

BUSHVELD MINERALS

Standing front & centre
to grow a world-class
vanadium business



Bushveld
Vametco mine

AIM-listed integrated vanadium producer **Bushveld Minerals'** ambition is to grow into one of the world's most significant, lowest cost and vertically integrated vanadium companies. Through its vanadium mining subsidiary Bushveld Vanadium and its energy subsidiary, Bushveld Energy, the company has set a strong base from which to unlock the opportunity for downstream integration – with Bushveld Vanadium as a captive vanadium supplier to Bushveld Energy, an energy storage project developer and component manufacturer. **CHANTELLE KOTZE** reports.

It was in 2014 that Bushveld Minerals first identified the fast-growing energy storage market as a key and attractive downstream industry for its vanadium production, says Bushveld Minerals founder and CEO Fortune Mojapelo.

Vanadium critical to the energy storage market

According to the latest estimates by United States-based multi-service professional firm Navigant, vanadium redox flow battery (VRFB) demand is expected to increase to over 18 000 MWh by 2027, assuming an 18% market share.

In an upside scenario, market researcher BMI Research suggests a 25% market share, which could increase VRFB demand to over 27 500 MWh by 2027.

If these forecasts hold true, over 82 000 t of vanadium will be needed just for VRFBs. Taking the BMI forecast into account, this could increase to over 96 000 t.

The amount of vanadium needed in the Navigant and BMI Research assumptions, just for VRFB production, equates to the total amount of vanadium produced in 2017, which means that by 2027, energy storage demand for vanadium, could actually increase by between 50% and 100% in terms of 2017's vanadium production. This is notwithstanding the vanadium demand underwritten by the steel market required for high strength rebar manufacture.

With the stationary energy storage market rapidly growing and, according to Navigant, expected to exceed US\$50 billion in annual revenues by 2027 with flow batteries poised to capture 20% of it, South Africa is extremely well-positioned to participate in this market by virtue of holding the largest

IN SHORT

Bushveld Minerals, through its Bushveld Energy subsidiary, is focused on developing and promoting the role of vanadium in the growing global energy storage market through application in vanadium redox flow battery technology.

high grade reserves of vanadium in the world in the Bushveld Complex.

Bushveld divisions align with market demand forecasts

In response to these assumptions and findings, it is Bushveld Minerals' intention to vertically grow the vanadium company through the supply of vanadium electrolyte for VRFBs for the energy storage sector in the medium-term and establish a regionally-oriented assembly and manufacturing capacity in the long-term: creating a global VRFB supply chain in South Africa with the added benefit of creating a captive market for Bushveld Minerals' vanadium production.

Bushveld Energy was accordingly established in 2016 to capture a share of this attractive market and is exclusively focused on developing and promoting the role of vanadium in the growing global energy storage market through the development of VRFB technology.

In doing so, Bushveld Energy is bringing the energy storage value chain to South Africa as a means of leveraging South Africa-mined and beneficiated vanadium. Bushveld Minerals will actively support the beneficiation of minerals mined in South Africa into higher value-added final products.

Bringing the energy storage value chain to South Africa

To realise the potential of VRFBs in energy storage, Bushveld Energy's first job was to undertake a market study to identify VRFB demand in Africa, as well as global vanadium electrolyte demand. In partnership with the Industrial Development Corporation (IDC) of South Africa, the parties undertook a study in the second half of 2016. This concluded in August 2017 that favourable demand exists for VRFBs, particularly in the utility (including transmission and distribution networks)



Bushveld Energy VRFB

DID YOU KNOW?
VRFBs are ideally suited for large-scale, long duration energy storage applications

off-grid – as well as minigrid – markets. Demand is expected to peak between 2025 and 2030.

The study also found that global electrolyte demand is likely to peak during the same timeframe and that Bushveld Minerals would be able to compete cost effectively for not just the electrolyte market in Africa but other regions, as well.

Moreover, the study found that South Africa serves as the logical base for VRFB manufacturing. With the IDC as a partner, Bushveld Minerals will benefit from the IDC's important stakeholder linkages with the South African government, regulators, utilities and other key players that are necessary to provide a catalytic stimulus for the energy storage industry – as they have for the renewable industry to date.

This study subsequently prompted Bushveld Energy's first project: the deployment of a utility-scale VRFB, a project that was co-developed by Bushveld Energy and the IDC with the system manu-

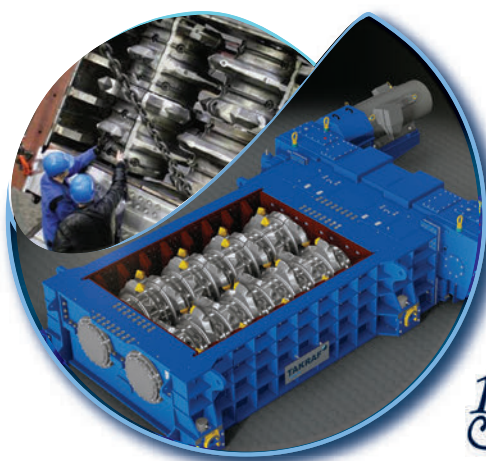
factured by Bushveld Energy's US-based technology partner, UniEnergy Technologies (UET) and deployed at Eskom's Research, Testing and Development (RT&D) Centre in Rosherville, South Africa. The VRFB, with a peak of over 120 kWh, was commissioned during the last quarter of 2018 and will be tested for a period of 18 months.

In parallel to the market study, Bushveld Energy and the IDC undertook a techno-economic study to evaluate the merit of establishing a vanadium electrolyte production plant in South Africa.

Study results have indicated that Bushveld Energy can manufacture vanadium electrolyte at globally competitive cost levels.

The study determined the viability of establishing a scalable plant with an initial production capacity of 200 MWh per annum that could easily scale to two or more times that capacity, as demand grows.

The scope of the project will entail the construction of an electrolyte



A CENTURY OF INNOVATION

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TAKRAF Africa
96 Loper Avenue, Aeroport, Spartan
Kempton Park, 1619, South Africa
T: +27 11 201 2300
takraf.afr@tenova.com
www.takraf.com





Three vanadium oxidation stages

currently nearing completion of the feasibility study. "In fact, the environmental impact assessment for the site, a critical long lead step, is well underway and should be completed in the first half of 2019, after which construction may only begin," he outlines.

Bushveld Energy is also currently working with an external company to finalise the process and produce some sample batches of electrolyte which should be completed in the first quarter of 2019. "If all goes well, we hope to be producing out of the facility either towards the end of 2019 or in the first half of 2020," says Nikomarov.

Moreover, Bushveld Energy is looking to invest in the construction of an assembly plant to assemble and manufacture VRFBs as a critical next step in the process of accelerating Bushveld Minerals' growth into the battery storage market in South Africa.

This longer term opportunity is dependent on the market demand and how quickly that grows, and could involve direct investment into a VRFB company that would own the facility.

The company will in 2019 execute a techno-economic study to evaluate how cost-effective this would be and identify which components should be imported or sourced locally, should this project go ahead. **MBA**

manufacturing plant as well as a chemicals plant to purify vanadium feedstock and convert it into a liquid electrolyte on a cost-competitive basis, thereby allowing it to compete both domestically and globally. This electrolyte will in turn be sold to VRFB companies or direct users/buyers of VRFB systems.

The estimated initial capital expenditure for the plant would be in the region of US\$10 million, which would be a combination of debt and equity; and be co-funded by Bushveld Minerals and the IDC.

Bushveld Minerals believes that significant scope exists to reduce the capex of the overall project further by co-locating the purification section of the electrolyte plant with Bushveld Minerals' Vametco mine and plant in Brits.

A dual site location strategy for electrolyte production has therefore been adopted for the project to improve its overall economics, shorten the environmental approval process, take advantage of local government incentives and establish the facility with a low operating cost platform.

According to Bushveld Energy CEO and co-founder Mikhail Nikomarov, it would be more cost effective to purify the vanadium feedstock in a chemicals facility co-located at the Vametco mine, while the final processing into electrolyte would occur at a Greenfields facility located within the East London Industrial Development Zone (IDZ), in South Africa's Eastern Cape province.

Nikomarov notes that while the location of this step offers fewer benefits in co-location, a manufacturing plant in East London would be closer to a port than the Vametco mine, which is over 600 km

inland, making logistics much cheaper and faster.

"Plus, there are significant government incentives offered to companies to locate specifically in the IDZ, including permitting, infrastructure and tax treatment," he notes.

According to the initial market study in 2016, the main driver of costs is the vanadium feedstock. This makes locally available, low-cost supply a critical success factor for vanadium electrolyte production and provides a natural competitive advantage for South Africa.

Nikomarov says that the project is

A CLOSER LOOK AT VRFBs

The VRFB, unlike a conventional battery, uses a liquid vanadium electrolyte to store energy in separated storage tanks, not in the power cell of the battery. During operation these electrolytes are pumped through a stack of power cells, or membranes, where an electrochemical reaction takes place and electricity is produced. VRFBs are the simplest and most developed flow battery in mass commercial operations, as their unique features make them ideal for utility scale, stationary energy storage applications.

