Lithium-Ion Batteries for EVs: Sector Study

Prepared for:

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TIKZN

Prepared by:

Name : Daniel Thwala

Position : Sector Specialist

Contact number : +27 65 586 4178

Email : daniel@tikzn.co.za

Website : www.tikzn.co.za

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1. INTRODUCTION

Lithium-ion batteries (LIBs) as a power source are currently dominating the portable electronics and penetrating the electric vehicle market and cater for the growing market. While the 12-volt lead acid battery that has been traditionally used in internal combustion engines relies on an electrolyte containing lead ions and electrodes that are lead-based, the lithium-ion battery on the other hand, uses lithium ions. South Africa currently does not have the manufacturing facilities for the LIBs used automotive market, however, there are a number of companies that assemble LIBs packs mainly for the industrial market. The country has made commitments to support localisation of LIBs for automotive applications and to further create prerequisites for charging infrastructure and recycling. Although LIBs are used in various sectors, this report focuses on the analysis of LIBs used in the automotive sector. The report further looks at South African market dynamics and opportunities that Kwa-Zulu Natal province can exploit in order to attract potential investments.

2. PRODUCT DESCRIPTION

The LIB technology was first commercialised by Sony Corporation in 1991 and was initially created for the consumer electronics sector. However, over the years the technology lent itself to further applications, and eventually became standard for all devices requiring a portable rechargeable battery (Renault Group, 2019). The LIB technology is also currently being used to electrify transportation and cater for the growing electric vehicle market. While the 12-volt lead acid battery that has been traditionally used in internal combustion engines relies on an electrolyte containing lead ions and electrodes that are lead-based, the lithium-ion battery on the other hand, uses lithium ions (Li+).

A lithium-ion battery (LIB) is a type of rechargeable battery in which lithium ions move from the negative electrode through an electrolyte to the positive electrode during discharge, and back when charging. These batteries use an intercalated lithium compound as the material at the positive electrode and typically graphite at the negative electrode. The battery is formed from the assembly of modules connecting battery cells to management systems. Cells consist largely of four components; a cathode, an anode, an electrolyte solution, and a separator which determines the safety of a battery. There are six types of lithium-ion chemistries.

The most prominent chemistries for electric vehicles are lithium nickel cobalt aluminium (NCA), lithium nickel manganese cobalt (NMC), lithium manganese oxide (LMO), lithium iron phosphate (LFP) and lithium-titanate (LTO). According to Renault Group (2018), the lithium-ion battery used in both hybrid and full electric motor vehicles is designed as an assembly of individual battery units (cells), connected to each other and monitored by a dedicated electronic circuit. The number of cells, the size of each cell and the way in which they are arranged determine both the voltage delivered by the battery and its capacity, meaning the amount of electricity it is able to store. This is generally stated in watt-hours (Wh), or in kilowatt-hours (kWh) within the automotive sector.

LIB is one of the major components in an electric vehicle and makes up between 30% and 40% of the total cost of an EV making them the costliest component (Yu and Sumangil, 2021). The battery stores electrical energy and is the equivalent of a fuel tank in an internal combustion engine vehicle. The manufacturing of LIBs requires a number of raw materials, majority of these raw materials are mined in Southern Africa. These raw materials include manganese, lithium, nickel, graphite and cobalt. Glencore and Gécamines in the Democratic Republic of Congo (DRC) mine cobalt, South32 in South Africa mines manganese, Bikita Minerals in Zimbabwe mines lithium, Bindura Nickel Corporation mines nickel in Zimbabwe and the Balama graphite mine operation in Mozambique mines graphite.

3. GLOBAL MARKET OVERVIEW

The global surge in the demand for electric vehicles as governments continue to decarbonise transportation and improve air quality has resulted in an increasing demand for LIBs. As a respond, global LIB manufacturers are deepening investments to meet the growing demand. BusinessWire (2021) estimates that the global market for electric vehicle batteries is expected from US$19,7 billion in 2020 to US$22,9 billion in 2021. Furthermore, the market is expected to reach 38,2 billion in 2025 representing a 14% compounded annual growth rate. The market for electric vehicle batteries is largely dominated by Asian companies. Yu and Sumangil (2021) posit that China is the market leader of LIBs and accounted for 77% of global capacity in 2020. Table 1 below shows some of the major global manufacturers of LIBs for electric vehicles.

Table 1: Global LIB manufacturers

Company Name	Operations	OEMs Supplied
China's Contemporary Amperex Technology	China and Germany	BMW, Volkswagen, Daimler, Volvo, Toyota and Honda
Panasonic Corporation	Japan, USA and China	Tesla, Honda, Ford and Toyota
BYD Company	China, Hungary, USA and Brazil	Mainly LIBs are made in-house for its own electric cars and buses
LG Chem	South Korea, USA, Poland, Vietnam and India	General Motors, Ford, Volvo, Tesla, Renault, Hyundai and Volkswagen
Samsung SDI	Austria, South Korea, China and Hungary	BMW, Volvo and Volkswagen
SK Innovation Co	United States, Hungary, China and South Korea	Volkswagen, Daimler, Kia, Jaguar Land Rover and Ferrari

Source: Yang and Jin, 2019

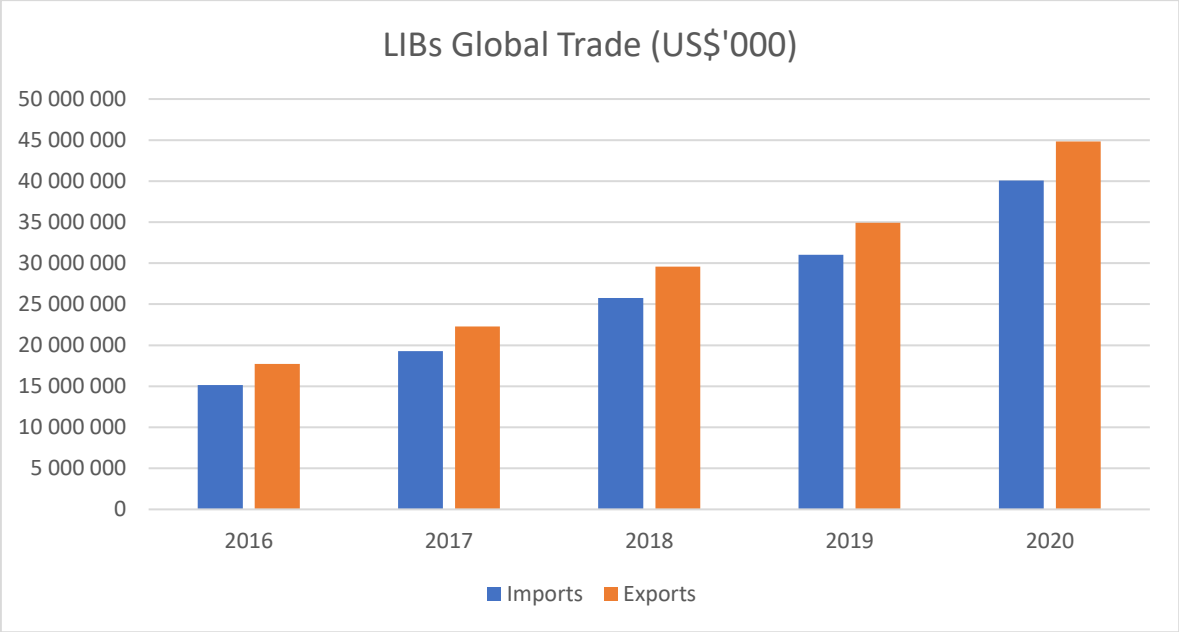
3.1 Global Trade

The demand for LIBs is mainly driven by the growing demand for electric vehicles. Global LIB manufacturers and OEMs are investing in larger factories called “giga-factories” with huge capacities anticipating growth in LIB demand for application in EVs, e-buses and e-trucks. Additionally, governments across the world are implementing significant incentives to encourage motorists to switch to electric vehicles in order to reduce emissions and preserve the environment. This has resulted in increase in sales as consumer demand is shifting to favour electric vehicles. Consumer spending on electric vehicles increased to US$120 billion in 2020 and by the end of the year, there were 10

million electric cars on the road (Fleming, 2021). As more people switch to electric vehicles, the demand for LIBs increases.

LIB manufacturers use a number of different chemistries in batteries. Lithium Iron Phosphate (LFP), Lithium Nickel Cobalt Aluminium Oxide (NCA), and Nickel Manganese Cobalt Oxide (NMC) are the three leading cathode chemistry types. Of the three, NMC is the most prevalent and the fastest growing. This is due to its high specific energy and low internal resistance. NMC cathodes currently account for about 28% of global EV sales, which is expected to grow to 53% by 2027. Between 2016 and 2020, global imports of LIBs increased by 28% on average while global exports increased by 26% on average annually. In 2020, global trade for LIBs amounted to US$84 billion, with imports accounting for 47% whilst exports accounted for 53%. Figure 1 below shows global imports and exports of LIBs and related products.

Figure 1: Imports and exports of LIBs



Source: International Trade Centre, 2021

From a country perspective, China is the largest exporter, accounting for 36% of total exports followed by South Korea, Poland and Germany accounting for 11%, 10% and 8% respectively. With regards to imports, Germany remains the largest importer accounting for 16%, followed by the USA, China, and Hong Kong accounting for 12%, 9% and 8% of total exports respectively. In Africa, South Africa remains the largest importer and exporter of LIBs and related products.

3.2 Global Recycling

The global LIB recycling industry was worth about US$1,5 billion in 2019 and is expected to increase to US$12,2 billion by 2025 and US$18,1 billion by 2030 (Gericke, Nyanjowa and Robertson 2021). The increase in global LIB production, global concern about the harmful environmental impacts of battery waste disposal as well as the anticipated rapid increase of electric vehicles are expected remain major drivers of growth in the LIB recycling industry.

3.3 Governments Support for Switching to Electric Vehicles

Governments across the globe are encouraging citizens to purchase electric vehicles through various incentives. The incentives were designed to reduce the price gap with conventional vehicles. These incentives differ from country to country and may include regulatory, tax, financial or a combination of all three. In total, governments across the world spent US$14 billion in 2020 to support the sale of electric vehicles representing an increase of 25% from 2019. Stronger incentives are mostly in Europe with countries like New Zealand offering cash incentives whiles Norway offers tax bonuses. Figure 2 below shows incentives offered by some of the top markets for electrical vehicles.

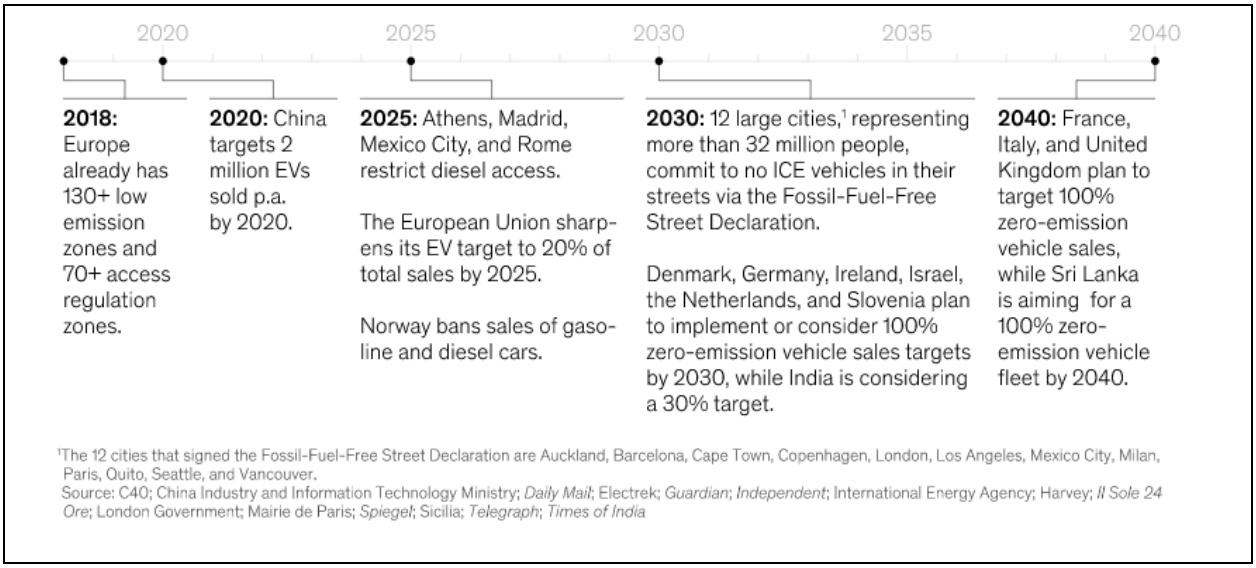
Figure 2: Incentives offered by countries for electrical vehicles

		Canada	China	European Union	India	Japan	United States
Regulations vehicles	ZEV mandate	**British Columbia**: 10% ZEV sales by 2025, 30% by 2030 and 100% by 2040. **Québec**: 9.5% EV credits in 2020, 22% in 2025.	**New Energy Vehicle dual credit system**: 10-12% EV credits in 2019-2020 and 14-18% in 2021-2023.				**California:** 22% EV credits by 2025. **Other states:** Varied between ten states.
	Fuel economy standards (most recent for cars)	114 g CO_2/km or 5.4 L/100 km*** (2021, CAFE)	117 g CO_2/km or 5.0 L/100 km (2020, NEDC)	95 g CO_2/km or 4.1 L/100 km (2021, petrol, NEDC)	134 g CO_2/km or 5.2 L/100 km (2022, NEDC)	132 g CO_2/km or 5.7 L/100 km (2020, WLTP Japan)	114 g CO_2/km or 5.4 L/100 km*** (2021, CAFE)
Incentives vehicles	Fiscal incentives	✓	✓	✓	✓	✓	✓
Regulations chargers**	Hardware standards.	✓	✓	✓	✓	✓	✓
	Building regulations.	✓ *	✓ *	✓	✓		✓ *
Incentives chargers	Fiscal incentives	✓	✓	✓	✓	✓	✓ *

Source: International Energy Agency, 2021

In addition, some countries and cities have set targets to end sales of internal combustion engine vehicles and allow electric vehicles. Figure 3 below shows the timeline of countries and cities that have committed to achieve full usage of electric vehicles.

Figure 3: Timelines for countries and cities



Source: Eddy, Pfeiffer and van de Staaij, 2019

3.4 Global Outlook

While LIBs can be used in other sectors such as electronics and energy storage, it is however anticipated that the automotive sector will increase its dominance of LIBs demand. Currently automotive OEMs are investing heavily in electric vehicles and partnering with major LIB manufacturing companies to take advantage of the rapidly growing market. China is expected to remain the largest battery manufacturer, while other existing manufacturers including Japan, South Korea, the US, and Hungary will most likely record a rise in battery manufacturing. Relatively new entrants are also establishing themselves as increasingly important manufacturers including Germany, Poland, Sweden, France, the UK, Thailand, and Indonesia.

LIB manufacturing companies continue to constantly innovate in order to lower the costs of LIBs by taking a holistic approach to battery design, from cells to modules and packs. For example, Contemporary Amperex Technology's cell-to-pack technology and BYD's blade battery technology attempt to eliminate excess space in battery packs, while Tesla is innovating tab-less technology in cell design to reduce cost and improve production

efficiency and battery performance. These innovations will result in lower costs for electric vehicle given that LIBs are major cost drivers.

Governments in raw material mining countries, particularly for lithium are encouraging greater value-add through developing a localised battery supply chain. Chile and Australia are two of the top lithium producing countries with growing interest to localise manufacturing of LIBs, although slow process has been made to date.

4. SOUTH AFRICAN MARKET OVERVIEW

There are currently three manufacturers of traditional lead acid batteries used in internal combustion engines vehicles in South Africa, namely: Dixon Batteries based in Vereeniging; AutoX based in Port Elizabeth and First National Batteries based in East London. While LIBs for the automotive market are currently not manufactured locally, there are a number of companies that assemble LIBs packs mainly for the industrial market. Furthermore, the country has made commitments to localise LIBs for automotive applications and to further create prerequisites for charging infrastructure and recycling. As of 2020, there are three companies, namely Metair Investments, Megamillion Energy Company and Bushveld Minerals that have invested in partnerships to manufacture automotive LIBs and redox-flow batteries locally.

Metair Investments, which also owns First National Batteries has committed to partner with the South African Institute for Advanced Materials Chemistry (SAIAMC), located at the University of the Western Cape (UWC), which houses the only pilot scale lithium-ion battery cell assembly facility in Africa. The agreement between UWC and Metair will see the company investing R3 million over three years to pilot a prototype lithium production project. The production will focus on mining cap lamp cells, 12V lithium-ion automotive batteries, 48V lithium-ion batteries for energy storage applications and solar panel recharge technology, using the efficient chemistry mixes based on widely available local minerals, such as manganese and nickel to support local beneficiation (Venter, 2017).

Megamillion Energy Company in partnership with a technical partner in China and the Nelson Mandela Metropolitan University (NMMU) plans to be Africa's first large-scale producer of LIBs, primarily for the energy storage market, electric vehicles e-bikes and e-buses. Venter (2020) reports that the funding for the US$35 million pilot plant was sourced

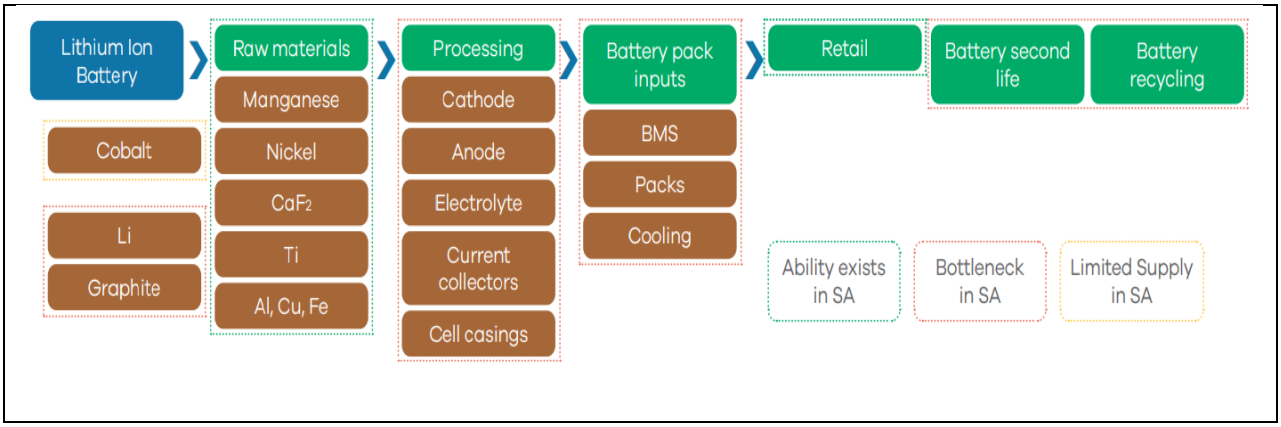
from local and global private equity investors and it will be located at Coega Special Economic Zone in East London. The initial 0.25GWh pilot plant will be capable of producing more than 10 million lithium-ion cells a year and it is estimated to reach 32 GWh cells by 2028. To date, a sample of LIBs have successfully been produced and have undergone tests at NMMU.

Bushveld Minerals is investing US$7.5 million in vanadium redox flow battery (VRFB) energy storage company Enerox, which is planning to scale up its manufacturing capabilities. The company has already put US$5 million towards Enerox's US$30 million plan to reach annual production output and sales of 30MW / 120MW – 240MWh by 2022. Vanadium which is currently mined by Bushveld is a key input in the VRFB which is an alternative battery technology to LIBs. VRFBs recharge EVs by an electrolyte exchange consisting primarily of water and chemical additive acids, such as sulphuric acid or hydrochloric acid. Currently the company manufacturers the VRBs for energy storage although the technology can be used in electric vehicles as well.

4.1 South African Value Chain Analysis

South Africa has a very strong automotive sector which is dominant player in the country's manufacturing sector. The automotive sector has been identified as a priority sector under the Industrial Policy Action Plan (IPAP) and has long history of government support and long-standing policy certainty that improves investor confidence. According to GreenCape (2020) South Africa is an attractive manufacturing market for LIBs because of its existing battery manufacturing and recycling sector. Furthermore, the country's mining sector is able to provide some of the raw materials required for to manufacture LIBs, especially manganese and cobalt. Moreover, other raw materials required in the cathode are mined in sub-Saharan Africa which provide the country with a further competitive leverage to deepen trade considering the African Continental Free Trade Area (AfCFTA). Figure 4 below shows the LIBs manufacturing value chain and areas that the country can focus to accelerate manufacturing.

Figure 4: LIB manufacturing Value Chain



Source: GreenCape, 2020

4.2 Local Recycling

Producers, including battery manufacturers in South Africa are required to set up procedures and processes and invest resources to implement measures to manage waste generated by their industries as per National Waste Management Strategy published in 2020. Currently, South Africa does not have facilities for recycling LIBs and therefore, recyclable batteries are shipped to facilities in other countries for recycling. Currently, 45% of the volumes available for recycling is found in China. According to a Mintek study by Gericke, Nyanjowa and Robertson (2021), there is currently no business case for establishing a commercially viable LIB recycling plant in South Africa because of low collection waste rates which originates mainly from the consumer electronics and ICT equipment sectors, and this represents around 1% of the estimated LIB waste annually generated in South Africa. Therefore, the low collection rates cannot provide adequate feed material to sustain the operations of a commercially viable LIB processing plant.

4.3 Policy support and tariff position

The South African automotive sector has a strong policy support from government through the APDP, however, while electric vehicles and components are not currently covered under the programme, there are ongoing plans to include them in the future. In May 2021, the Department of Trade Industry and Competition (DTIC) issued a draft Green Paper on the advancement of new-energy vehicles in South Africa (defined as electric vehicles or hybrid cars and fuel-cell vehicles using hydrogen to store energy). The aim is to finalise the strategy for approval by cabinet in October 2021. The Green Paper looks at how to expand support provided to vehicle and component manufacturers under the

APDP to start producing new energy vehicles. The DTIC has mandated the Industrial Development Corporation (IDC) and Department of Science and Innovation to help develop a road map and will appoint a panel to finalise a report on actions that need to be taken to realise electric vehicles opportunities for South Africa.

The Department of Transport (DoT) developed the green transport strategy to address the significant contribution of transport to national greenhouse gas emissions. The strategy, which is based on sustainable development principles, aims to minimise the impact of transport on the environment, and meet current and future transport demands. In order to radically grow the uptake of electric vehicles in South Africa DoT, in conjunction with DTIC and National Treasury, will:

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

In terms of tariff position, LIBs are currently imported free of duty in South Africa. Table 2 below shows the tariff position of LIBs.

Table 2: Tariff position for LIBs in South Africa

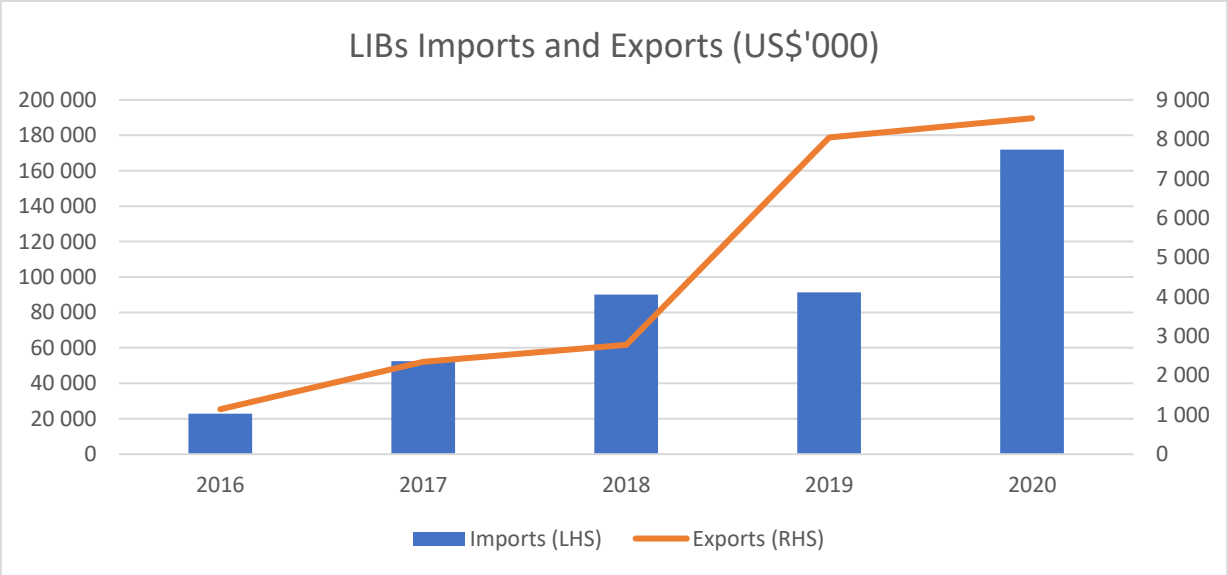
Tariff heading/ Subheading	Description	Statistical unit	Rate of duty					
			General	EU	EFTA	SADC	MERCOSUR	AfCFTA
85.07	Electric accumulators, including separators therefor, whether or not rectangular (including square):							
8507.60[1]	Lithium-ion	U	Free	Free	Free	Free	Free	Free

Source: South African Revenue Services, 2021

4.4 Trade dynamics

South Africa is a net importer of batteries and battery trade is heavily dominated by the import of rechargeable batteries (also referred to as accumulators, which include car batteries). In 2020, total trade of LIBs in South Africa amounted to US$180 million with imports accounting for 95% whilst exports accounted for 5%. Figure 5 below shows imports and exports of LIBs in South Africa.

Figure 5: Imports and Exports of LIBs

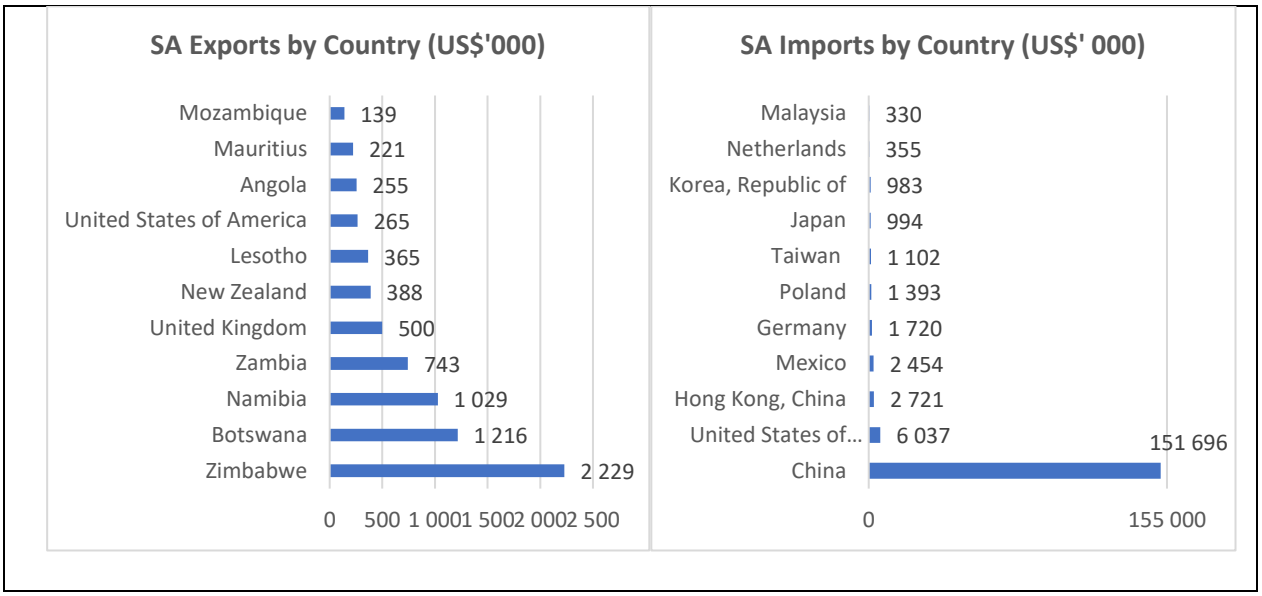


Source: International Trade Centre, 2021

[1] Tariff subheading 8507.60 includes other lithium ion batteries used in other sectors such as storage

Between 2016 and 2020, imports of LIBs increased by 73% on average annually while exports increased by 80% on average annually over the same period. China is the largest source market for LIBs accounting for 88% of total imports followed by USA at 4%. The export market for LIBs is predominantly driven by neighbouring countries. Zimbabwe is the largest export market accounting for 26% of total exports followed by Botswana, Namibia and Zambia accounting for 14%, 12% and 9% respectively. Figures 6 below shows South Africa's imports and exports of LIBs by country.

Figure 6: Imports and exports of LIBs by country



Source: International Trade Centre, 2021

4.5 Barriers to entry

While the automotive LIBs manufacturing sector in South Africa is still in the planning phase, the major barrier to entry is the capital-intensive nature of the sector with significant investment and long periods of time required for research and development, manufacturing equipment and maintenance. The other major barriers include skills shortage across the value chain and the slow uptake of electric vehicles which will make manufacturers to completely rely on the export market. Furthermore, the market dominance of a small number of large global players which have the benefits of established markets, large efficient manufacturing operations, a deep knowledge of the industry and technology, and well-developed sales and distribution channels. In addition, global automotive OEMs are currently moving towards manufacturing LIBs in-house to minimize cost, and this can potentially disrupt the entire supply chain. Policy uncertainty

pertaining to manufacturing of electric vehicles and components locally further poses another barrier.

5. KWA-ZULU NATAL MARKET OVERVIEW AND OPPORTUNITIES

Currently there is one manufacturer in the province involved in LIBs for the industrial market. Maxwell and Spark, a Durban-based battery manufacturer, designs and assembles batteries and associated mobile systems. The company launched its Fridge.Li system, the first-ever commercial electric truck refrigeration system powered by lithium-ion batteries for the logistics and transport industry, in 2020. The company also manufactures LIBs for forklift and has recently clinched a contract to supply the forklift batteries to a large USA based company.

The presence of local manufacturing of LIBs within the province demonstrate strong capabilities as well as existing supply chain to leverage on. Although the manufacturer focuses on the industrial market, manufacturing capabilities for automotive applications can be developed and provide a foundation on which the industry can be built. The country already has an abundance of raw materials needed to manufacture LIBs thus making it an attractive destination for LIB manufacturing. Furthermore, other materials needed are mined in Sub-Saharan Africa region this affords the province with stronger supply chain that can further drive localisation. The current automotive supplier park Special Economic Zone currently in pipeline to manufacture electric vehicle provides additional industrial policy support that can further be leveraged to attract local manufacturing and recycling of LIBs and further deepen the values chain.

REFERENCES

BusinessWire. 2021. Electric Vehicle (EV) Batteries Global Market Report 2021. [Online] Available from: https://www.businesswire.com/news/home/20210819005494/en/Electric-Vehicle-EV-Batteries-Global-Market-Report-2021-Market-is-Expected-to-Reach-38.32-Billion-in-2025---Forecast-to-2030---ResearchAndMarkets.com (Accessed 15 September 2021)

Eddy, J., Pfeiffer, A. and van de Staaij, J., 2019. Recharging economies: The EV-battery manufacturing outlook for Europe. McKinsey & Company. [Online] Available from: https://www.mckinsey.com/industries/oil-and-gas/our-insights/recharging-economies-the-ev-battery-manufacturing-outlook-for-europe (Accessed 13 September 2021).

Fleming, S., 2021. These Countries Offer The Best Electric Car Incentives to Boost Sales. [Online] Available from: https://www.weforum.org/agenda/2021/06/electric-vehicles-financial-incentives/ (Accessed 12 September 2021)

Gericke, M., Nyanjowa, W. and Robertson, S., 2021. Technology landscape report and business case for the recycling of Li-ion batteries in South Africa. Mintek, Randburg

GreenCape. 2020. Electric Vehicles 2020 Market Intelligence Report. [Online] Available from: https://www.greencape.co.za/assets/ELECTRIC_VEHICLES_MARKET_INTELLIGENCE_REPORT_25_3_20_WEB.pdf. (Accessed 16 September 2021)

International Trade Centre. 2021. [Online] Available from: https://www.trademap.org/Index.aspx (Accessed 31 August 2021)

Renault Group., 2019. The electric car: how does its lithium-ion battery work? [Online] Available from: https://www.renaultgroup.com/en/news-on-air/news/the-electric-car-how-does-its-lithium-ion-battery-work/ (Accessed 09 September 2021)

South African Revenue Service (SARS). 2021. Electronic Data. [Online], Available form: http://www.sars.gov.za (Accessed: 13 September 2021).

Venter, I., 2017. Metair launches SA lithium-ion battery production programme. [Online] Available from: https://www.engineeringnews.co.za/article/metair-launches-sa-lithium-ion-battery-production-programme-2017-11-27/rep_id:4136 (Accessed 13 September 2021).

Venter, I., 2020. Local lithium-ion battery plant to open its doors this year. [Online] Available from: https://www.engineeringnews.co.za/article/coega-based-lithium-ion-battery-plant-to-open-its-doors-this-year-2020-01-20/rep_id:4136 (Accessed 13 September 2021).

Yang, H., and Jin, H., 2019. Factbox: The world's biggest electric vehicle battery makers. [Online] Available from: https://www.reuters.com/article/us-autos-batteries-factbox-idUSKBN1Y02JG (Accessed 09 September 2021)

Yu, A., and Sumangil M., 2021. Top electric vehicle markets dominate lithium-ion battery capacity growth. [Online] Available from: https://www.spglobal.com/marketintelligence/en/news-insights/blog/top-electric-vehicle-markets-dominate-lithium-ion-battery-capacity-growth (Accessed 09 September 2021).