LOW CARBON TRANSPORT
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OPPORTUNITIES TO DEVELOP THE LITHIUM-ION BATTERY VALUE CHAIN IN SOUTH AFRICA

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INTRODUCTION

The world of mobility is rapidly changing. The market for electric vehicles (EVs), in all their forms, is growing exponentially. Combined with technological disruptions in the energy space, the rise of EVs puts battery technologies at the core of sustainable development.

Multiple technologies and chemistries, with their respective advantages and shortcomings, are competing in a market currently dominated by lithium-ion batteries (LIBs).

Both South Africa's government and industry have indicated their intention to position the local value chain as a key player in the mobility of the future (Montmasson-Clair et al., 2020). This is critical to ensure a just transition to e-mobility which could notably preserve, if not increase, job creation.

Indeed, South Africa hosts a vibrant automotive manufacturing value chain. As in the rest of the world, the domestic industry, however, produces internal-combustion engine vehicles and components, This raises the question of the positioning of South Africa in the value chain.

This policy brief explores the opportunities for South Africa to play a role in the LIB value chain.

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GLOBAL DYNAMICS

While economies of scale as well as improvements in battery technologies have led to battery prices falling dramatically over the past decade, batteries still make up between 40% and 50% of the total cost of an EV. Battery cells typically account for 70% of the total value of the battery pack, and cell costs are roughly composed of 50% raw materials and 50% manufacturing.

A LIB is formed from the assembly of modules connecting battery cells to management systems. Cells consists mainly of four components: a cathode that determines capacity and the average voltage of a battery; an anode; an electrolyte solution; and a separator which determines the safety of a battery. There are six types of LIB chemistries. The most prominent chemistries for EVs are lithium nickel cobalt aluminium (NCA), lithium nickel manganese cobalt (NMC), lithium manganese oxide (LMO), lithium iron phosphate (LFP) and lithium titanate (LTO).

China is the dominant player in manufacturing LIBs, with three-quarters of production capacity. Panasonic and Contemporary Amperex Technology (CATL) are the leading manufacturers of LIBs, while the cell manufacturing market is dominated by LG Chem, BYD Auto and Panasonic.

Similarly, the supply of cathodes, anodes, separators, electrolytes and electrolyte salts is concentrated in a few countries (China, Japan, South Korea, United States) and a limited number of firms. Correspondingly, looking at patents related to climate change mitigation in transport and LIBs in particular, the landscape is heavily dominated by a few countries (United States, Japan, Germany, South Korea, France, China and the United Kingdom).

SOUTH AFRICA'S R&D CAPABILITIES

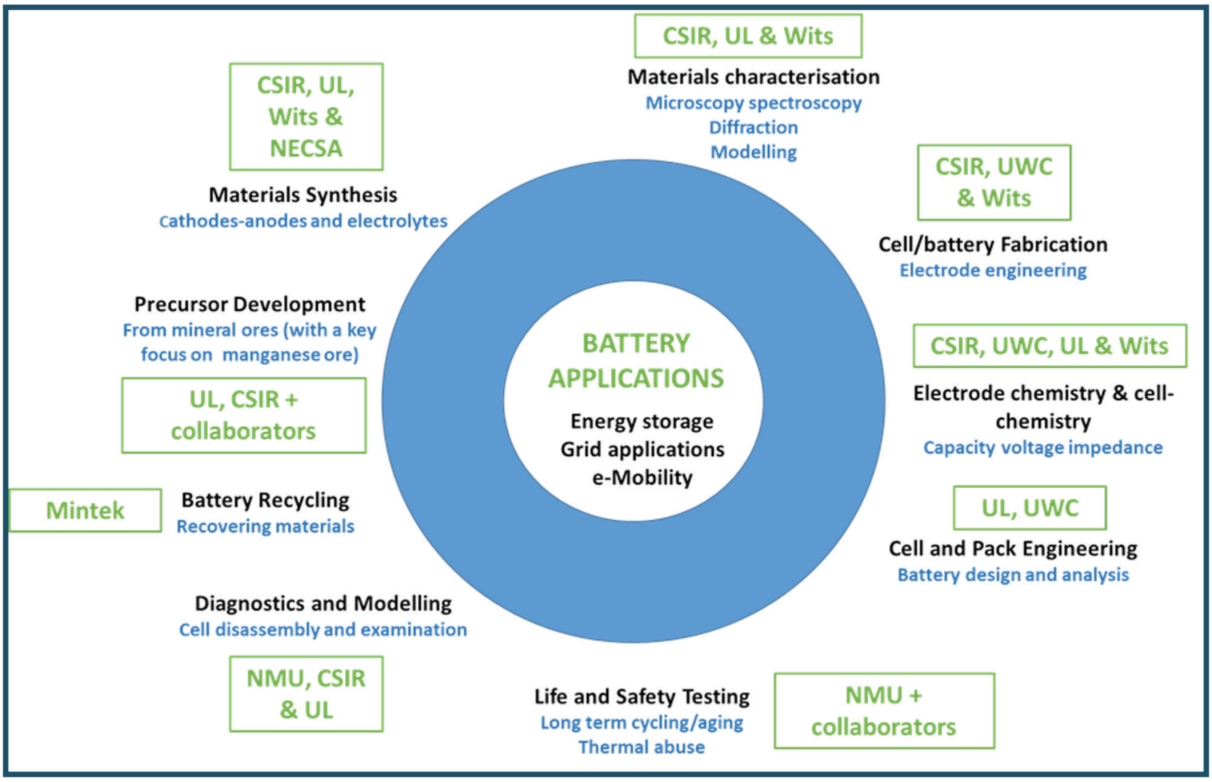
South Africa has committed to developing a LIB value chain, notably to feed into the automotive and energy storage sectors. As part of South Africa's Energy Storage Research, Development and Innovation Programme, a consortium was established in 2011 to work on developing the LIB value chain. Spearheaded by the Department of Science and Innovation (DSI), the consortium works on the whole value chain, from precursor and material development, to cell and battery manufacturing, to testing and validation, to recycling.

As illustrated in Figure 1, it is composed of the Council for Scientific and Industrial Research, the University of Western Cape, the University of Limpopo, the University of the Witwatersrand, the Nuclear Energy Council of South Africa, the Nelson Mandela University and Mintek.

The consortium, while limited in scale, has demonstrated the existence of domestic pockets of excellence. The initial ambition was to develop South African intellectual property and position the country at the cutting edge of research and development (R&D) in the space. While all institutions still pursue this mandate, the inability to compete with leading countries has led to a shift in function.

The primary function of the consortium is effectively to build skills and expertise in the country.

Figure 1. Structure of South Africa's energy Storage Consortium



Source: *Authors, updated from DSI, 2020*

SOUTH AFRICA'S MINING AND BENEFICIATION CAPABILITIES

A wide array of minerals are used in the production of LIBs, including lithium, cobalt, manganese, nickel, graphite, bauxite, copper, iron, phosphate rock and titanium. South Africa is well endowed in such minerals (manganese, cobalt, iron ore, nickel, titanium).

In the case of manganese, the country even benefits from a quasi-monopolistic position. The country also boasts longstanding experience and expertise in mineral beneficiation.

However, to date, there is little beneficiation of minerals to battery grade in the country.

Only manganese and aluminium are refined to battery grade at the moment, while nickel and lithium are in the pipeline.

The Manganese Metal Company beneficiates manganese ore (into manganese metal) for various applications, including LIB batteries.

It is the world's largest producer of selenium-free manganese and the only supplier of electrolytic manganese metal outside of China.

Hulamin, an aluminium semi-fabricator, is developing an array of LIB-related products, from battery-grade cathode aluminium foil to battery casing and structural support, to covers and insulation products.

Table 1. Africa's main reserves and production of key minerals related to lithium-ion batteries

MINERALS	COUNTRY	RESERVES	SHARE OF GLOBAL RESERVES	PRODUCTION	SHARE OF GLOBAL PRODUCTION
Bauxite (thousand metric tonnes)	Guinea	7 400 000	24%	46 160	15%
Copper (metric tonnes of copper content)	DRC	19 000 000	2%	1 020 000	5%
	Zambia	19 000 000	2%	712 000	4%
Cobalt (metric tonnes, cobalt content)	DRC	3 600 000	51%	64 000	57%
	Madagascar	120 000	2%	3 800	3%
	South Africa	50 000	<1%	2 300	2%
Graphite (metric tonnes)	Mozambique	25 000 000	8%	300	<1%
	Tanzania	18 000 000	6%	n/d	n/d
	Madagascar	1 600 000	<1%	9 000	1%
Iron ore content (metric tonnes)	South Africa	770 000 000	1%	52 000 000	3%
Lithium (metric tonnes)	Zimbabwe	230 000 (lithium content)	1%	40 000 (gross weight)	2%
Manganese (metric tonnes gross weight)	South Africa	230 000 000	30%	5 500 000	31%
	Gabon	61 000 000	8%	1 929 000	11%
Nickel (metric tonnes, contained nickel)	South Africa	3 700 000	4%	44 000	2%
	Zimbabwe	n/d	<1%	17 743	<1%
	Botswana	n/d	<1%	16 878	<1%
Phosphate rock (thousand metric tonnes)	Morocco	50 000 000	72%	9 400	12%
	Algeria	2 200 000	3%	390 (P_2O_5 content)	<1%
	South Africa	1 400 000	2%	772 (P_2O_5 content)	<1%
	Egypt	1 300 000	2%	1 300 (P_2O_5 content)	2%
Titanium (metric tonnes)	South Africa	71 300 000 (TiO_2 content)	8%	600 000 (gross weight)	5%
	Mozambique	14 880 000 (TiO_2 content)	2%	1 347 780 (gross weight)	2%
	Madagascar	8 600 000 (TiO_2 content)	1%	244 800 (gross weight	3%

Source: *Authors, based on a data from the Department of Mineral Resources and Energy, Series on Mineral Statistics: National Production & Sales (Monthly), downloaded from Quantec in October 2020 and data from the US Geological Survey, Minerals Yearbook, downloaded from https://www.usgs.gov in October 2020.*

SOUTH AFRICA'S MINING AND BENEFICIATION CAPABILITIES (...continued)

Beyond South Africa, the African continent has incomparable reserves and mining capacity in key minerals supporting the LIB value chain, as listed in Table 1.

Bauxite (Guinea), copper (Democratic Republic of the Congo – DRC, Zambia), cobalt (the DRC, Madagascar, South Africa), graphite (Mozambique, Tanzania, Madagascar), iron ore (South Africa), lithium (Zimbabwe), manganese (South Africa, Gabon), nickel (South Africa, Zimbabwe, Botswana), phosphate rock (Morocco, Algeria, South Africa, Egypt) and titanium (South Africa, Mozambique Madagascar) are widely available on the continent.

However, Africa remains an extractive economy, as most minerals are refined and processed outside the continent.

This opens for the door for regional integration, notably though the implementation of the Southern African Development Community Industrialization Strategy and Roadmap 2015-2063 (SADC, 2015).

Importantly though, LIB costs depend less on raw material costs than on production volumes, putting the emphasis of economies of scale.

SOUTH AFRICA'S MANUFACTURING CAPABILITIES

There is currently no commercial production of battery cells in South Africa1 and, despite some projects in development,2 it remains to be proven whether such an activity would be competitive domestically.

Battery manufacturing based on imported cells (from East Asia) is, however, a vibrant industry in the country. Numerous firms, in collaboration with academia, have developed intellectual property and expertise in the manufacturing of specific components, parts and systems (most notably battery management systems) as well as the assembly of battery packs (Balancell, Blue Nova, EV Dynamics, FreedomWon).

In some cases, companies have further leveraged this expertise to develop additional offerings, such as specialised vehicles (Maxwell and Sparks, and MellowCabs). A number of companies (such as Revov) are also involved in marketing second-life batteries on the local (and regional) market.

At the end of life, there is currently no facility in South Africa in a position to effectively recycle LIB. Batteries are stockpiled and/or shipped to available facilities around the globe.

All hazardous e-waste, including LIBs, will, however, be banned from being landfilled from August 2021.

In line with the National Environmental Management: Waste Act No. 59 of 2008 and regulations regarding Extended Producer Responsibility (EPR), an effective waste management scheme for LIBs should be established in 2021-2022, including a pilot recycling facility.

POLICY IMPLICATIONS

Looking ahead, several key policy implications arise from the research:

- First, the policy priorities should be to identify where in the entire LIB value chain South African industries are (or could be) competitive. Mining is a comparative advantage for the country. Battery manufacturing as well as mineral refining emerge as competitive areas. Others stages of the value chain cell manufacturing, recycling) remain to be proven viable.

- Second, key components of an enabling policy framework should be formulated. Sending clear, positive signals in favour of the development of the industry would contribute to attracting investments. Access to funding, particularly for commercialisation, remains a key hindering factor, along with testing and certification, and the provision of warranty.

- Third, accessing markets, both domestically and globally, is a challenge for firms operating in the LIB value chain from South Africa. On the domestic front, the lack of demand is a critical factor hindering development. Access to global markets is, moreover, extremely competitive and requires niche expertise. In the short term, a dual strategy aimed at growing local demand as well as local manufacturing (primarily on the back of global demand) would be required.

- Last, access to a pool of skilled and experienced people is crucial for developing the innovation-heavy LIB value chain in South Africa. While access to skills has not been a key constraint to date, South Africa is far behind leading countries in LIB-related R&D and skills development. More resources are required to develop skills and intellectual property in niches in which South Africa displays a competitive advantage.

WEIGHING OPTIONS GOING FORWARD

Four avenues emerge as possible pathways to support the development of the LIB value chain in South Africa.

These are fostering:
1. mineral refining;
2. cell manufacturing;
3. battery manufacturing and assembly; and
4. battery recycling.

Importantly, such options are not mutually exclusive and are complementary in nature. However, the viability of these pathways largely differs in the short term.

Similarly, industrial development associated with these options is at different levels of maturity in the country.

Indeed, only two pathways, namely developing battery manufacturing and mineral refining, are ready for scale-up.

The other two avenues, i.e. developing commercially viable cell manufacturing and recycling, are yet to be proved viable in the South African context.

First, fostering the growth of battery manufacturing (i.e. battery pack manufacturing) is the most viable option in the short to medium term.

Programmes aimed at nurturing existing companies (for expansion, particularly to global markets) as well as assisting the emergence of new, additional businesses would be necessary:

- Financial assistance would go a long way in facilitating access to finance (particularly for commercialisation). This could be complemented by leveraging international development finance, innovative funding instruments, private finance and business development services.
- The domestic capacity to test and certify battery packs would need to be materially enhanced.
- An increased focus on R&D and skills development, in partnership with the Energy Storage Consortium, would contribute to improved access to human and intellectual capital. Making the existing R&D tax incentive more accessible to small, medium and micro enterprises (SMMEs) would also accelerate the development of innovative firms.
- Improving the ease of doing business for SMMEs would enhance their development and growth. This would range from reducing bottlenecks and factors that disproportionally impact on small businesses to improving the ecosystem of business facilitation services. Consideration could also be given to setting up local content requirements for the public procurement of LIBs.

A second avenue to enhance the involvement of South Africa's industry in the LIB value chain is to develop the beneficiation of local minerals to battery grade. South Africa can leverage its expertise and existing value chains to develop battery-grade products.

This hinges on a set of measures:

- Access to modern infrastructure would be required, particularly reliable, affordable and clean energy and transport services.
- Investment support could be enhanced through both financial (such as development finance) and non-financial assistance (such as special economic zones and industrial parks). This could also extend to R&D and skills development support.
- A mineral beneficiation policy could be enacted to further improve the competitiveness of the industry. A bottom-up approach, through an export tax or a development pricing policy, would represent the most viable option. A top-down approach, though the Automotive Production and Development Programme and localisation requirements, would also be supportive.

A third avenue to expand the LIB value chain in South Africa is to explore the possibility of building cell manufacturing capacity domestically.

Effectively, it remains to be proven whether a South Africa-based company could be competitive in this market segment. Attracting investors to establish a giga-factory in South Africa would require confirming the business case.

On the supply side, this would call for a partnership with an existing manufacturer and a leading research institution, as well as favourable investment conditions.

WEIGHING OPTIONS GOING FORWARD (...continued)

On the demand side, a sizeable market, which remains to materialise, would need to be serviced from such a giga-factory.

A fourth avenue to consider in the development of South Africa's LIB value chain is battery recycling. South Africa does not at present have such a recycling facility.

While the country has expertise in mineral processing and recovery, the economic viability of a possible plant is unknown at this point.

The ongoing process of establishing an EPR scheme for batteries sold in the country could provide the impetus for the establishing a recycling facility in the medium term.

CONCLUSION

The possibility of developing the domestic LIB value chain should not be overestimated: South Africa displays key pockets of excellence but not all activities in the value chain are likely viable domestically.

At the same time, the importance of developing the LIB value chain should not be underestimated: an established LIB industry is instrumental for the local development of both the (renewable) energy and (electric) transport industries.

In fact, provided the emphasis is put on the country's evidenced strengths, rather than unsubstantiated aspirations, an electrifying opportunity lies ahead for South Africa. Eureka?

FOOTNOTES

1. The University of the Western Cape hosts a pilot plant for R&D and skills development purposes.
2. Metair produces cells in Europe and is exploring the opportunity to do sin South Africa. MegaMillion and AutoX are also investigating the possibility of manufacturing cells domestically.

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