Manufacturing and the energy storage value chain

World Bank ESP Stakeholder session
21 January 2020

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.

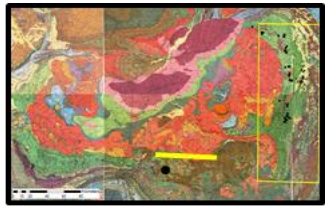
Bushveld Minerals' integrated strategy allows the Group to participate in activities across the vanadium value chain

BUSHVELD MINERALS

BUSHVELD VANADIUM

BUSHVELD ENERGY

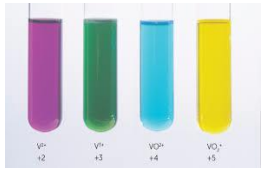
A low cost, vertically integrated primary vanadium producer



- High grade ore for primary vanadium mining & processing
- Largest primary vanadium resource base in the world
- Large, low cost vanadium processing facilities
- Focus on expansion and enhancement of brownfield operations

Employing 650 people in SA, supplying 4% of world's vanadium and growing production by over 100% in the next 2-4 years

An energy storage project developer and solutions provider



- Vanadium electrolyte manufacturing of 200MWh
- Global electrolyte rental product
- Battery assembly & manufacturing in SA
- Investment into battery OEMs
- MW scale energy storage project development
- Core offering is a long duration RE + VRFB mini-grid solution

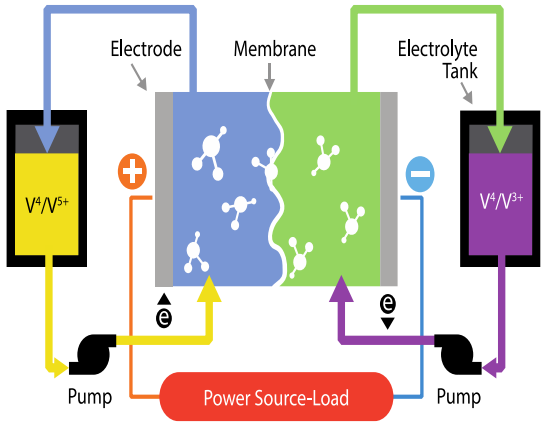
Manufacturing base in South Africa - oriented for export; investing and marketing globally

Pan-Africa focus

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

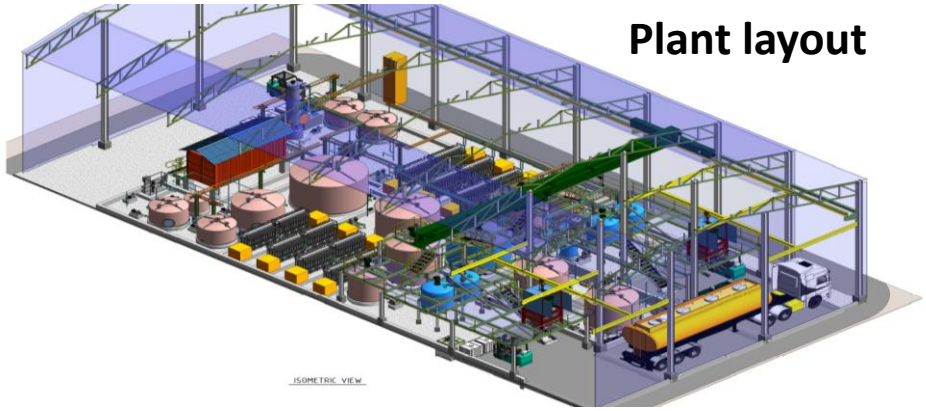
- In 2016, Bushveld Energy and the Industrial Development Corporation (IDC) started working to establish electrolyte production in SA;
- The plant is designed to take vanadium oxide from Bushveld Vametco; however, material from Bushveld Vanchem, Glencore's Rhovan or other South African providers can 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

Plant layout



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*.