Manufacturing and the energy storage value chain

World Bank ESP Stakeholder session
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The energy storage market opportunity for South Africa

• The growing energy storage market presents a unique opportunity for South Africa’s mining and manufacturing industry.

• South Africa has some of the world’s largest and highest-grade resources in at least 6 key metals that are set to play a major role in the value chain of the global battery industry. These are vanadium, platinum group metals, nickel, manganese, copper and cobalt.

• It is an opportune time to develop vertically integrated opportunities that maximize South Africa’s share of the value chain.

• South Africa already has a lot of the metallurgical infrastructure that can be leveraged to create or expand the downstream capabilities required. Not only infrastructure, but also metallurgical expertise, Research and Development platforms that to date have been under-utilized.

• When energy storage applications in the electric transport sectors are considered, total demand for batteries is forecast to be 4,584GWh by 2040. South Africa is well positioned build an industry that will play a critical role in Africa and beyond.
Bushveld Minerals’ integrated strategy allows the Group to participate in activities across the vanadium value chain

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<tr>
<th>A low cost, vertically integrated primary vanadium producer</th>
<th>An energy storage project developer and solutions provider</th>
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<td>- High grade ore for primary vanadium mining &amp; processing</td>
<td>- Vanadium electrolyte manufacturing of 200MWh</td>
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<td>- Largest primary vanadium resource base in the world</td>
<td>- Battery assembly &amp; manufacturing in SA</td>
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<td>- Focus on expansion and enhancement of brownfield operations</td>
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<td><strong>Employing 650 people in SA, supplying 4% of world’s vanadium and growing production by over 100% in the next 2-4 years</strong></td>
<td><strong>Manufacturing base in South Africa - oriented for export; investing and marketing globally</strong></td>
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Within long duration storage, VRFBs have distinct advantages that Bushveld Minerals seeks to exploit

A vanadium redox flow battery (VRFB) exploits energy differences in the oxidation states of vanadium to store or discharge energy

- Simple architecture
- High vanadium content
- Non-degradation of vanadium creates high residual value
- Technology in commercial deployment with hundreds of deployments
- Long lifespan cycles: Ability to repeatedly charge / discharge over 35,000 times for a lifespan of over 20 years
- 100% depth of discharge: Without performance degradation
- Lowest cost per kWh when fully used at least once daily makes VRFBs today cheaper than Li-ion batteries
- Safe, with no fire risk from thermal runaway
- 100% of vanadium is re-usable upon decommissioning of the system
- Scalable capacity to store large quantities of energy
- Flexibility: Allows capture of the multi-stacked value of energy storage in grid applications
- Very fast response time of less than 70ms
- No cross-contamination: Only one battery element, unique among flow batteries

Source: IEEE, Rocky Mountain Institute, The University of New South Wales,
We have taken an incremental and scalable approach to local manufacturing to reduce market risk

Vanadium operations

- Started with geology and exploration in early 2010’s in the Bushveld complex;
- Became a full-fledged vanadium miner and processor in 2017 entered mining and mineral processing;
- Through acquisition and own research, now expanding into chemicals, including electrolyte for vanadium redox flow batteries (VRFBs);
- Starting to offer new products, such as vanadium electrolyte rental and vanadium recycling;
- Pushing further into downstream energy activities, such as project development and investment into VRFB companies.

Local content in local battery deployments

- The first VRFB systems featured nearly all components imported (from US or China);
- Currently, we do partial processing in SA and have vanadium converted into electrolyte under agreement with overseas chemical companies;
- By end of year, we plan to have local component manufacturing on-line for electrolyte, the most expensive part of the VRFB;
- As the market grows, we plan to assemble full systems here, including local sourcing of components besides electrolyte, creating up to 80% in local content for SA projects.

Increase in commitment
Bushveld Energy and the IDC are developing a vanadium electrolyte plant in East London, South Africa

### Electrolyte plant context

- In 2016, Bushveld Energy and the Industrial Development Corporation (IDC) started working to establish electrolyte production in SA;
- The plant is designed to take vanadium oxide from Bushveld Vametco; however, material from Bushveld Vanchem, Glencore’s Rhovan or other South African providers can also be used;
- The plant will be located in the East London Industrial Development Zone (ELIDZ) for logistical and financial reasons;
- Plant design is modular to support scale up from initial annual capacity of 200MWh / 8 ML and up to 800MWh / 32ML;

### Current status

- All environmental permitting approved for four times the initial plant size;
- Approval for site by ELIDZ, including construction of building and all civils works by the ELZIDZ, obtained;
- Test production completed, including at own pilot plant and at a third-party electrolyte production facility. Samples batches are now with global buyers;
- EPC tender launched at end of 2019, with award expected in Q1 2020;

![Current view of site](image)

![Plant layout](image)
The WB energy storage programme is exciting for our emerging business

Validation of our strategy

• Bushveld began investigating the downstream energy storage opportunity back *in 2014*;
• Over the first few years, we experienced “*significant hesitancy*”;
• The program and the commitment from the WBG and its partners validates that the *energy storage market in Africa is significant and imminent*.

Immediate local value chain opportunity for South Africa

• If *local content* in the Eskom Battery programme achieves the 40-50% level, *as was prescribed during REIPPP*, from the start, it will accelerate the manufacturing and investment business case;
• This is important to set the tone from the first installation to ensure an *export-oriented industry* emerges as the programme’s legacy.

Progress and innovation

• *Forward thinking* on ESS use cases and technology, such as the additional value from *longer duration systems* with 4 to 10 or even more hours of storage, creates opportunity for *improved solutions and technologies*;
• New solutions favour new entrants, which is the only way South Africa can focus on links in the ESS value chain *where SA firms still has a chance to be competitive*.