Disclaimer (1 of 2)

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The technical information contained within this presentation has been reviewed and approved by Professor Richard Viljoen. Professor Richard Viljoen has more than 30 years’ experience in the mining industry, including 15 years as chief consulting geologist for Gold Fields of South Africa. Notable past experience includes the development of significant mines including Northam Platinum and the Leedouarn and Tarkwa gold mines, identifying and developing a significant platinum deposit in the Bushveld Complex for Akanani Resources as well as acting as consultant for exploration and mining companies in Canada, Mexico, Venezuela, India and China in the fields of base metals, gold and platinum.

Professor Richard Viljoen has extensive experience relevant to the style of mineralisation and type of deposit under consideration and to the activity which he is undertaking to qualify as a Competent Person as defined under the JORC Code (2012). Professor Richard Viljoen consents to the inclusion in this presentation of the matters based on his information in the form and context in which it appears.

Presentation of data unless specified otherwise: variance analysis relates to the relative performance of Bushveld Minerals and/or its operations during the 2018 financial year compared with the 2017 financial year.
A primary vanadium platform with downstream integration in the energy storage market through VRFBs

A low cost, vertically integrated primary vanadium producer

- High grade ore for primary vanadium mining & processing
- Largest primary vanadium resource base in the world

The Group is targeting a production nameplate capacity of 10,000 mtVp.a. in the medium term

An energy storage solutions provider, exclusively focused on vanadium based energy storage systems

- Electrolyte manufacturing
- Co-location in Vametco process => significantly lowering costs

Targeting initial 200MWh of electrolyte p.a.

- Vanadium Redox Flow Battery (VRFB) Assembly & manufacturing
- MW scale energy storage project development
- Deployment models include PPAs, leasing models

Targeting 1,000 MWh opportunities by 2020

Our vertically integrated business model provides a natural hedge against vanadium price volatility
Bushveld Minerals performance is mainly driven by M&A

- April 2017: Bushveld Minerals acquired an effective interest in Vametco of 27%
- December 2017: Bushveld Minerals increased its effective interest in Vametco to 59%
- September 2018: Bushveld Minerals increased its effective interest in Vametco to 74%
- May 2019: Bushveld Minerals conditional acquisition of Vanchem

Source: Bloomberg, 27 May 2019

Bushveld Minerals share price (GBP)
Market Metrics

**Bushveld Minerals Top Shareholders**

<table>
<thead>
<tr>
<th>#</th>
<th>Shareholder</th>
<th>Shares</th>
<th>% Ownership</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hargreaves Lansdown Asset Mgt</td>
<td>190,967,598</td>
<td>17.05</td>
</tr>
<tr>
<td>2</td>
<td>Halifax Share Dealing</td>
<td>112,203,655</td>
<td>10.02</td>
</tr>
<tr>
<td>3</td>
<td>Interactive Investor</td>
<td>108,906,692</td>
<td>9.73</td>
</tr>
<tr>
<td>4</td>
<td>Acacia Resources Limited</td>
<td>70,598,644</td>
<td>6.30</td>
</tr>
<tr>
<td>5</td>
<td>Yellow Dragon Holding Limited</td>
<td>67,832,778</td>
<td>6.06</td>
</tr>
</tbody>
</table>

**Bushveld Minerals Top Institutional Shareholders**

<table>
<thead>
<tr>
<th>#</th>
<th>Shareholder</th>
<th>Shares</th>
<th>% Ownership</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Jarvis Investment Mgt</td>
<td>21,866,260</td>
<td>1.95</td>
</tr>
<tr>
<td>2</td>
<td>Invesco Perpetual Asset Mgt</td>
<td>21,418,938</td>
<td>1.91</td>
</tr>
<tr>
<td>3</td>
<td>Canaccord Genuity Wealth Mgt</td>
<td>6,800,587</td>
<td>0.61</td>
</tr>
<tr>
<td>4</td>
<td>Oppenheimer Funds</td>
<td>5,200,000</td>
<td>0.46</td>
</tr>
<tr>
<td>5</td>
<td>Raymond James Investment Services</td>
<td>1,578,877</td>
<td>0.14</td>
</tr>
<tr>
<td>6</td>
<td>Standard Life Wealth</td>
<td>1,070,605</td>
<td>0.10</td>
</tr>
<tr>
<td>7</td>
<td>Amati Global Investors</td>
<td>1,000,000</td>
<td>0.09</td>
</tr>
<tr>
<td>8</td>
<td>FIL Investment International</td>
<td>548,550</td>
<td>0.05</td>
</tr>
</tbody>
</table>

**Bushveld Minerals Ownership**

<table>
<thead>
<tr>
<th>Shareholder</th>
<th>Shares</th>
<th>% Ownership</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bushveld Minerals Ltd Director</td>
<td>31,731,667</td>
<td>2.83</td>
</tr>
</tbody>
</table>

**Source:** Bloomberg, 28 May 2019; Link Asset Services, as at 30 April 2019; Metal Bulletin, 28 May 2019.
# 2018 Performance

## Solid financial performance

<table>
<thead>
<tr>
<th>Bushveld Minerals</th>
<th>2018</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenue (US$'m)</td>
<td>192.1</td>
<td>2.8</td>
</tr>
<tr>
<td>Adjusted EBITDA</td>
<td>101</td>
<td>-</td>
</tr>
<tr>
<td>Cash (US$'m)</td>
<td>42</td>
<td>9.7</td>
</tr>
<tr>
<td>EPS (US cents)</td>
<td>2.9</td>
<td>(0.2)</td>
</tr>
</tbody>
</table>

**Vametco (100% basis)**

<table>
<thead>
<tr>
<th>2018</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenue (US$'m)</td>
<td>183</td>
</tr>
<tr>
<td>EBITDA (US$'m)</td>
<td>108</td>
</tr>
<tr>
<td>FeV LMB price (US$/KgV)</td>
<td>81.2</td>
</tr>
</tbody>
</table>

## Strong share price performance

### FTSE AIM Share 2018 Total Return %

- REGAL PETROLEUM PLC
- BUSHVELD MINERALS LTD
- PEBBLE BEACH SYSTEMS GROUP
- ANGLO ASIAN MINING PLC
- BEEKS FINANCIAL CLOUD GROUP

### FTSE AIM Basic Resources 2018 Total Return %

- BUSHVELD MINERALS LTD
- ORMONDE MINING PLC
- SCOTGOLD RESOURCES LTD
- SHANTA GOLD LTD
- AFRITIN MINING LTD

**Source:** Bloomberg; Company records.
Bushveld Vanadium Overview

A low cost, vertically integrated primary vanadium producer

- High grade ore for primary vanadium mining & processing
- Largest primary vanadium resource base in the world

The Group is targeting a production nameplate capacity of 10,000 mtVp.a. in the medium term

An energy storage solutions provider, exclusively focused on vanadium based energy storage systems

- Electrolyte manufacturing
- Co-location in Vametco process => significantly lowering costs
- Vanadium Redox Flow Battery (VRFB) Assembly & manufacturing
- MW scale energy storage project development
- Deployment models include PPAs, leasing models

Targeting initial 200MWh of electrolyte p.a.

Targeting 1,000 MWh opportunities by 2020

Our vertically integrated business model provides a natural hedge against vanadium price volatility
Operations Overview
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

The Group is targeting a production >8,400 mtVp.a. and a nameplate capacity of 10,000 mtVp.a. within the next 5 years

1. Vametco
   - Primary vanadium mine and plant.
   - Production of 2,560 mtV in 2018.
   - Production of >4,200 mtVp.a. to be achieved post completion of Phase 3 of the Expansion project.
   - 186.7 Mt Resource, 48.4 Mt reserve grade of 1.98% V₂O₅ in magnetite.
   - Life of Mine of 27 years.

2. Brits
   - Outcropping, strike extension of the Vametco mine.
   - Drilling confirms Vanadium in-magnetite grades for the lower seam of 1.66% V₂O₅.
   - Provides the potential for additional ore feed for Vametco and Vanchem.

3. Vanchem (conditional acquisition)
   - Low cost primary vanadium processing facility.
   - Currently producing circa 80mtV per month using 1 of the 3 kilns.
   - Production of 4,200 mtVp.a. to be achieved post completion of a 5 year refurbishment programme.

4. Mokopane
   - 298 Mt JORC, outcropping reserve and resource, vanadium in-magnetite grades of 1.75% V₂O₅.
   - Mokopane to become a primary source of feedstock for Vanchem and supply dry magnetic separated ore.
1. Vametco Overview

- **Production capacity**
  - Vametco produced 2,560 mtV in 2018.
  - Production guidance of 2,800 mtV to 2,900 mtV is expected for the 2019 calendar year a 9-13% increase vs 2018.
  - Production of > 4,200 mtVp.a. to be achieved post completion of Phase 3 of the Expansion project.

- **Cost**
  - 2018 cost of US$19.7/kgV among the lowest in the world.
  - 2019 production costs guidance of US$18.90/kgV to US$19.50/kgV, a 2-4% reduction vs 2019.
  - Implementing several productivity initiatives to further reduce cost.

- **Safety**
  Zero fatalities in 2018
  - Vametco achieved 5,375,484 man-hours without recording a lost time injury.

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### Bushveld Vametco results\(^1\) (100%)

<table>
<thead>
<tr>
<th></th>
<th>CY18</th>
<th>CY17</th>
<th>CY16</th>
<th>CY15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vanadium produced (mtV)</td>
<td>2,560</td>
<td>2,649</td>
<td>2,856</td>
<td>2,419</td>
</tr>
<tr>
<td>Vanadium sold (mtV)</td>
<td>2,573</td>
<td>2,721</td>
<td>2,810</td>
<td>2,340</td>
</tr>
<tr>
<td>FeV LMB price US$/Kg V</td>
<td>81.2</td>
<td>32.6</td>
<td>18.5</td>
<td>18.6</td>
</tr>
<tr>
<td>USD/ZAR exchange $=ZAR</td>
<td>13.2</td>
<td>13.3</td>
<td>14.7</td>
<td>12.8</td>
</tr>
<tr>
<td>Revenue(^2) US$'m</td>
<td>183.0</td>
<td>79.1</td>
<td>51.7</td>
<td>49.2</td>
</tr>
<tr>
<td>EBITDA US$'m</td>
<td>108.3</td>
<td>23.9</td>
<td>3.3</td>
<td>1.3</td>
</tr>
<tr>
<td>Production (cash) costs(^3) US$/kgV</td>
<td>19.7</td>
<td>16.6</td>
<td>12.9</td>
<td>14.6</td>
</tr>
</tbody>
</table>

### Vametco 2018 sales by region

<table>
<thead>
<tr>
<th>Region</th>
<th>Sales %</th>
</tr>
</thead>
<tbody>
<tr>
<td>America</td>
<td>60%</td>
</tr>
<tr>
<td>Europe</td>
<td>16%</td>
</tr>
<tr>
<td>Asia</td>
<td>10%</td>
</tr>
<tr>
<td>Oceania</td>
<td>4%</td>
</tr>
<tr>
<td>Africa</td>
<td>7%</td>
</tr>
<tr>
<td>Middle East</td>
<td>3%</td>
</tr>
</tbody>
</table>

1. Following the completion of the acquisition of the remaining 55% share in Vametco in December 2017, Bushveld’s net attributable interest was 59.1%, this subsequently increased to 74% in September 2018, through a series of transactions.

2. Revenue reported net of all sales commissions.

3. Excludes depreciation, royalties, selling, general and administrative expenses, and impact from production stoppages.

Source: Metal Bulletin, Company records.
Vametco Cost Position

**Vametco Costs (100%)**

<table>
<thead>
<tr>
<th></th>
<th>CY18</th>
<th>CY17</th>
<th>CY16</th>
<th>CY15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production (cash) costs ¹</td>
<td>US$/kgV</td>
<td>19.7</td>
<td>16.6</td>
<td>12.9</td>
</tr>
<tr>
<td>Total cash cost ²</td>
<td>US$/kgV</td>
<td>29.2</td>
<td>20.8</td>
<td>17.0</td>
</tr>
</tbody>
</table>

1 Excludes depreciation, royalties, selling, general and administrative expenses.
2 Total Cash cost calculated as Revenue – EBITDA. Excludes depreciation and royalties. It includes sustaining and non-sustaining capex and exploration capex, selling, general and administrative expenses.

### Vametco 2018 cost breakdown

- **Variable Cost**: 49%
- **Fixed Cost**: 51%

**Source**: Bushveld Minerals, Roskill 2019 Vanadium Report
Following an operational diagnostic exercise in 2018, Vametco has developed a transformation programme to:

- Implement initiatives designed to improve plant operational stability;
- Grow production throughput and lower production costs; and
- Improve organisational health.

- Improve mine production scheduling;
- Increase crusher and mill availability and throughput rates
- Increase kiln availability, hourly feed rate and recoveries;
- Improve leach plant recoveries; and
- Improve organisational health.

- Requires capital investment
- Improve Kiln availability;
- Increase Kiln recovery; and
- Improve Leach recovery.

**Vametco Improvement Programme to Achieve >4,200 mtV**

<table>
<thead>
<tr>
<th>Phase II Expansion Project</th>
<th>Phase III Expansion Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nameplate capacity</td>
<td>Nameplate capacity</td>
</tr>
<tr>
<td>3,750 mtVp.a.</td>
<td>5,000 mtVp.a.</td>
</tr>
<tr>
<td>3,400 mtV</td>
<td>&gt;4,200 mtV</td>
</tr>
<tr>
<td>2,800 - 2,900 mtV</td>
<td>3,400 mtV</td>
</tr>
<tr>
<td>CY19 guidance</td>
<td>3,400 mtV</td>
</tr>
</tbody>
</table>
Communities and Sustainability

Health & Safety

- Vametco had zero fatalities in 2018 and achieved a safety milestone of 5,375,848 man-hours worked without recording a lost-time injury.

- The Department of Mineral Resources’ Mine Health and Safety inspectors made no major findings in 2018 and all action plans were implemented.

Socio-Economic Development

- Vametco has developed a Community Engagement Strategy, the central principle of which is to nurture an environment of mutual trust, respect and effective communication between Vametco and all its stakeholders.

- The Peo Matlafatso Trust a development trust to benefit the community in at Vametco, was established by Bushveld to house a shareholding of up to 12.5% in the Vametco operations.

- In 2018 Vametco spent a total of US$51 million on procurement of goods and services. Of this, US$27 million or 52.5% was spent on BBBEEE compliant companies.
Communities and Sustainability...continued

Environmental Management

- Embarked on the installation of an off-gas scrubber to reduce dust emissions.
- Built a new tailings dump to prevent groundwater contamination and rehabilitated current tailings dams to eliminate fall-out dust.
- Bushveld Minerals plans to upgrade its baghouses to reduce particulate matter and cap its tailings dams to prevent groundwater contamination.
- Our objective is to align our activities with international standards, including those of the International Finance Corporation and ISO 14001:2015.
- We are targeting ISO 14001 certification by the third quarter of 2020.

Human Resources Development

- Employed a total of 503 employees and contractors in 2018.
- 84% of our employees are members of our local communities.
- Vametco is negotiating an ESOP scheme which is aimed at closely aligning the interests of Vametco’s workforce with its operational targets.
- Vametco has developed an Employees’ Financial Wellness Programme to help improve the financial wellbeing of employees.
- 5 main initiatives are under way to provide skills to the local community: learnerships, internships, higher education funding, portable skills and Adult Basic Education and Training.
2. Brits Vanadium Project Overview

• Outcropping, strike extension of the Vametco mine.

• A maiden Mineral Resource estimate will be published in the June 2019 quarter.

• Drilling results to date have indicated:
  
  – Lower seam weighted average $V_2O_5$ grade in-situ of 0.66% and 1.66% in magnetite;
  
  – The marginally lower average grade in comparison to the grades at the Vametco mine is due to the geological trend of decreasing grades in vanadium for magnetite-rich orebodies from west to east in the Bushveld Complex.

• Brits has the potential to provide additional feed tonnage for Vametco and, if required, concentrate feed for the Vanchem plant.
3. Vanchem Acquisition
Bushveld Minerals Limited has conditionally agreed to acquire, through a South African subsidiary, from Vanchem Vanadium Products (Pty) Limited ("VVP") the Vanchem Plant and the SAJV Business collectively referred to as ("the Vanchem Business") and 100% of the outstanding shares of Ivanti Resources (Pty) Limited ("Ivanti") from Duferco Participations Holding S.A for an aggregate cash consideration of US$68 million.

The Vanchem Plant is a primary vanadium producing facility with a beneficiation plant capable of producing various vanadium oxides, ferrovanadium and vanadium chemicals.

Bushveld Minerals has estimated a refurbishment capital amount of US$45 million, which will be incurred over a 5 year period to bring the Vanchem Plant to a steady state annual production of 4,200 mtVp.a.

This acquisition will support Bushveld Minerals’ Mokopane Vanadium Project ("Mokopane") development, which will be a primary supply of feedstock to the Vanchem Plant. Bushveld Minerals has allocated an additional US$20 million capital for the Mokopane development.

The Vanchem-Mokopane model will create a fully integrated business in a shorter time frame and at a lower cost than building a new plant of the same capacity.

This acquisition is consistent with Bushveld Minerals’ growth strategy of achieving a 10,000 mtVp.a. production platform capacity through targeting brownfield processing infrastructure in close proximity to its deposits.

Bushveld Minerals carried out detailed Due Diligence on the Vanchem Plant, SAJV and Ivanti and has concluded the acquisition is value accretive.
The Vanchem Plant History and Future Plans

- Situated at Ferrobank Industrial Park in Emalahleni Local Municipality, Mpumalanga Province and has been operating since the 1970s.
- VVP entered into Business Rescue in November 2015 due to lack of feedstock, following cessation of operations at Highveld Steel & Vanadium and the Mapochs Mine, which supplied both Highveld and Vanchem with ore.
- Parts of the Vanchem Plant have been recommissioned since Q3 2018 after VVP was able to procure magnetite ore from third parties.
- The Vanchem consists of integrated vanadium extraction and production facilities which can produce range of vanadium products.
  - A core salt-roast processing plant, including 3 roasting kilns, that produces vanadium trioxide, vanadium pentoxide;
  - An electric smelting ferrovanadium converter, located at the Highveld Steel & Vanadium (“Highveld”) site, situated approximately 10 km from the Vanchem Plant, which converts vanadium trioxide into ferrovanadium;
  - An alumino-thermic smelting facility, also located at Highveld which converts vanadium pentoxide into ferrovanadium;
  - A vanadium chemical plant producing various vanadium chemical products; and
  - A rail siding linking the plant with Bushveld deposits and additional potential supply sources through the national rail network.
- Vanchem is currently producing circa 80 mtV per month using a single kiln.
- A US$45 million refurbishment programme, incurred over a 5 years period from completion of the Transaction, will allow Vanchem to reach a steady state production of 4,200 mtVp.a. from all 3 kilns.
- The refurbishment programme comprises three phases designed to:
  - Progressively bring the other 2 kilns and all associated production units into full production; and
  - Invest in appropriate environmental management infrastructure.
Vanchem Acquisition Highlights

The acquisition is consistent with the Company’s growth strategy of becoming one of the largest vertically integrated primary vanadium producers:

- **Diversification of Bushveld’s geographic mining and production footprint within South Africa.**

- **Expedites the development of Mokopane, as the primary source of feedstock to the Vanchem Plant.**

- **Provides optimal product diversification with the addition of vanadium pentoxide, vanadium trioxide, ferrovanadium and vanadium chemicals, complementing Vametco’s existing Nitrovan™ offering.**

- **Supports Bushveld in its production target to 10,000 mtvp.a. capacity.**

- **Enhances Bushveld’s ambitions in the global energy storage and vanadium redox flow battery space as it provides capacity for electrolyte manufacturing through the existing chemical plant.**

Collectively, the US$68 million consideration, the US$45 million refurbishment capital expenditure and US$20 million capital spend for Mokopane is substantially less than the cost of building a new plant of the same capacity.
4. Mokopane Vanadium Project Overview

Development strategy options
- Secure mining right and commence mining;
- Become a primary source of feedstock for Vanchem;
- Supply ore to other primary or secondary producers worldwide;
- Optionality to develop as a standalone operation.

<table>
<thead>
<tr>
<th>2016 PFS</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mineral Resource</td>
<td>Mt</td>
<td>298¹</td>
</tr>
<tr>
<td>Ore Reserve</td>
<td>Mt</td>
<td>28.5</td>
</tr>
<tr>
<td>Grade (in-situ)</td>
<td>%</td>
<td>1.4%</td>
</tr>
<tr>
<td>Grade (in-magnetite)</td>
<td>%</td>
<td>1.7%</td>
</tr>
<tr>
<td>Assumed vanadium Price</td>
<td>US$/kg FeV</td>
<td>33</td>
</tr>
<tr>
<td>Initial Capital Costs</td>
<td>US$ m</td>
<td>298</td>
</tr>
<tr>
<td>NPV @ 9% real</td>
<td>US$ m</td>
<td>418</td>
</tr>
<tr>
<td>IRR real</td>
<td>%</td>
<td>25%</td>
</tr>
</tbody>
</table>

1. The Mokopane Vanadium Project PFS, completed by MSA Group was based on the MML only which is 63Mt even though the overall project resource is 298 Mt
2. Vametco after two stage expansion from 3Mtpa to 5Mtpa. Mokopane costs based on operating costs and capital expenditure as estimated in pre-feasibility study. Mokopane project shown for illustration purposes only and does not imply judgement on Roskill’s behalf of the likelihood of Mokopane being commissioned, nor does it imply a judgement of Mokopane’s economics as compared to other brownfield and greenfield expansion projects not included in this cost curve

Source: Bushveld Minerals analysis, Roskill. The measured and indicated resources chart and the cost curve chart are based on Roskill’s 2018 Vanadium report
Diverse Product Offering

- Following the acquisition of Vanchem, the Bushveld Group will have an attractive portfolio of vanadium products.
- Ferrovanadium production will access a market of steelmakers that to date have been inaccessible to Bushveld.
- Vanchem’s high purity chemicals capability complements Bushveld’s electrolyte manufacturing initiatives.

**Vanadium trioxide** ($V_2O_3$)
- Added to steel in the form of ferrovanadium or vanadium-nitrogen proprietary alloys in order to increase strength.

**Vanadium pentoxide** ($V_2O_5$)
- Commonly produced through the treatment of magnetite iron ores, vanadium-bearing slags and secondary materials.

**Modified vanadium oxide** (MVO)
- A combination of $V_2O_3$ and $V_2O_5$.

**Ferrovanadium** (FeV)
- Vanadium is added to steel in the form of ferrovanadium or vanadium-nitrogen proprietary alloys in order to increase strength.

**Nitrovan™**
- Nitrovan™ is a vanadium-nitrogen (VCN) product. Has similar characteristics and uses as FeV.

**Vanadium chemicals** (incl. vanadium electrolyte)
- Vanadium chemicals are used in the manufacturing process of industrial chemicals, and in the cleaning of industrial process waste streams. Electrolytes used in VRFBs.

**Nitrovan™**
- Nitrovan™ is a vanadium-nitrogen (VCN) product. Has similar characteristics and uses as FeV.
Bushveld Energy Overview

A low cost, vertically integrated primary vanadium producer

- High grade ore for primary vanadium mining & processing
- Largest primary vanadium resource base in the world

The Group is targeting a production nameplate capacity of 10,000 mtVp.a. in the medium term

An energy storage solutions provider, exclusively focused on vanadium based energy storage systems

- Electrolyte manufacturing
- Co-location in Vametco process => significantly lowering costs

- Vanadium Redox Flow Battery (VRFB) Assembly & manufacturing
- MW scale energy storage project development
- Deployment models include PPAs, leasing models

Targeting initial 200MWh of electrolyte p.a.

Targeting 1,000 MWh opportunities by 2020

Our vertically integrated business model provides a natural hedge against vanadium price volatility
An Energy Storage Project Developer and Component Manufacturer, Focusing on the African Market

- Bushveld Minerals’ ambition is to grow into one of the world’s most significant, lowest cost and vertically integrated vanadium companies

- This allows Bushveld to leverage its large low cost production base and be a catalyst in the emerging energy storage industry

- Large high grade ore for primary vanadium mining

- Significant resource base in the best areas of the Bushveld complex

<table>
<thead>
<tr>
<th>Bushveld Energy’s focus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrolyte manufacturing</td>
</tr>
<tr>
<td>Large, low cost vanadium processing</td>
</tr>
</tbody>
</table>

Bushveld Energy recognises that electricity in Africa intersects paramount potential for social transformation with an immense commercial opportunity

The Company is focused on developing and promoting the role of vanadium in the growing global energy storage market through application in VRFBs

Its strategy is to install several VRFB systems as part of its longer term vision to become a significant electricity storage provider in Africa by 2020, meeting the demand for utility scale energy storage in Africa by leveraging South Africa-mined and beneficiated vanadium

Bushveld Energy delivered VRFB with a peak power of 120kW and peak energy of 450 kWh into Eskom’s Research Testing & Development (“RT&D”) facility

Bushveld Energy, together with the Industrial Development Corporation (“IDC”) of South Africa, is currently establishing the manufacturing of vanadium electrolyte in South Africa

Source: Bushveld Minerals
The World Bank Group (WBG) has committed **US$1 billion** to accelerate investments in battery storage for low and middle-income countries

- Expected to mobilise another **US$4 billion** in concessional climate financing and public and private investments.
- The programme is expected to help these countries grow use of renewables, particularly wind and solar power, to improve energy security, increase grid stability and expand access to electricity.
- The program aims to finance **17.5GWh of battery storage by 2025**

**South Africa’s draft integrated resource plan (the country’s electricity plan) has massive opportunities for battery energy storage**

- **15,000MW** of new renewable electricity generation by 2040
- **9,000 MW** in peaking generation capacity with provision for alternative technologies (such as battery energy storage).
- New allocation of an **additional 200MW per annum** for small-scale embedded generation that can include storage.
- South African Renewable Energy Independent Power Producer (REIPP) Procurement Programme restarted to add more renewable energy to the grid, creating opportunities for battery storage.

**Bushveld Energy is well positioned in geography and capabilities to take advantage of the massive opportunities in the region**

- Nearly **40% of WBG funding historically has gone to sub-Saharan Africa**, suggesting that a similar amount of the battery energy storage programme will be deployed there
- State-owned electricity utility, Eskom is preparing to roll-out **1400MWh** of battery energy by 2022.
- Deteriorating performance of the South African power system and recent return of “load shedding” creates significant demand from electricity consumers for self supply of electricity, including large amounts of storage.
Bushveld Energy Overview

- Bushveld Minerals’ ambition is to grow into one of the world’s most significant, lowest cost and vertically integrated vanadium companies.
- This allows Bushveld to leverage its large low cost production base and be a catalyst in the emerging energy storage industry.

- Large high grade ore for primary vanadium mining.
- Significant resource base in the best areas of the Bushveld complex.
- Large, low cost vanadium processing facilities.
- Focus on expansion and enhancement of brownfield operation.

Source: Bushveld Minerals

Energy storage solutions provider, exclusively focused on vanadium based energy storage systems

- Electrolyte manufacturing.
- Initial 200MWh electrolyte facility in East London, SA.
- Designed to convert vanadium feedstock from Vametco.

- VRFB assembly & manufacturing.
- Partnership or investment with VRFB firms and local partners.
- Medium term focus, once local market for storage is established.

Targeting initial 200MWh of electrolyte p.a.

- MW scale energy storage project development & Direct VRFB sales.
- Deployment models include PPAs, leasing models.
- 1st battery project with Eskom installed.
- Significant success to date in creating the market, especially in South Africa.

Targeting 1,000 MWh opportunities by 2020.
Bushveld Minerals Growth Plans and Upcoming Catalysts

- List on the Johannesburg Stock Exchange.
- Develop organisational capacity to align with the Company’s growth.
- Continuing simplification and the Bushveld Minerals organisational structure for efficient management.

- Execution of the transformation programme at Vametco to increase production to 3,400 mtVp.a. and then to 4,200 mtVp.a.
- Mokopane secure Mining Right.
- Brits maiden mineral resource estimate to be published in Q2 2019.
- Complete the announced Vanchem acquisition.
- Achieve a production platform >8,400 mtV with a name plate capacity of 10,000 mtVp.a. within the next 5 years.

- Grow the VRFB project pipeline across Africa.
- Working with the IDC to advance development of an electrolyte manufacturing plant.
- Launch and expand deployment of vanadium electrolyte rental product.
- Design and implement a vanadium electrolyte rental product.
- Design and construction of a solar/VRFB mini-grid at Vametco.
Bushveld Minerals Investment Proposition

1. Higher vanadium price outlook than long-term average due to sustained structural deficit

2. Largest primary vanadium resource globally (439.6Mt) High grade resource of ~2% in-magnetite 1st quartile cost curve position

3. Brownfield infrastructure creates scope for low capex and quick scale-up of production capacity

4. A diversified vanadium product portfolio which can serve both the steel industry and the energy storage market

5. Vertical integration with high quality, low cost production base allows us to be a key player in the multibillion-dollar energy storage industry through VRFBs

6. Management team combines decades of experience

7. Concentrated global supply - South Africa has the largest high-grade primary vanadium resources

8. Shareholder Returns Commitment to delivering attractive returns to shareholders
Vanadium Market
Robust and growing demand from steel sector with significant upside from energy storage application uses

Constrained supply, with short term reductions and limited new supply prospects

A sustained structural market deficit, with significant price upside

Russia’s vanadium material disappeared, the market price moved up and thereafter Russia restarted production

Advent of grade 3 rebar in China: The new standard forced Chinese rebar producers to start using vanadium (grade 3) for high strength rebar applications

Problems with production of electrical power and resulting load shedding in South Africa negatively impacted vanadium production leading to the 2008 price spike

Highveld Steel & Vanadium stops production

Reduction due to temporary drivers such as seasonality & destocking, “tolerance period” and substitution.

Ferrovanadium Price Chart

FeV historical mid-price US$/kgV

Source: Bushveld Minerals, Metal Bulletin

May-80  May-81  May-82  May-83  May-84  May-85  May-86  May-87  May-88  May-89  May-90  May-91  May-92  May-93  May-94  May-95  May-96  May-97  May-98  May-99  May-00  May-01  May-02  May-03  May-04  May-05  May-06  May-07  May-08  May-09  May-10  May-11  May-12  May-13  May-14  May-15  May-16  May-17  May'18  May'19
Vanadium Characteristics and Uses

**Characteristics**

- Vanadium (V) is a transition metal, in pure form is a grey, soft, ductile element that does not occur in native form but as a component of minerals and as an impurity amongst hydrocarbons and bauxites.
- It readily forms several stable oxidation states (II, III, IV, and V).

**Steel**

- Fabricability
- High strength-to-weight ratio
- Corrosion resistance
- Weldability
- Ability to exist in 4 different oxidation states
- Water-soluble
- Resistant to attack by alkalis, hydrochloric acid, sulphuric acid, and salt water

**Chemicals**

- Electrolyte accounted for ~3% of 2018 global vanadium consumption, but could grow up to 44% by 2027 as VRFB’s gain momentum.

**Construction steel - rebar**

**Alloys for aerospace industry**

**Long duration utility scale batteries**

The steel industry accounts for ~93% of total vanadium consumption in 2018.
Vanadium Demand - The Steel Story Remains Robust

- Strong correlation between economic development and vanadium intensity of use in steel
- Industrialised economies, such as the USA, typically use more vanadium per tonne of steel than emerging economies such as India and China
- As emerging markets develop, the gap will narrow, driving up vanadium intensity of use and thus vanadium demand
- Greater enforcement of rebar standards will drive up specific vanadium consumption rates in China, bringing it closer to the levels of developed economies
- Implications of closing the gap between emerging economies and the developed world:
  - Steel production in China in 2018 = 928Mt
  - Improving Chinese specific vanadium consumption from 0.048 to 0.078=> 0.03kgV/t additional vanadium demand = 27,840 mtV (~30% of the 2018 V production)

Source: Bushveld Minerals, TTPSquared, Roskill
Vanadium Demand - The Steel Story Remains Robust... continued

New Chinese Rebar Standards will increase intensity of use of Vanadium. This provides a structural shift in demand steel application profile

Enforcement of the new rebar standard is expected to ramp up during the course of 2019.

- Successive rebar regulations/standards responsible for driving greater penetration, post 2005, of higher quality Grade 3+ rebar in place of grade 2.
- Quenching and tempering practices responsible for the slow down of the shift to higher quality rebar between 2014 and 2017.
- New rebar standard introduced in November 2018 to, among others, to deal with quenching and tempering practices in continued push for greater quality rebar
- New rebar standard, however, not immediately thoroughly enforced.
- Seasonality, de-stocking and “Tolerance period” and FeNb substitution in Grade 3 rebar key among reasons for recent V price reduction.
- Chinese rebar manufacturers are required to renew their licenses when there is a change in rebar standards. Enforcement in the form of inspections takes place after renewal of licenses.
- Issuance of licenses is expected to take place in June/July 2019. From the beginning of H2FY19 going forward, all producers shall be bound by the terms of their licenses i.e. new standards.
- The incentive to substitute vanadium with FeNb is significantly diminished by the recent price reductions, while in the longer term, vanadium continues to have several advantages to FeNb in steel applications.
- Longer term, vanadium continues to offer several advantages over niobium in steel applications.

![China Rebar Product Structure](image_url)

Source: Bushveld Minerals, World Bank
Substitution Consideration

Factors supportive of substitution

• Sustained high vanadium prices above US$100/kgV.
• Long term niobium contracts provide reasonable price stability for steel plants.
• Concentration in niobium supply means supply response better coordinated.

Recent data

• China imported 45% more FeNb in 2018 compared to 2017 (35,737mt in 2018 compared to 24,644mt in 2017).
• Much of the substitution is price elastic.
• The incentive to substitute FeV with FeNb is significantly diminished by the recent price reductions in FeV.

Source: Bushveld Mineral analysis, Roskill
The Energy Storage Proposition for VRFBs

- Electricity’s share of energy consumption expected to continue to grow at a rapid pace, doubling from 10% in 1980 to 20% today.
- This has enormous implications not only for global energy production but also for all minerals involved in the electricity value chain.

By 2050 electricity’s share of global energy consumption is expected to be 45% of all energy use

Source: DNV GL Energy Transition Outlook 2018; Navigant
While Vanadium Demand Remains Anchored to Steel, there is Significant Demand Upside from Energy Storage

- Vanadium demand has for decades been underwritten by the steel market, which accounts for over 90% of vanadium consumption.

- Steel market set to continue supporting robust vanadium demand, growing by 2.2% CAGR from 2017 to 2027 through. With expected increase of vanadium intensity of steel, vanadium demand CAGR from steel is expect to be 2.5% through 2027.

- Significant demand upside from growing applications of vanadium in energy storage industry via VRFBs.
  - Stationary energy storage is forecast to grow at CAGR of 58% over the next 10 years, becoming a $US50 billion industry by 2027.
  - While forecasts for VRFBs vary, they could add between 8,000 and 96,000 mtV demand by 2027.
  - This energy storage “upside” may increase vanadium demand CAGR from 2.5% up to 8.4% for the next 10 years.

Source: Bloomberg New Energy Finance, Bushveld Minerals analysis, Roskill
Supply: Concentrated Supply

### SALT ROAST FLOWSHEET (18% of Global Vanadium Feedstock Production)

Three key steps:

- **Salt roasting** of magnetite concentrate with sodium salts at ~1,200°C to form water soluble sodium vanadate material.
- **Leaching, filtration, desilication, precipitation** followed by reaction to form vanadium pentoxide/trioxide.
- **Vanadium pentoxide/trioxide** is converted into FeV or NV or other vanadium end products.

- Grade a key barrier to entry
- Three active primary producers – two in SA and one in Brazil
- Vanadium is the primary driver of economics
- Financing remains a challenge even for primary greenfield projects

### STEEL PLANT CO-PRODUCTION FLOWSHEET (70% of Global Vanadium Feedstock Production)

- Magnetite concentrate is smelted in a blast furnace/EAF.
- TiO₂ is extracted as a slag, while vanadium reports with hot metal.
- Vanadium extracted as a slag through controlled re-oxidation of hot metal, which is further processed into pig-iron/steel.
- Vanadium slag, with elevated vanadium grade, is processed through primary vanadium extraction (salt roast flowsheet).

- Steel and iron ore are the primary drivers of economics
- Capex is key barrier to entry is capex – 5x as much capex as primary production
- Concentrated in China and Russia
- 54% of global V production from China, 20% of global V production from Russia – mostly co-production
- Process produces a V slag further processed into vanadium through primary V process

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Source: Bushveld Minerals, Roskill
Supply: Co-production Supply Is Constrained

High input costs
- Low Fe grade <30% deposits, require concentrating to ~60% Fe
- Higher input costs than steel plants processing haematite ores

High operating costs
- Complex steel plant design
- Inferior Fe grade
- Additional processing steps to remove Ti and V

No leverage on steel prices
- Such plants make up small share of steel production – too small to influence steel prices
- Improved margins from cheaper seaborne iron ore not available
- Being mostly co-producer steel plants, their environmental footprint is negative
- In the firing line of the Central Governments crackdown on pollution

Environmental constraints

Three response options:
- **Switch** – to haematite ores to blend and upgrade magnetite feed
- **Curtail**
- **Stop** – production (e.g. Highveld)

Significant reduction in V supply and limited scope for new production from co-producers

Environmental inspections, challenging iron ore and steel market conditions, and a ban on the import of Vanadium-bearing slags will continue to impact Chinese Vanadium production

Source: Bushveld Minerals, Roskill
Appendix
Bushveld Minerals’ Leadership Team

Fortune Mojapelo
Chief Executive Officer

- Co-founder and Chief Executive Officer (CEO) of Bushveld Minerals
- Co-founder and director of VM Investment (Pty) Ltd, a principal investments and advisory company focusing on developing mining projects in Africa
- Founding CEO of Bushveld Minerals Limited where he has played a lead role developing and executing the company’s vanadium strategy
- Played a leading role in the origination, establishment and project development of several junior mining companies
- His corporate career started at McKinsey & Company as a strategy consultant

Geoff Sproule
Financial Director

- Chartered accountant with experience spanning over 40 years in numerous financial management roles
- Prior to joining Bushveld Minerals Geoff was a partner at Deloitte and Touche

Mikhail Nikomarov
Chief Executive Officer of Bushveld Energy

- Co-founder and Chief Executive Officer of Bushveld Energy, an energy storage solutions company, part of AIM-listed Bushveld Minerals, an integrated vanadium company
- Chairman of the South Africa Energy Storage Association (SAESA)
- Chair of the Energy Storage Committee of Vanitec, the global non-profit organisation of vanadium producers
- Previously worked for McKinsey & Company in Russia and across Africa, focusing on the power sector and economic development
Bertina Symonds  
General Manager  
• Appointed Vametco General Manager in April 2019  
• Previously General Manager of the Nkomati Nickel Mine owned by JSE-listed African Rainbow Minerals Ltd  
• Prior positions at Nkomati Nickel Mine include HOD of Concentrate Production and Concentrate Production Manager  
• Has over 20 years of mining and beneficiation experience  
• Solid track record in general management, stakeholder engagement and operations improvement

Lyndon Williams  
Group Vanadium Specialist  
• Previously Vametco General Manager, COO. Was an acting CEO until promotion to Group Vanadium Specialist role in April 2019  
• Has held a range of roles within Highveld Steel & Vanadium including Metallurgist, Superintendent Vantra, Assistant Manager Steel Plant, Manager Vanchem Manager Steelmaking, Manager Ironmaking, Works Manager Steel and Vanadium, and global Vanadium sales and marketing  
• Is a qualified Metallurgical Engineer  
• Has over 35 years’ experience in the extraction of vanadium as well as vanadium slag production and processing

William Steinberg  
Chief Transformation Officer  
• Chief Transformation Officer since May 2019  
• Previously Vametco’s Works Manager since March 2012  
• Formerly Manager for Iron Plant 2 at Highveld Steel & Vanadium (“HSV”)  
• Prior positions at HSV include Project Manager Furnace 7 rebuild, Iron Making Technologist, Production Manager Iron making, Shift Manager Steel Making, EIT Steel Making  
• Holds a Master’s degree in Metallurgical Engineering from the University of Pretoria, with a thesis in EAF control  
• Also has a Diploma in Organisational Management from the Moscow School of Business  
• Over 10 years’ experience in iron, steel, vanadium processing and management

Tania Mostert  
Chief Financial Officer  
• CFO since April 2011 with overall responsibility for Financial & Management Accounting and Procurement  
• Worked within the Financial and Internal Audit Functions of Highveld Steel & Vanadium  
• Various roles previously held at Highveld Steel & Vanadium include Senior Internal Auditor, Section Manager Management Accounting and Unit Manager Financial Accountant  
• Is a Certified Professional Accountant  
• Over 21 years’ experience in management and financial accounting.
Bushveld Minerals’ Board Of Directors

- Ian Watson, Non-Executive Chairman
- Fortune Mojapelo, Chief Executive Officer
- Geoff Sproule, Financial Director
- Jeremy Friedlander, Non-Executive Director
- Anthony Viljoen, Non-Executive Director
- Michael Kirkwood, Non-Executive Director
Capital Allocation and Dividend Policy

• Despite recent vanadium price trends, Vametco continues to generate healthy cash flows at prevailing prices
• The Company is confident that by maintaining its strategy to target the lower 1st quartile of the cost curve alongside ramping up production, it will continue to maintain a competitive position to generate strong cash flow margins throughout the commodity cycle
• Bushveld Minerals value proposition to shareholders is primarily capital growth
• The Company has sufficient cash generating capacity to pay dividends in the future

Bushveld follows a consistent and disciplined approach to capital allocation to manage the funding of several capital expenditure items in the near- and medium-term

| Maintain existing operations to achieve stable and efficient production |
| Support a strong balance sheet that is resilient through any commodity price environment |
| Invest in the Group’s growth projects, either through organic growth or brownfields acquisitions, to achieve 10,000 mtVp.a. production capacity and downstream integration |

Return cash to shareholders via a dividend
Our dividend policy is based on a free-cash-flow pay-out ratio
The 74% underlying interest in Vametco Alloys (Pty) Ltd was achieved with a total cash outlay of approximately US$49 million, which is 0.5x Vametco’s 2018 EBITDA. 1

1. This outlay will, however, increase following the settlement of the residual deferred consideration payable in 2021 based on a 4.5 multiple applied to 5.9 per cent of Vametco’s EBITDA in 2020.
Ore Reserves have more than doubled to 279,100 tonnes $V_2O_5$ in magnetite.

- grade has increased by 3% to 2.02% $V_2O_5$.
- Updated Resource and Reserve statements with 31% and 85% growth in resources and reserves respectively.
- Resource 186.7Mt average grade 1.98% $V_2O_5$ in concentrate.
- Reserves 48.43Mt average grade 2.02% $V_2O_5$ in concentrate.
- Average magnetite content of 35% and 28.5% in the resources and reserves respectively.
- Magnetite Content % increase in the Ore Reserves from 26.8% to 28.5% is a result of the increase in Magnetite content in the Mineral Resources.
Stratigraphy of Mokopane Vanadium Project

- Main Ore Seam comprising of 2 sublayers: MML Upper (MAG3) & MML Lower (MAG4)
  - Average 1.48 % $V_2O_5$ in situ & 1.75% in magnetite
  - Over 60% Magnetite

Drill core showing a complete MML Intersection: MML Upper, parting & MML Lower
Bushveld Energy’s Electrolyte Rental Model

Financial Institution
- Advances a credit facility to Intermediary
- Delivers required vanadium units to the Intermediary

Intermediary
- Special Purpose Lease Co.
- Pays interest on the credit facility
- Settles the outstanding loan at contract termination
- Converts vanadium into electrolyte
- Supplies vanadium under rental contract
- Recovers vanadium at contract expiration
- Pays nominal upfront deposit for electrolyte
- Pays annual rental fee for the electrolyte (covering interest payments and a price risk premium)

Miner
- Vametco
- Pays cash for the supplied vanadium units at market rates

VRFB customer (Off-Taker)
- Pays for the supplied vanadium units at market rates

Benefits of the product to VRFB customers or manufacturers include:
- Significantly lower and predictable CAPEX for the electrolyte components of the battery
- A manageable annual fee that is added to the battery’s maintenance costs
- Overall lower total cost of ownership / levelized cost for a VRFB than if an outright purchase

Source: Bushveld Energy
Robust Demand for Vanadium

Steel sector

- Circa 90% of vanadium demand is underwritten by the steel industry where it is used as an additive.
- China is the largest market for vanadium.
- The country’s vanadium consumption is anticipated to grow at a CAGR of 2.3% up to 2027 due to a revision of the tensile strength of steel rebar products, announced in 2017.
- China’s new standard is designed to limit and eliminate the use of inferior steels in construction (Grade 2 rebar):
  - Grade 3 (400MPa), Grade 4 (500MPa), and Grade 5 (600MPa), will require 0.03% V, 0.06% V, and more than 0.1% V respectively.
  - The above may lead to an increase in Chinese vanadium demand of over 30% or 10,000 tpa in 2019.

Energy storage

- Vanadium’s unique characteristics positions it well for large scale, long duration energy storage using VRFBs.
- VRFB technology is already in commercial production with large (MW) scale deployments globally.
- China’s new National Development Plan’s (Document #1701) focus “includes 100MW-grade, vanadium redox flow battery energy storage stations.”
- Impact on vanadium demand significant as vanadium comprises 30-50% of cost of VRFB systems.
- Commercialisation of Energy in Europe, EC report: there will be economic potential for very large amounts (about 400 GW) of storage in the EU.
- The amount of vanadium used for energy storage has doubled in the past 12 to 18 months, according to Vanitec.
Vanadium Demand is Underwritten by the Steel Sector

Vanadium consumption and steel production are strongly correlated.

China’s new high-strength rebar standard effective November 2018 estimated to increase global Vanadium demand by 10-15%.

Regulatory prescriptions make it possible to estimate with relative certainty demand outlook for vanadium in the steel sector.

In a nascent energy storage industry, the steel anchor is important for vanadium supply development.

Source: Bushveld Minerals analysis, Roskill, World Steel Association
The flow battery, unlike conventional batteries, 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 membrane, where an electrochemical reaction takes place and electricity is produced.

VRFB is the simplest and most developed flow battery in mass commercial operations.

The unique features of VRFBs make them ideal for utility scale, stationary energy storage applications.

Applications of VRFBs

1. **Driving grid efficiency – operational and capital expenditure**
   - Peak shaving or peaking capacity
   - Regulating load frequency and providing other ancillary services
   - Balancing PV and wind intermittency
   - Reducing and deferring capex for transmission and distribution lines

2. **Driving grid independence**
   - Storing electricity from solar PV for use at night
   - Lowering system costs for micro grids and islands

VRFBs are ideally suited for large scale, long duration storage applications

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“Vanadium has soared more than 130% in the past, outperforming better-known battery components like cobalt, lithium and nickel. Analysts are expecting a shift in uses of vanadium. The metal can be used in industrial-scale batteries, which help to even out daily peaks and troughs from renewables...”

*Bloomberg, January 2018*

<table>
<thead>
<tr>
<th>Year Announced</th>
<th>Company</th>
<th>Location</th>
<th>Size</th>
</tr>
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<tr>
<td>2016</td>
<td>Rongke Power</td>
<td>Dalina, China</td>
<td>800 MWh</td>
</tr>
<tr>
<td>2017</td>
<td>VRB Energy</td>
<td>Hubei, China</td>
<td>400 MWh</td>
</tr>
<tr>
<td>2018</td>
<td>RedT</td>
<td>Austria, Germany</td>
<td>60 MWh</td>
</tr>
</tbody>
</table>
Global challenge

- 1,000 MWh of VRFB-based energy storage requires ~6% of global vanadium supply.
- VRFBs could contribute ~44% of vanadium consumption by 2027.

- Vanadium input costs contribute 30-50% of the cost of the VRFB systems.

Bushveld Minerals opportunity

- Extensive vanadium resource in South Africa of ~ 485 Mt.
- High grade of vanadium resources in Bushveld complex allow for low cost, primary vanadium production.
- Existing low cost cash generating and scalable production platform.

- Bushveld vanadium projects are well positioned with a lower first-quartile cash cost to mitigate security of cost risk.
- Bushveld’s new electrolyte rental product will reduce upfront costs and allocate them over long life-span of VRFB and reduce vanadium price risk.
## Performance Benefits of VRFBs and Lithium-ion

<table>
<thead>
<tr>
<th>Metric</th>
<th>VRFB</th>
<th>Lithium-ion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub-chemistries</td>
<td>$\text{H}_2\text{SO}_4$-based, HCl-based</td>
<td>LFP, LMO, NCA, NMC, LTO</td>
</tr>
<tr>
<td>Energy Density</td>
<td>20-40 Wh / kg</td>
<td>80-200 Wh/kg</td>
</tr>
<tr>
<td>Discharge Time</td>
<td>3-10 hours</td>
<td>0.5-5 hours</td>
</tr>
<tr>
<td>DC Efficiency</td>
<td>75-90%</td>
<td>92%-99%</td>
</tr>
<tr>
<td>Cycle Life</td>
<td>20,000-30,000 cycles</td>
<td>600-12,000 cycles</td>
</tr>
<tr>
<td>Calendar Life</td>
<td>20-25 years</td>
<td>3-10 years</td>
</tr>
<tr>
<td>Depth of Discharge</td>
<td>100%</td>
<td>80-95%</td>
</tr>
<tr>
<td>Ambient temperature</td>
<td>-20 - 50°C</td>
<td>0-30°C</td>
</tr>
<tr>
<td>Self-discharge (24h)</td>
<td>2.5%</td>
<td>5%</td>
</tr>
<tr>
<td>Safety Notes</td>
<td>Corrosive electrolyte</td>
<td>Susceptible to thermal runaway</td>
</tr>
<tr>
<td>Applications</td>
<td>Suited for energy applications</td>
<td>Suited for power and energy applications</td>
</tr>
</tbody>
</table>

Source: Bushveld Energy, Navigant
Vanchem Processing Steps

The processing plant at Vanchem is fed ore. Vanchem has access to a rail siding for delivery of ore to the plant.

The magnetite is conveyed to the separate feed tables and ore sheds of the 3 kilns. A roasting process is employed at the three kilns where magnetite is mixed with sodium containing reagents and calcined in the kiln.

The magnetite is dewatered through belt filters. The ore is conveyed for milling and magnetic separation. The magnetite material is then dewatered through belt filters.

Leach dams/vats are used to leach out the water soluble sodium vanadate as a pregnant solution. The waste calcine is transported by road to the remote calcine waste disposal facility.

Leach Milling & Purification

The pregnant solution is split between the Oxide Section and the Chemical Plant. At the former, an ammonium polyvanadate ("APV") batch precipitation process is employed. The product stream is them split between \( V_2O_5 \) flake and \( V_2O_3 \).

APV precipitation

The dried APV is pneumatically conveyed to the \( V_2O_3 \) reactors where ammonia gas is added from tanks to facilitate the reaction. The \( V_2O_3 \) is conveyed to a holding bin before being loaded into a tanker for transport to the FeV site.

\( V_2O_3 \) Production

At the FeV furnace facility \( V_2O_3 \) is used to produce FeV using an electric smelting furnace.

FeV production

FeV is produced from \( V_2O_5 \) flake using an alumina-thermic reaction process.

\( V_2O_5 \) Production

Pregnant solution is sent to the Chemical Plant for the production of various vanadium chemicals, including \( V_2O_5 \) powders, Electrolyte and Vanadyl Oxalate.

Vanadium Chemicals production

The dried APV is first de-ammoniated and then smelted in the gas fired or electric powered fusion furnaces and flaked on a flaking where it is packed either for sale of \( V_2O_5 \) flake or conversion to FeV.

FeV production

V_{2}O_{5} Production
Vametco Employs the Standard Salt Roast and Leach Process to Produce Nitrovan™
The ore is passed through a three-stage crushing and milling circuit to produce a product sizing suitable to liberate the gangue materials in the ore, typically 20% passing 75 microns and passed through a low intensity magnetic separation circuit to produce a magnetite concentrate product.

The concentrate is roasted with sodium carbonate and sodium sulphate in a rotary kiln at temperatures of up to 1,150°C to form water-soluble sodium vanadates. Solids exiting the rotary kiln are discharged directly into a rotary cooler that cools the solids sufficient for conveying to the leaching circuit.

The cooled calcine is fed to a wet ball mill which grinds the agglomerated material for improved leaching and also acts as the first stage of leaching. The mill discharge slurry is pumped to belt filters to separate the vanadium rich solution and calcine tailings. The vanadium rich solution is pumped to thickeners where desilication and concentration of the vanadium-bearing leach liquor takes place. Calcine tailings are conveyed to the tailings disposal facility.

Ammonium sulphate is added to the vanadium-bearing leach liquor which allows for the precipitation of vanadium in the form of ammonium metavanadate (AMV).

The AMV filter cake is dried in a rotary dryer and thereafter transferred to the MVO Rotary Calciners to produce Modified Vanadium Oxide (MVO).

Nitrovan™ production – the MVO is mixed with carbon and a binder which is briquetted and fed into an induction shaft furnace under a nitrogen atmosphere to produce Nitrovan™.
Stationary energy storage usage parallels that of transmission lines, which move electricity from one location to another. Similarly, energy storage moves electricity from one time to another.

Different types of storage and storage technologies are relevant for different applications, often determined by the amount of time stored energy that is required.

While storage is needed to stabilise and make variable generation from solar and wind dispatchable (or “base load”), the value of storage goes far beyond supporting renewable energy.

Boxes in grey: Storage services directly supporting the integration of renewable energy

Source: International Renewable Energy Agency (IRENA)
Bushveld Minerals Corporate Video: https://www.brrmedia.co.uk/broadcasts/5a5626af9ed50c2f9b04679c/bushveld-minerals-an-emerging-integrated-vanadium-producer
Vanadium 101 Webinar:
https://edge.media-server.com/m6/p/i2wo6bk9
Vanadium 101 Slides:
Energy Storage 101 Webinar:
http://webcasting.brrmedia.co.uk/broadcast/5bd2eae5b01efb6b20c2f9eb/5bd348eba21632633b00003d