineral reserves (Zimbabwe, Mozambique, Tanzania, DRC, Zambia)
ii. Stimulate demand for locally manufactured battery storage by specifying higher and increasing levels of local content in public sector energy storage tenders (including IPP tenders that include storage), and issuing tenders early with longer delivery deadlines to allow for the build-up of local manufacturing capacity.

8.2.3 The Whole Nine Yards

The Whole Nine Yards development stage is predicated on the local automotive industry pivoting into EV manufacture, as this is the key lever that could stimulate the establishment of local EV battery system components manufacture and assembly, including cells. Since the EV industry accounts for the bulk of battery demand, as outlined in Section 3, this would take the scale of the local battery industry to another level, with positive spin-off effects on other battery storage market segments.

The South African government and the local automotive industry have realized both the threat and the opportunities related to the rapid shift to e-mobility. In May 2021, South Africa's Trade, Industry and Competition Minister published an **Auto Green Paper** on the advancement of new energy vehicles in South Africa for comment[25]. Developed after initial consultation with the automotive industry, the Green Paper outlines a policy framework and options for stimulating and supporting the local manufacture of electric vehicles and EV components. The Green paper also notes that in order to meet the desired local content of 60% by value, there is general agreement between government and the automotive industry that the local production of EV batteries needs to be "seriously considered", although no mention is made of the local manufacture of battery cells. Proposed mechanisms include lower or zero import duties on EVs and identified and unique EV components as well as introduction of deemed value of EV component imported content as local for purposes of the Volume Assembly Localization Allowance (VALA). These measures would reduce and offset the OEMs customs account. Initially, the local production of EVs would be focused on the export market, since the local market demand is lagging.

However, the **stimulation of local EV demand** is also important and public sector procurement could take the lead by promoting (specifying) the use of electric buses and public sector passenger vehicles (pool cars used typically for urban trips in government departments). This would also stimulate the development of EV charging infrastructure, which should be driven by the private sector.

The **minibus taxi sector** could also be important in stimulating local EVB battery demand. There are some 200,000 minibus taxis on SA roads and they are the primary public transport means in SA, used by well over 60% of commuters as primary transport. SA Taxi, a financing provider for taxipreneurs who operate minibus

[25] Government Gazette, 21 May 2021.

taxis and may not otherwise have access to credit from traditional banks, is planning to import and trial electric minibus taxis in South Africa. They also note this is a medium- to long-term project and there are numerous barriers and constraints such as import duties (making EV taxis twice as costly as ICE taxis), fewer passenger numbers per taxi due to batteries, impact on SA fiscus due to loss of tax revenue on fuel sales. These could be addressed through relevant policies and incentives. SA has a **taxi recapitalization programme** that has been successful in scrapping more than 61,000 old taxis by 2015 with a total payment of R3,4 billion for scrapping allowances. More recently, the transport ministry announced plans to scrap 63,000 taxis over the next 3 years as part of recapitalization[26]. This programme could, in concert with other measures such as scrapping of import duties, provide an opportunity to push for a **certain percentage of EV taxis in the replacement fleet**.

Further considerations include:

- adaptation of the existing Automotive Production Development Programme (APDP);
- reintroduction of the Productive Asset Allowance;
- utilization of the Technology Automotive Investment Scheme to stimulate New Energy vehicle technology investments;
- non APDP support policies, including beneficiation policies to incentivise the use of regional raw materials especially those used in new energy vehicles (NEV) manufacturing value chains, which would stimulate the battery value chain;
- increasing logistics efficiencies to reduce the cost of vehicle exports (Transnet, ports authorities).

The **policy development process** is clearly still in a relatively early phase and the above considerations are not exhaustive. In view of the rapid global developments in electromobility and projections for the next ten years, it is **imperative that this process be accelerated**, in collaboration with the automotive industry.

Other government support measures could include:

- attracting new OEMs to manufacturing EVs locally through the automotive incentive schemes, development finance and infrastructure;
- attracting a battery cell manufacturer to establish a production facility in South Africa;
- **Special Economic Zones** (SEZ) could play an important part in the development of local battery value chains in South Africa. For example, the vanadium electrolyte plant of Bushveld Energy is being established in the Coega SEZ in the Eastern Cape, located at the port of Coega. It is potentially advantageous to locate additional battery value chain activities, such as VRFB battery manufacture, in the same SEZ. Similarly, an **automotive battery value chain** could also be located in an automotive-focused SEZ, such as the Silverton Automotive Supplier Park in Pretoria. Alternatively, an **advanced battery supplier park** could be established at an SEZ like Coega, fostering the **co-location** of various value chain activities such as **battery cell imports, battery pack assembly, manufacture of enclosures and harnesses,** and **software development**. With time, even the local manufacture of battery material precursors could be contemplated in such a supplier park. The co-location of value chain activities would benefit from logistics efficiencies, duty-free areas for local value addition for subsequent export, incentives, and technical and business services.

Key policy recommendations for the Whole Nine Yards value chain development stage are summarised in the text box below.

[26] Times Live, 17.2.2021, https://www.timeslive.co.za/politics/2021-02-17-fikile-mbalula-to-scrap-63000-taxis-in-three-years-as-part-of-recapitalisation/, accessed 22.3.2022.

Recommendations 5

The Whole Nine Yards – Integrated battery value chain including EV batteries/cells

ii. Accelerate the policy development and implementation process outlined in the Auto Green Paper published by the DTIC in May 2021, to assist the local automotive industry in pivoting to EV vehicle and components production, including batteries.

iii. Stimulate local EV demand by
   - Introducing electric buses on a trial basis in all major metros with a view to roll-out;
   - Specify a significant percentage of EVs for public sector passenger vehicles typically used for urban trips by government departments (light vehicles);
   - Specification of a significant (15%) percentage in the taxi recapitalisation programme to stimulate EV adoption.

iv. Launch a feasibility study on the development of a BESS Special Economic Zone (possibly within an existing SEZ).

8.3 Investing in Skill Development and R&D

A comprehensive analysis has been done to determine the skills requirements for the localisation of battery value chains and how the South African education and training system is positioned to address these requirements. The key findings are summarised in Figure 41.

Over half of the jobs opportunities that could be created through a localised battery manufacturing value chain are skilled occupations. While South Africa has a well-developed tertiary education system comprising TVET colleges, universities of technology as well as academic universities, there is a lack of qualifications and training offerings that are tailored to battery energy storage technologies. On-the-job training is thus the norm in the existing industry, which puts significant strain on companies and reduces their agility and efficiency. There is a shortage of software engineers, exacerbated by competition from other industry sectors such as social media and e-commerce multinationals. Electrical engineers are typically specialised in low- and high-current electrical engineering, but battery storage technologies require a combination of both.

There is clearly a need for the establishment of accredited educational and training programmes, in cooperation with international institutions and training providers, for energy storage technology professionals. On a more general note, efforts need to be made to limit the brain drain that South Africa is experiencing, which is leading to the loss of many young, talented and educated professionals.

It is recommended that the Energy and Water SETA (EWSETA) establish a programme to support and (partially) fund **skills development and training** for the battery industry. This should be done in collaboration with the Department of Science and Innovation (DSI), universities and colleges, and the battery industry. The DSI should also consider establishing a **research programme on battery energy storage systems**. This should include a strong focus on engineering, manufacturing, and systems integration and thus contribute to supporting the development of the local industry.

The key recommendations are summarised in the text box below.

Figure 41: Skills requirements and policy implications - key findings

Key findings	Policy implication
• Various types of skills will be required with just over half of direct FTE jobs – skilled occupations	Targeted skills supply-demand analysis by SETAs
• Many of the skills required - high demand and in short supply: • Finance and business managers • Software engineers; Electrical engineers • Welders; Metal working machine tool setters and operators • Mechanical machinery assemblers; Electrical and electronic equipment assemblers • Heavy truck drivers	Need to attract new skills and reduce brain drain
• SA PSET system can provide supply of graduates, but acquiring necessary qualification - insufficient	Requirement for on-job training
• No registered skills development, training, and education programmes focusing on modern battery energy storage technologies in SA	Set-up local accredited educational and training programmes in co-operation with international institutions/service providers
• Non accredited courses aimed at professional development are available, but focus on BESS is limited	Set-up of professional development courses focusing on Li-Ion and VRF battery technologies

Recommendations 6

Skills Development and R&D

i. Facilitate the establishment of a training programme for the battery industry by the EWSETA, in collaboration with the tertiary education sector and the battery industry.

ii. DSI to consider establishing a research programme on energy storage systems, with strong focus on engineering, manufacturing technologies, and systems integration.

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10. Glossary

EV	Electric Vehicle
LIB	Lithium-ion Battery
NMC	Nickel Manganese Cobalt
VRFB	Vanadium Flow Battery
BESS	Battery Energy Storage System
Li	Lithium
FTM	In-front of the Meter
BTM	Behind the Meter
FTE	Full-time Equivalent
SADC	Southern African Development Community
CES	Customized Energy Solutions
RE	Renewable Energy
UPS	Uninterruptible Power Supplies
LFP	Lithium Ferro Phosphate
BMS	Battery Management System
CAN	Controller Area Network
iESS	Intelligent Energy Storage Systems
C&I	Commercial and Industrial
REIPPP	Renewable Independent Power Producer Programme
IRP	Integrated Resource Plan
RM-IPPPP	Risk Mitigation IPP Procurement Program
OCGT	Open cycle gas turbine
SSEG	Small-Scale Embedded Generation
TSO	Transmission System Operator
NERSA	National Electricity Authority of South Africa
DMRE	Department Mineral Resources and Energy
SHS	Solar Home Systems
SAAM	South African Automotive Masterplan
DoT	Department of Transport
ICE	Internal Combustion Engine
LMNO	Lithium Manganese Nickel Oxide
NCMA	Nickel Cobalt Manganese Aluminum

NCA	Lithium Nickel-Cobalt-Aluminum Oxide
LCO	Lithium Cobalt Oxide
LTO	Lithium Titanate Oxide
LMO	Lithium Manganese Oxide
OEM	Original Equipment Maker
EPR	Extended Producer Responsibility
PRO	Producer Responsibility Organization
MMC	Manganese Metal Company
AfCFTA	African Continental Free Trade Area Agreement
DRC	Democratic Republic of Congo
IDC	Industrial Development Corporation
LHA	LHA Management Consultants
APDP	Automotive Production and Development Programme
PGM	Platinum Group Metal
IPAP	Industrial Policy Action Plan
NGP	New Growth Path
IPP	Independent Power Producer
SACU	Southern African Customs Union
WA	Western Australia
SETA	Sector Education and Training Authorities
SA PSET	South Africa Post-school Education and Training
TVET	Technical and Vocational Education and Training

Appendix A – Production potential assessment assumptions

Opportunity	Estimated production volume pa – near term	Future estimate given market growth potential up to 2030	Production revenue pa for 2030 potential (2021 prices, R/USD = 13.5)	Comment on assumptions
Primary and processing activities (Upstream)				
Mining of manganese ore	100 000 tons	330 000 tpa	R 620 m	Mn ore price 3.48 USD/mtu (40% Mn, FOB South Africa) (Source: Mining Bulletin 1.6.2021) Rand:USD = 13,5:1 (assumed for all commodities)
Nickel sulphate (low grade)	0	0	0	Ni is a by-product of the PGM industry, no incremental volumes envisaged
Mining of aluminium ore	0	0	0	SA has no bauxite reserves
Mining of vanadium ore (pentoxide)	9 000	18 000 tpa	R 4 470 m	Near term production = Glencore. Price 8.35 USD/lb (1.6.2021) or 18.39 USD/kg (Source: VanadiumPrice.com, 1.6.2021)
100-300 µm graphite flake	-	-	-	Main graphite deposits are not in South Africa
Manganese sulphate	30 000 tons	100 000 tpa	R 860 m	635 USD/ton (Source: CES analysis)
Nickel sulphate	25 000 tons	80 000 tpa	R 5 830 m	USD 5 400/ton (Source: Shanghai Metals market, SMM, June 2021)
Manufacturing activities (Midstream)				
Lithium hydroxide / carbonate	-	20 000 tpa	R 2 430 m	9 USD/kg (Source: CES analysis)
NMC cathode material	-	10 000 tpa	R 2 835 m	21 USD/kg (Source: CES analysis)
Aluminium foil	1 000 tons	5 000 tpa	R 1 000 m	Future estimate calculated as 1% of demand outside China. 14.81 USD/kg
Vanadium electrolyte	8 ML	16 ML	R 1 230 m	200 USD/kWh electrolyte cost ~35 l/kWh, thus 5.7 USD/l (Source: LHA research)
Spherical graphite	-	20 000 tpa	R 850 m	3 500 USD/ton, uncoated spherical graphite (uSPG) (Source: Benchmark Mineral Intelligence)

Opportunity	Estimated production volume pa – near term	Future estimate given market growth potential up to 2030	Production revenue pa for 2030 potential (2021 prices, R/USD = 13.5)	Comment on assumptions
				Flake graphite feedstock would need to be imported from e.g. Mozambique, Madagascar.
Manufacturing and assembly activities (Downstream)				
Li-ion cell manufacturing	-	5 000 MWh	R 6 750 m	Estimated cell cost – US100/kWh. (Source: CES analysis)
Li-ion battery assembling for stationary applications	840 MWh	1 740 MWh	R 3 990 m	Estimated from total battery storage demand (CES analysis) with split 64% Li-ion, 23% lead acid, 13% VRFB. 178 USD/kWh (30% higher than EV packs due to lower economies of scale, more diffuse market) (Source: CES analysis)