BUSHVELD PRICE 3.65p
VALUATION (UPSIDE) 4.80p (+32%) ▪ 6.80p (+86%)

Turning the corner?

26 MAY 2023 at 06:40*

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Material position within primary vanadium production market

Bushveld produces a range of vanadium products at its operations in South Africa. It operates 2 of the world's 4 operational vanadium ore processing facilities and 1 of only 3 operating vanadium mines. Vanadium is predominantly used in steel production with a small but growing portion used in utility scale battery storage systems.

Considerable asset value potential, but challenges to be overcome

We believe the assets have the potential to deliver considerable value, however, we need to see completion of the convertible debt refinancing on the agreed terms and continued ramp-up in production for this to be delivered. The latest phase of ramp-up got underway in H2 2022 following the completion of plant refurbishment which should result in reduced capex requirements. Power supply interruptions (load shedding) have impacted operations but a revised agreement on power supplies should reduce this impact in 2023. We expect a return to positive EBITDA in 2022, with additional growth in production and cash generation driven by continued production optimisation. After a period of underperformance it appears Bushveld is turning the corner. Additional expansion phases have been identified, offering additional growth potential.

Valuation range of 4.8-6.8p/sh incorporating producing assets and growth projects

The bottom end of our valuation range is set equal to our base case risked NAV for the producing assets, incorporating the agreed convertible debt refinancing terms. The top end of our range incorporates risked potential from expansion projects and the group's investments in grid scale storage related technology. We believe operational progress ramping up production with a resultant improvement in cash generation to pay-down the refinanced debt should de-risk the equity story.

Price (25 May 2023)	3.65p
Market cap (USDm / GBPm)	61 / 49
Free float (USDm / GBPm)	49 / 39
EV (USDm / GBPm)	177.0 / 143
3m avg volume (USDm / GBPm)	0.3 / 0.2
Refinitiv / Bloomberg	BMNB.L / BMN LN
Country	UK

Performance[1]	1w	1m	3m	12m
Absolute(%)	(3)	(10)	(26)	(59)
Rel. Mining(%)	0	(5)	(11)	(52)
Rel. MSCI Europe(%)	(1)	(7)	(25)	(63)

Financials	12/22e	12/23e	12/24e	12/25e
EPS, Adjusted (USD)	(0.01)	(0.01)	0.00	0.00
EPS, Company (USD)				
EPS - Refinitiv (USD)	(0.37)	(0.46)	(0.26)	-
Net dividend (USD)	-	-	-	-
Sales (USDm)	152	169	180	195
EBITA, Adj. (USDm)	2.4	5.6	17.4	25.0
Net profit, Adj.(USDm)	(16.5)	(7.1)	1.6	7.3
ROCE (%)	0.7	1.7	5.4	7.8
Net Debt/EBITDA, Adj. (x)	3.3	2.7	1.5	0.9

Valuation metrics[2]	12/22e	12/23e	12/24e	12/25e
P/E (x)	-	-	74.5	16.6
Net yield (%)	-	-	-	-
FCF yield (%)	0.3	(0.1)	10.6	14.3
EV/Sales (x)	1.6	1.0	0.9	0.8
EV/EBITDA (x)	11.2	7.3	4.8	3.7
EV/EBITA (x)	98.0	31.8	9.6	6.1
EV/CE (x)	1.0	0.8	0.7	0.7

All valuation metrics based on adjusted figures

Source: BNP Paribas Exane (estimates), Refinitiv (consensus) (1) In listing currency, with dividend reinvested (2) Yearly average price for FY ended 12/22

Price at 25 May 23: 3.65p

Valuation range (p): 4.80 (+32%) | 6.80 (+86%)

BUSHVELD

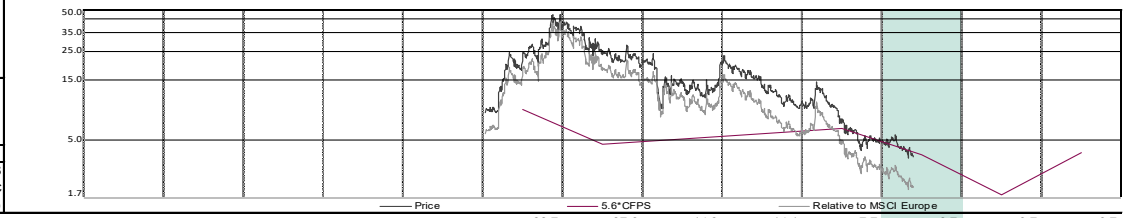
Refinitiv / Bloomberg: BMNB.L / BMN LN — Analyst: Thomas Martin (+44) 203 430 8435 — Mining - United Kingdom

Company Highlights	USDm / EURm
Enterprise value	177 / 165
Market capitalisation	61 / 57
Free float	49 / 45
3m average volume	0.3 / 0.2

Performance (*)	1m	3m	12m
Absolute	(10%)	(26%)	(59%)
Rel. Sector	(5%)	(11%)	(52%)
Rel. MSCI Europe	(7%)	(25%)	(63%)

12m Hi/Lo : 9.3p -61% / 3.60p +1%

CAGR	2019/2022	2022/2025
EPS restated	NC	NC
CFPS	10%	(14%)



Price (yearly avg from Dec. 18 to Dec. 22)	22.7	27.6	14.3	14.1	7.7	3.7	3.7	3.7
PER SHARE DATA (USD)	**Dec. 18**	**Dec. 19**	**Dec. 20**	**Dec. 21**	**Dec. 22e**	**Dec. 23e**	**Dec. 24e**	**Dec. 25e**
No of shares year end, basic, (m)	1 119.728	1 153.643	1 190.758	1 260.459	1 287.818	1 348.611	1 348.611	1 348.611
Avg no of shares, diluted, excl. treasury stocks (m)	2 163.636	2 279.205	1 164.710	1 201.683	1 267.299	1 303.016	2 697.222	2 697.222
EPS reported, Gaap								
EPS company definition								
EPS restated, fully diluted	0.01	0.03	(0.03)	(0.03)	(0.01)	(0.01)	0.00	0.00
% change	*NS*	*94.7%*	*NS*	*(29.2%)*	*61.6%*	*58.1%*	*NS*	*349.2%*
Book value (BVPS) (a)	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1
Net dividend								
STOCKMARKET RATIOS	**Dec. 18**	**Dec. 19**	**Dec. 20**	**Dec. 21**	**Dec. 22e**	**Dec. 23e**	**Dec. 24e**	**Dec. 25e**
P / E (P/ EPS restated)	21.6x	12.9x	NC	NC	NC	NC	74.5x	16.6x
P / E relative to MSCI Europe	143%	94%	NC	NC	NC	NC	626%	150%
P / CF	14.7x	33.7x	NC	NC	7.0x	5.4x	11.2x	5.2x
FCF yield	4.6%	(4.0%)	(12.4%)	(13.8%)	0.3%	(0.1%)	10.6%	14.3%
P / BVPS	2.61x	2.22x	1.32x	2.07x	1.20x	0.61x	0.60x	0.56x
Net yield								
Payout			NC	NC	NC	NC		
EV / Sales	1.67x	3.96x	3.37x	3.20x	1.56x	1.05x	0.93x	0.79x
EV / Restated EBITDA	3.2x	14.2x	NS	NS	11.2x	7.3x	4.8x	3.7x
EV / Restated EBITA	3.4x	20.8x	NS	NS	98.0x	31.8x	9.6x	6.1x
EV / NOPAT	4.7x	29.2x	NS	NS	NS	44.8x	13.6x	8.7x
EV / OpFCF	7.0x	NS	NS	NS	50.8x	13.4x	8.0x	5.5x
EV / Capital employed (incl. gross goodwill)	2.2x	1.7x	1.1x	1.4x	1.0x	0.8x	0.7x	0.7x
ENTERPRISE VALUE (USDm)	**321**	**462**	**304**	**342**	**237**	**177**	**168**	**154**
Market cap	316	396	213	233	120	61	61	61
+ Adjusted net debt	(42)	13	40	70	70	66	53	35
+ Other liabilities and commitments	2	2	2	2	2	2	2	2
+ Revalued minority interests	45	50	48	49	52	56	60	63
- Revalued investments	0	0	0	12	8	8	8	8
P & L HIGHLIGHTS (USDm)	**Dec. 18**	**Dec. 19**	**Dec. 20**	**Dec. 21**	**Dec. 22e**	**Dec. 23e**	**Dec. 24e**	**Dec. 25e**
Sales	**192**	**117**	**90**	**107**	**152**	**169**	**180**	**195**
Restated EBITDA (b)	**101**	**33**	**(15)**	**(10)**	**21**	**24**	**35**	**41**
Depreciation	(6)	(10)	(18)	(19)	(19)	(19)	(17)	(16)
Restated EBITA (b)	**95**	**22**	**(33)**	**(29)**	**2**	**6**	**17**	**25**
Reported operating profit (loss)	95	22	(33)	(29)	2	6	17	25
Net financial income (charges)	(9)	61	(5)	(13)	(11)	(12)	(12)	(11)
Affiliates	0	0	0	(4)	(4)	0	0	0
Other	0	0	0	0	0	0	0	0
Tax	(38)	(14)	7	5	(2)	2	(2)	(4)
Minorities	(19)	(7)	1	1	(2)	(2)	(2)	(2)
Net attributable profit reported	30	62	(31)	(41)	(17)	(7)	2	7
Net attributable profit restated (c)	**30**	**62**	**(31)**	**(41)**	**(17)**	**(7)**	**2**	**7**
CASH FLOW HIGHLIGHTS (USDm)	**Dec. 18**	**Dec. 19**	**Dec. 20**	**Dec. 21**	**Dec. 22e**	**Dec. 23e**	**Dec. 24e**	**Dec. 25e**
EBITDA (reported)	**101**	**33**	**(15)**	**(7)**	**21**	**24**	**35**	**41**
EBITDA adjustment (b)	**0**	**0**	**0**	**(2)**	**0**	**0**	**0**	**0**
Other items	0	(0)	(0)	2	0	0	0	0
Change in WCR	(25)	5	1	(5)	4	(0)	(6)	(3)
Operating cash flow	**76**	**37**	**(14)**	**(12)**	**25**	**24**	**29**	**38**
Capex	(30)	(49)	(12)	(24)	(21)	(11)	(8)	(10)
Operating free cash flow (OpFCF)	**46**	**(12)**	**(26)**	**(37)**	**5**	**13**	**21**	**28**
Net financial items + tax paid	(29)	(6)	(6)	(2)	(4)	(13)	(8)	(10)
Free cash flow	**17**	**(18)**	**(32)**	**(39)**	**1**	**(0)**	**13**	**18**
Net financial investments & acquisitions	0	(4)	(2)	6	(1)	0	0	0
Other	2	(23)	6	3	0	0	0	0
Capital increase (decrease)	23	0	0	0	0	5	0	0
Dividends paid	0	(4)	0	0	0	0	0	0
Increase (decrease) in net financial debt	**(42)**	**50**	**28**	**30**	**1**	**(4)**	**(13)**	**(18)**
Cash flow, group share	**45**	**24**	**(21)**	**(10)**	**17**	**11**	**11**	**23**
BALANCE SHEET HIGHLIGHTS (USDm)	**Dec. 18**	**Dec. 19**	**Dec. 20**	**Dec. 21**	**Dec. 22e**	**Dec. 23e**	**Dec. 24e**	**Dec. 25e**
Net operating assets	105	245	227	212	216	208	199	193
WCR	38	33	49	29	25	25	31	35
Restated capital employed, incl. gross goodwill	**143**	**278**	**275**	**242**	**241**	**234**	**231**	**228**
Shareholders' funds, group share	130	183	165	118	102	99	101	108
Minorities	30	34	32	32	35	37	40	42
Provisions/ Other liabilities	31	60	46	36	45	42	48	53
Net financial debt (cash)	(42)	8	35	65	66	62	49	31
FINANCIAL RATIOS (%)	**Dec. 18**	**Dec. 19**	**Dec. 20**	**Dec. 21**	**Dec. 22e**	**Dec. 23e**	**Dec. 24e**	**Dec. 25e**
Sales (% change)	NC	(39.3%)	(22.8%)	18.7%	42.4%	11.0%	6.3%	8.6%
Organic sales growth								
Restated EBITA (% change)	NC	(76.6%)	NC	10.7%	NC	130.2%	213.0%	43.7%
Restated attributable net profit (% change)	NC	105.1%	NC	(33.3%)	59.5%	57.0%	NC	349.2%
Personnel costs / Sales	3.7%	8.3%	9.1%	10.1%	5.3%	4.8%	4.9%	4.8%
Restated EBITDA margin	52.7%	28.0%	(16.6%)	(9.3%)	13.9%	14.3%	19.4%	21.2%
Restated EBITA margin	49.5%	19.1%	(36.5%)	(27.4%)	1.6%	3.3%	9.7%	12.8%
Tax rate	43.4%	16.8%	NC	NC	NC	NC	29.0%	29.0%
Net margin	25.5%	59.4%	(34.6%)	(39.4%)	(9.3%)	(2.8%)	2.2%	5.0%
Capex / Sales	15.8%	42.0%	13.8%	22.7%	13.5%	6.3%	4.4%	5.2%
OpFCF / Sales	23.7%	(10.0%)	(29.0%)	(34.4%)	3.1%	7.8%	11.6%	14.4%
WCR / Sales	19.5%	28.2%	54.3%	27.5%	16.6%	15.1%	17.5%	17.7%
Capital employed (excl. gdw./intangibles) / Sales	44.5%	187.2%	240.5%	170.8%	119.4%	103.3%	95.5%	86.6%
ROE	23.3%	33.8%	(18.5%)	(34.5%)	(16.2%)	(7.2%)	1.6%	6.8%
Gearing	(26%)	6%	20%	46%	52%	48%	38%	24%
EBITDA / Financial charges	NC	NC	NC	NC	2.0x	2.0x	3.0x	3.7x
Adjusted financial debt / EBITDA	NC	0.4x	NC	NC	3.3x	2.7x	1.5x	0.9x
ROCE, excl. gdw./intangibles	79.1%	7.2%	(10.8%)	(11.4%)	0.9%	2.3%	7.2%	10.5%
ROCE, incl. gross goodwill	47.4%	5.7%	(8.5%)	(8.6%)	0.7%	1.7%	5.4%	7.8%
WACC	15.7%				12.0%	11.3%	11.3%	11.3%

Latest Model update: 26 May. 23

(a) Intangibles: USD59.25m, or 0p per share. (b) adjusted for capital gains/losses, exceptional restructuring charges, capitalized R&D; EBITA also adjusted for impairments and am. of intangibles from M&A
(c) after EBITA adjustments and financial result/tax adjustments, (*) In listing currency, with div. reinvested

Contents

Investment summary

Significant position within primary vanadium production market

Bushveld operates two of the world's four operational vanadium ore processing facilities (Vametco and Vanchem), and one of only three operating primary vanadium mines (the Vametco mine). Vanadium is a metal primarily used in steel production (92% of demand) which is increasingly being used globally in utility scale battery storage systems (Vanadium Redox Flow Batteries – VRFBs).

~3/4 of global vanadium production through co-production with steel

Primary vanadium production via mining only accounts for ~17% of global vanadium supply, with ~73% produced in conjunction with steelmaking.

Considerable asset value potential, recently announced refinancing paves way to unlock potential

We believe the assets have the potential to deliver considerable value and the recently announced refinancing paves the way to unlock this value.

Secure enhanced funding visibility

Bushveld announced on 5 May 2023 it had entered into a non-binding refinancing agreement with Orion Mine Finance, a global asset management firm specialising in precious/base metals and minerals. This agreement replaces the existing ~US$45m convertible debt with a portion of new debt, partial conversion and into equity at 6p/sh and an additional royalty. The new debt structure better aligns with forecast cash generation from the business.

This proposal is conditional upon several items, including due diligence, shareholder approval at a general meeting (potentially the AGM which is typically held in August) and definitive documentation. Completion of the refinancing is critical to the equity story and we assume in our analysis it is completed on the agreed terms.

Delivering production ramp-up

Production from the Vanchem facility has not yet ramped up to targeted levels following refurbishment of kiln 3 in 2022. Uninterrupted periods of operation are required to optimise operating parameters for new/refurbished equipment; unfortunately load shedding on the South African power grid has been particularly extreme in late 2022. This has disproportionately impacted Vanchem, since all power to the facility was lost during periods of load shedding, however, an agreement was recently reached with the local municipality whereby during periods of *scheduled* load shedding power supply to Vanchem will be curtailed rather than cut off.

This should have a positive impact on production on two fronts. Firstly increased uptime should enable plant operators optimise kiln 3 operating parameters. Secondly the revised power arrangement should increase overall operating hours, driving increased production. During *unscheduled* periods of load-shedding, however, power supply to Vanchem will still be cut-off.

Further expansion potential identified

We forecast production of 4,200 mtV in 2023 (2,700 Vametco and 1,500 Vanchem), at the bottom of Bushveld's 4,200-4,500mtV guidance range. We forecast the group's steady state production target of 5,000-5,400 mtV pa will be reached in 2026; management has not yet indicated the time by which this target is expected to be achieved.

Beyond this target for the existing asset base four expansion programs have been identified which are anticipated to take production from 5,000-5,400mtV pa to 8,000mtV pa, a ~50% increase over the steady-state production target. Feasibility and pre-feasibility studies have been undertaken, but commencement of these expansion stages is contingent upon achievement of the steady-state production target, funding and third-party validation of project economics.

We have modelled these potential expansion cases but for the time being our – and we believe the market's – focus is on the performance of the existing producing assets which we believe is key to the equity story.

Financial summary

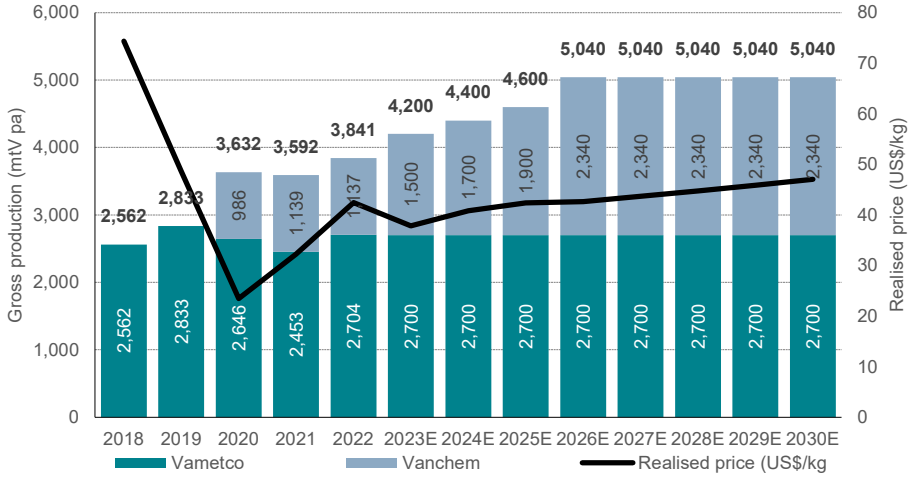
We forecast steady growth at Vanchem and hold Vametco production flat at 2022/23 levels in our base case. Refurbishment of equipment at Vanchem during 2022 has not yet fully contributed to production since it has not been possible to optimise the operation of the equipment owing to power interruptions. A revised agreement with the local municipality is expected to improve power supply to Vanchem from 2023.

Our production forecast for 2023 is at the bottom-end of management guidance and we do not forecast production reaching the bottom-end of the anticipated 5,000-5,400 mt V pa sustainable run-rate until 2026. Operational stability, including the reliable supply of power to the company's facilities, will be a key determinant of the production ramp-up.

We examine a sensitivity case in this report where Vanchem production is maintained at 2023 production levels. In this case we still forecast healthy levels of cash-generation and the ability to pay-down debt.

Figure 1: Group production forecast

Gross production (mt V pa) and realised vanadium price (US$/kg)

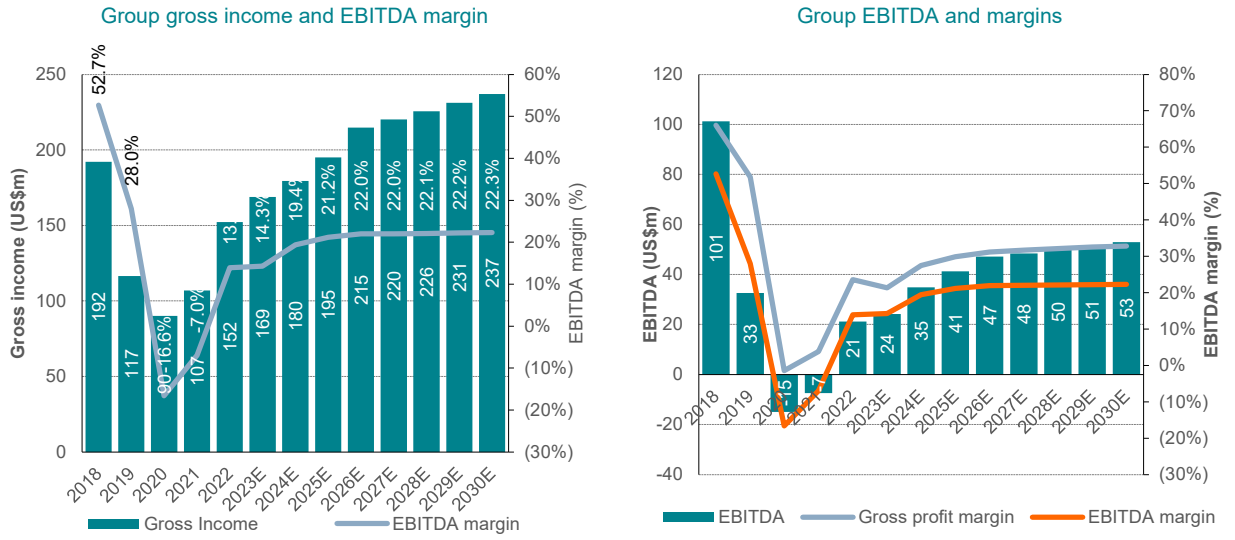


Source: Company, BNP Paribas Exane estimates. Note Vanchem acquired in late 2019.

We forecast steady growth in gross income proportional to production, with a LMB vanadium price of US$37/kg in H1 2023, and US$33/kg in H2 2023, rising back to US$37/kg in H1 2024 and US$40/kg in H2 2023. We forecast Bushveld realising an 8% premium to LMB pricing in 2023 reflecting recent strong North American pricing and increased sales into that market, falling to a 2% premium to LMB by 2026. We incorporate 2.5% pa inflation in our vanadium price and opex forecasts.

The ramp-up in production at Vanchem drives a steady increase in forecast EBITDA margins to 22%from 2026.

Figure 2: Steady performance at Vametco and growing production at Vanchem drives revenue growth and EBITDA margin expansion

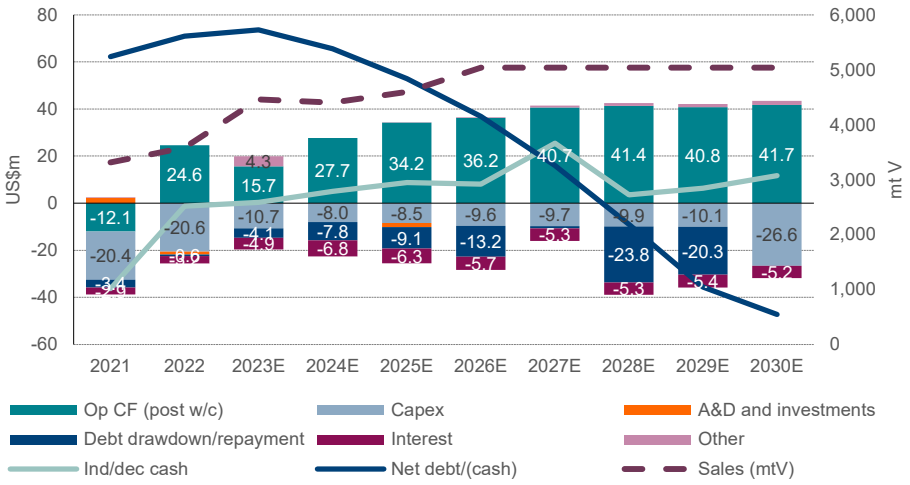


Source: Company, BNP Paribas Exane estimates

We forecast an improvement in operating cash-flow generation (pre w/c) from 2024 towards ~US$41m pa from 2026, following two negative cash-flow years in 2020 and 2021. We model a decline in cash generation in 2023 owing to lower assumed vanadium prices. We model working capital outflows as the business ramps up to steady state with post w/c cash-flow generation reaching ~US$40m pa from 2027.

Figure 3: Historic investment program provides operational base for cash generation and debt pay-down in our base case

Cash-flow forecast summary chart, net debt and production



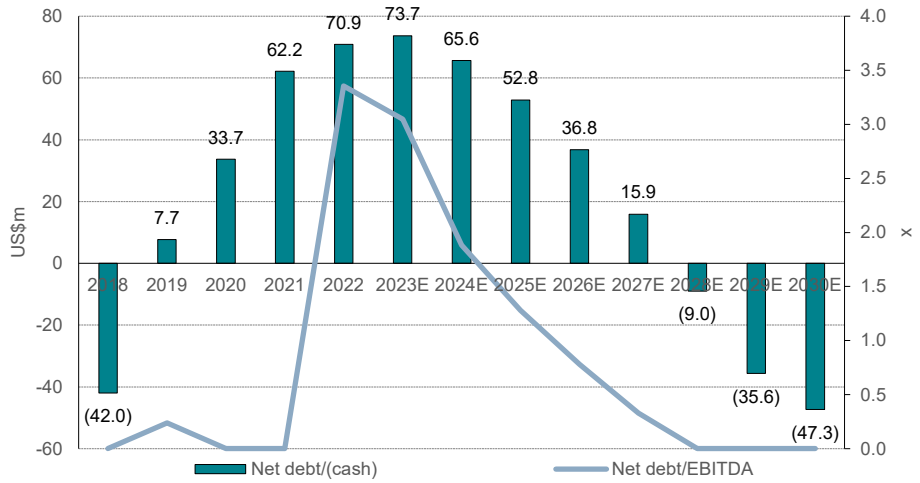
Source: Company. BNP Paribas Exane estimates

Our base case forecasts incorporate the proposed conversion of ~US$4.5m of the existing convertible into equity at 6p/sh. On our base case forecasts net debt peaks in 2023 on lower vanadium prices, with improving profitability thereafter, enabling debt pay-down to achieve a net cash position in 2028.

Excess cash generation could potentially be reinvested in the identified expansion programs at Vametco and Vanchem, which are not modelled in our base case assumptions, delivering further growth for the business towards ~8,000 mt V pa.

Figure 4: We forecast peak net debt being sustained through 2023 and falling thereafter. Our forecasts incorporate the US$4.5m debt for equity conversion announced as part of the refi

Net debt and covenant metric



Source: Company, BNP Paribas Exane estimates

Valuation summary

We set a valuation range of 4.8-6.8p/sh. The lower end of our range is set in-line with our base case risked NAV for the producing assets, incorporating the impact of the convertible refinancing. The upper end incorporates risked contribution from the potential expansion projects at Vametco and Vanchem, plus risked potential for the company's battery-storage related investments. The cost of capital is an important sensitivity for Bushveld; we incorporate a 16.2% WACC in our base case and include sensitivities in this report.

Risks

The principal near-term risks for the business are completion of the announced convertible refinancing on the terms announced, the stability of operations (linked in part to the impact of load shedding on operations) and the ability to ramp-up production. In addition vanadium prices have recently declined from ~US$41/kg in March 2023 towards US$32/kg today (European price), impacting near-term cash generation. Our base case forecasts incorporate the impact of recent movements, but our valuation exhibits significant sensitivity to long-term commodity price forecasts, as summarised in the valuation section of this report. With Vanadium prices quoted in US$, and the company's cost base predominantly Rand denominated, the business is also exposed to US$/ZAR currency fluctuations.

Recent performance disappointing but outlook improving

Execution has proven more costly and time consuming than anticipated

Bushveld acquired a substantial vanadium resource – the Vametco mine and associated beneficiation plant in 2017/18 – and has acquired additional processing facilities at Vanchem in 2019. The strategy adopted was to buy brownfield processing facilities and invest to improve reliability and increase available production capacity to monetise the resource base. The acquisition and refurbishment of existing brownfield sites was assessed to be lower cost and offer better economics than the construction of new facilities.

Substantial refurbishment of both Vametco and Vanchem is now complete; the process has, however, been more costly and time consuming than originally anticipated. Although Vametco is now delivering at steady state, Vanchem has not yet achieved its targeted run-rate post completion of the investment program. Load shedding in South Africa has frustrated the commissioning and optimisation process post investment and impacted run rates/uptime.

We summarise below the evolution of the business over recent years and highlight why the business could now be turning the corner, aided by new agreements offering more stable power supply and more suitable ore feed at Vanchem, and the refinancing of the outstanding convertible debt.

Three principal operating assets

Bushveld Minerals comprises three principal operating assets:

- the Vametco mine,
- the Vametco processing facility,
- and the Vanchem processing facility.

In addition the company's Bushveld Energy subsidiary is constructing a battery electrolyte manufacturing plant which is currently being commissioned.

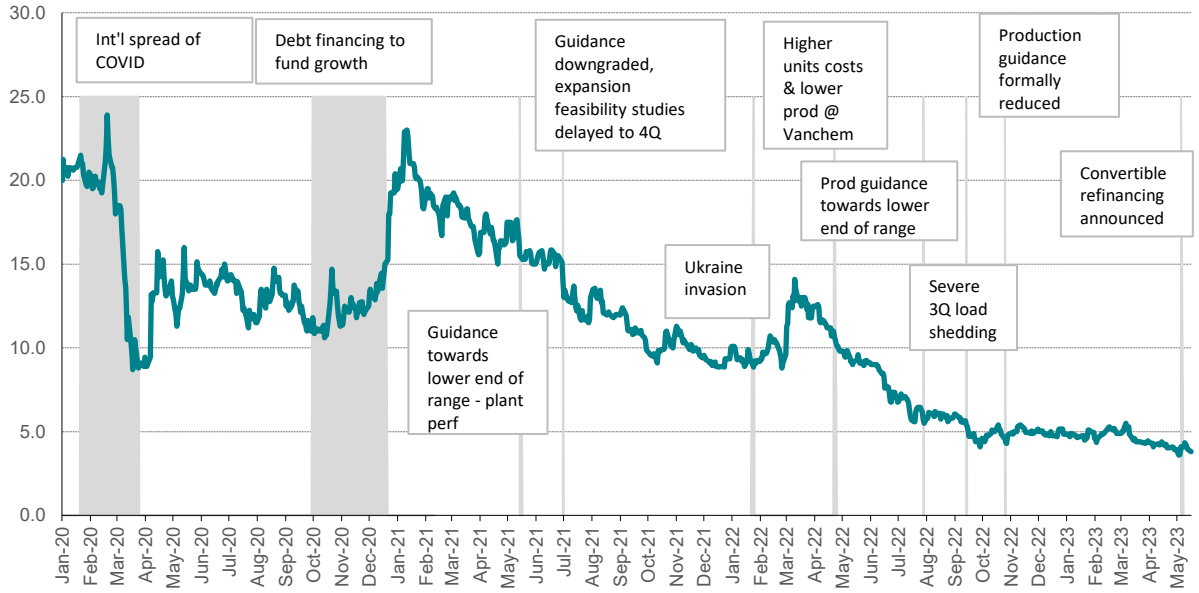
Bushveld also holds:

- a 30-year mining right over the Mokopane vanadium deposit,
- a prospecting right over the Brits vanadium resource

Although these resources could be developed in the future we believe the focus is on optimising, and eventually ramping up production from the existing assets.

Performance has not met market expectations over the last two years, but could be turning the corner

Figure 5: Business performance has not met market expectations, but could be turning a corner



Source: Datastream, BNP Paribas Exane estimates

Expansion financing secured in 4Q 2020 targeting 5,000-5,400 mtV pa

In late 2020 Bushveld secured US$65m financing from Orion Mine Finance, a global asset management firm specialising in precious/base metals and minerals. This was intended to fund expansion of production to 5,000-5,400 mtV pa, with studies ongoing at the time to determine the optimal route to deploy capital for further growth to 6,400-6,800 mtV pa.

Production has, however, fallen short of targets

The Orion convertible matures this year, however, production of 3,842 mt V in 2022 (100% of Vametco + Vanchem) has fallen short of the targeted 5,000-5,400 mtV pa range the funding was intended to deliver.

Guidance for 2023 of 4,200-4,500 mtV, whilst up ~9% y-o-y at the low-end of the range, remains considerably short of the target, attributed to the impact of load shedding. This has been felt particularly severely at Vanchem, which has suffered complete power supply loss during these periods, but steps have been taken to reduce the impact of load shedding in 2023.

The chart below shows production guidance vs delivery for the last 3 years. Bushveld typically provides detailed one-year forward guidance with the 4Q operating update; in some years exit rate guidance is provided earlier in the year (noted as 'prior guidance' in the charts below).

– 2020 was impacted by the onset of COVID, which resulted in temporary shutdowns and lockdowns. Unscheduled shutdowns also impacted production.

– 2021 – Vametco: impacted by ~5 days of industrial action in early 2021. Investment was undertaken to improve the reliability of critical segments of the plant, however, ramp-up was slower than expected post completion of maintenance and there were unforeseen mechanical breakdowns post start-up.

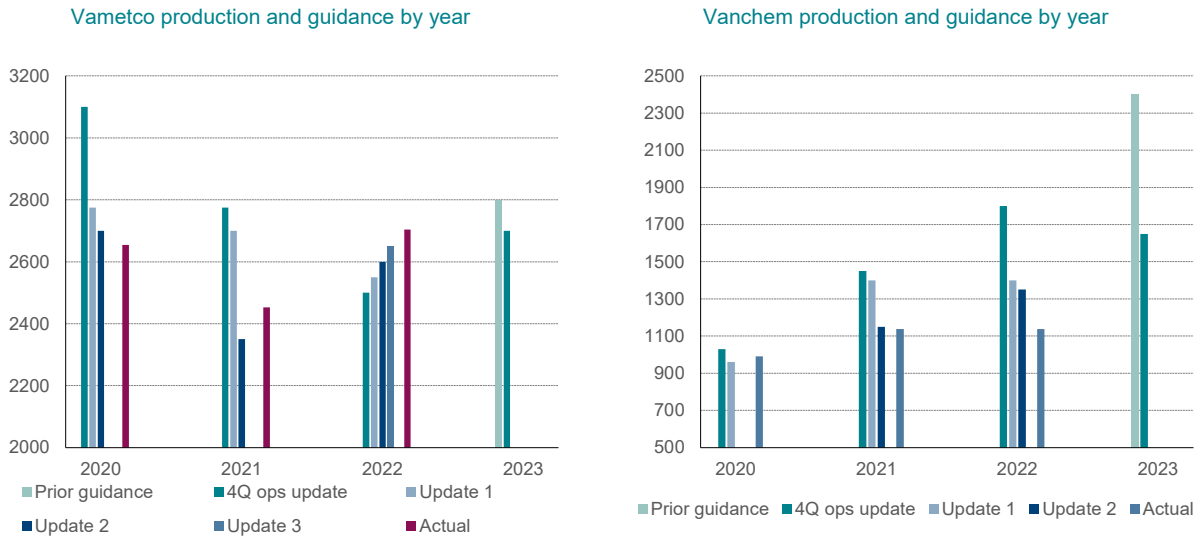
– 2021 Vanchem: planned refurb of kiln 3 was impacted by delays in securing steel supplies, pushing completion of the work into 2022 and impacting 2021 production levels as the performance of kiln 1 began to deteriorate. Introduction of ore from Vametco also caused operational issues resulting in an unplanned shutdown.

– 2022 – Vametco: delivered strong production performance during the year driven by improved operational performance and stability. Production guidance was upgraded during the year, and was subsequently beaten

– 2022 – Vanchem: Impacted by kiln 1 reaching end of its operational life in H1 owing to the delay of the kiln 3 refurb. Operational stability also continued to be impacted in early H1 by the introduction of Vametco ore, and more generally across year by load shedding. Severe load shedding in H2 impacted the ability to ramp-up and optimise kiln 3 post refurb.

– 2023: Vametco expected to produce in-line with 2022 levels. Vanchem expected to ramp-up further driven by ongoing optimisation of kiln 3, which should progress following a revised agreement on power supplies to reduce the impact of load shedding, and agreement for more suitable ore supply. Production guidance was reiterated with the 1Q operational update.

Figure 6: Vametco production has stabilised ~2,700mtV pa, however, Vanchem has yet to reach guidance levels post recent investments, with new power agreement intended to mitigate impact of load shedding



Source: BNP Paribas Exane estimates. Bars show mid-point of guidance ranges, except for periods where guidance was specifically revised to indicate production anticipated towards the bottom/top of the range.

In addition logistic constraints globally post COVID, and more specifically at times in South Africa impacted by heavy rain, have impacted the company's ability to get product to market. Heavy rain was a particular factor in 4Q 2022, but excess inventories which built up at Vanchem during 2022 were drawn down during a two-week maintenance shutdown in 1Q 2023 and sales were unaffected during the shutdown.

Bushveld has been selling an increasing proportion of its product into US markets, reflecting strong North American pricing.

Figure 7: Sales have been impacted by logistics challenges, including during 4Q 2022, with a recovery in 1Q 2023

% of production sold

Source: BNP Paribas Exane estimates

C1 cash costs have been rising, impacted by inflation and uptime

The broad inflationary environment post COVID is well understood, and Bushveld has not been immune with rising consumables costs and wages impacting the cost base. In June 2022 Bushveld signed a 5-year wage agreement with the Association of Mineworkers and Construction Union (AMCU) which provides for a 7% wage increase in 2023, then ~6.5% increases in subsequent years. Although energy cost increases were nowhere near as severe in South Africa last year as they were in Europe, from 2Q 2023 Eskom will institute a 19% increase in power costs.

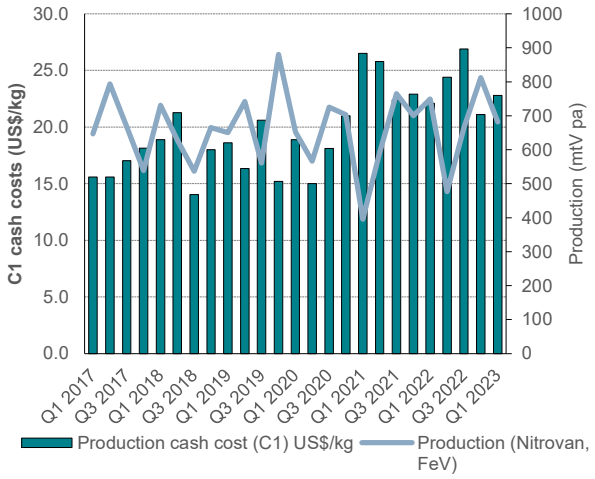
Management is taking actions to mitigate this where possible with changes to some operating parameters planned in 2023, which should help offset some cost increases and improve operational stability. Load shedding has had a significant impact upon unit costs, both through its impact upon production levels (both directly and through the inability to optimise new equipment post investment) and costs (diesel is consumed at Vanchem during periods of absolute power loss to maintain kiln temperature).

The charts below show unit costs and production for each site. At Vametco unit costs have been rising over the longer term, but increased production rates and improved reliability have kept unit costs broadly under control since mid-2021.

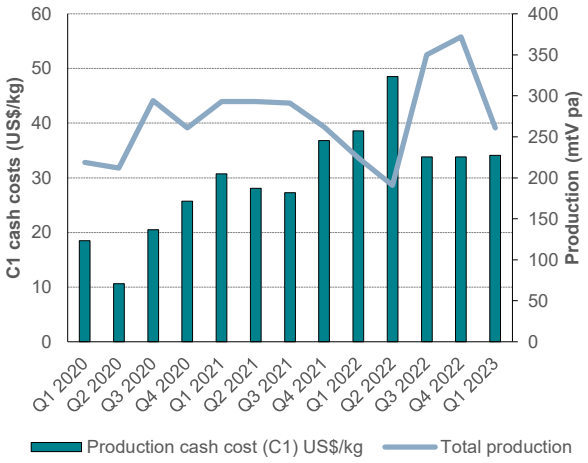
At Vanchem unit costs have been rising significantly, impacted by production/reliability and the disproportionate impact of load shedding upon Vanchem. Having reached agreement with the local municipality that Vanchem will be curtailed (i.e. have to reduce its power consumption) rather than cut-off during periods of planned load shedding should significant improve the outlook. Increased stability and predictability in the power supply to Vanchem should enable higher production rates and optimisation of kiln 3 alongside lower diesel consumption during 2023. During periods of unscheduled load shedding, however, Vanchem will still have its power supply interrupted.

Figure 8: Unit costs have risen but showing signs of stabilising with production at Vametco. Growing production at Vanchem, combined with operational measures, has begun to reverse 2021-22 unit cost inflation

Vametco C1 unit cash costs and production



Vanchem C1 unit cash costs and production



Source: BNP Paribas Exane estimates

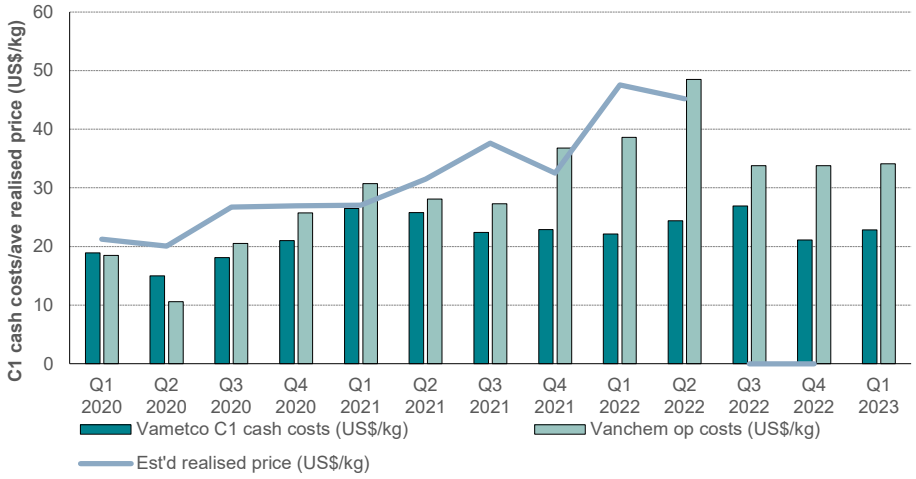
Vametco profitable; high unit costs have hampered Vanchem profitability but should be normalising in 2023

The chart below compares reported quarterly C1 cash costs and our estimate of realised prices. Rising unit costs at Vanchem over the last three years have significantly impacted profitability, whilst Vametco has, on our estimates, delivered robust profitability during the period.

Vanchem's unit costs have fallen significantly in H2 2022, driven by rising production, and Bushveld's guidance is for Vanchem costs to fall back towards US$30/kg in 2023.

Figure 9: Vametco costs at a profitable level; Vanchem costs returning towards US$30/kg

C1 cash costs and estimated realised prices (US$/kg)



Source: BNP Paribas Exane estimates. Note Bushveld does not report quarterly realised prices, we have estimated realised prices from semi-annual reported revenues, sales volumes and market price trends.

No further 'big ticket' capex items scheduled until around the end of the decade

Following recent investments to increase reliability capital investment in 2023 is primarily related to sustaining capital. Bushveld does not plan significant capex above sustaining capital over the next few years, with the next 'big ticket' item the upgrade of the slimes dam which is anticipated around 2030.

Asset level forecast summary

We provide detailed asset level cash-flow summaries later in this report and include summary figures below.

For Vametco guidance is for 2023 production to be 'broadly in-line with' 2022 levels of 2,704 mtV, and we model this being sustained going forwards.

Vametco produced 682 mtV during 1Q 2023, broadly in-line with 1Q 2019 and 2020 levels, but was 8.9% below the 749 mtV achieved in 1Q 2022. 1Q 2023 production was impacted by 10-days of high rainfall, and a one-week maintenance shutdown to replace the secondary crusher.

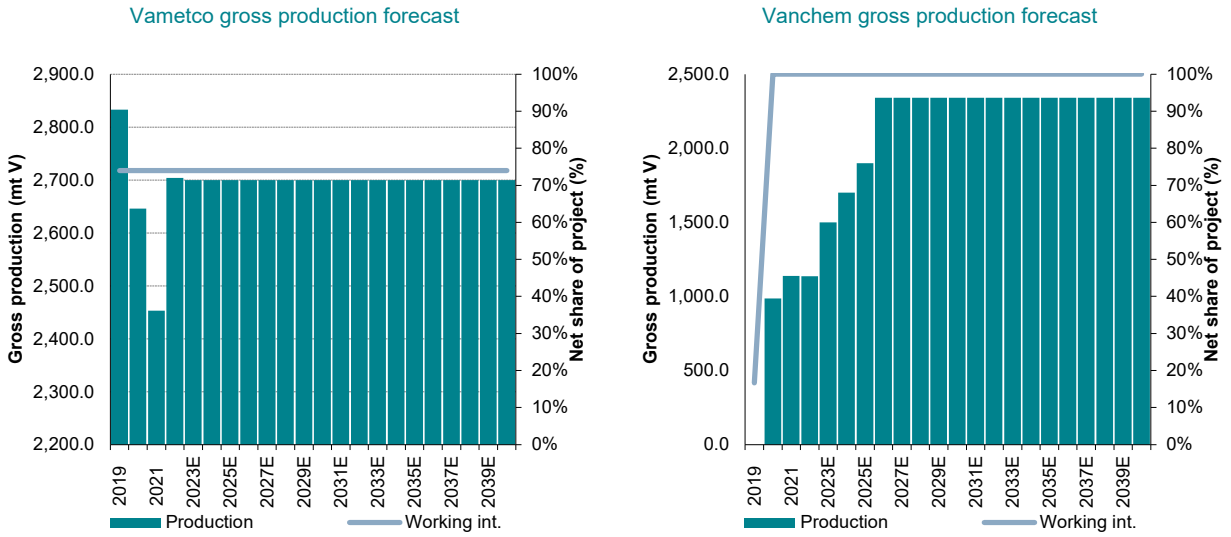
At Vanchem production gains were made in H2 2022 towards an annual run-rate of ~1,275-1,350 mtV pa (allowing for a month of maintenance), and if the agreement on power supplies delivers increased up-time additional optimisation could further benefit production. Bushveld has guided to production growth at Vanchem in 2023 with levels highly dependent upon the consistency of power supply. Backing out Vametco guidance from group level guidance of 4,200-4,500 mtV implies ~1,500-1,800 mtV for Vanchem in 2023; we model the bottom end of this range.

Vanchem produced 261mtV during 1Q 2023, ~17% above last year's level, but down ~30% on 4Q 2022. The revised load-shedding agreement and improved kiln-3 availability is supporting production levels, however, a two-week maintenance shutdown was undertaken during the quarter. Excess inventories built up during 2022 were drawn down during this period and sales were not affected. A new third party ore source was secured for Vanchem which has a lower-silica content than the Upper seam Vametco ore used previously. This is anticipated to result in higher recoveries and more stable production rates with no additional cost. Vanchem production will need to increase significantly in the coming quarters to meet guidance; production totalled 140mtV during March 2023 and 117mtV during the first 24 days of April suggesting a run-rate of ~150mtV for the month, which should be sufficient to reach guidance.

We model a progressive ramp-up at Vanchem over subsequent years to reach the bottom of the targeted 5,000-5,400 mtV pa range in 2026. The considerable challenges within the South African power market do not appear likely to be resolved in the near-term, suggesting power interruptions may continue to impact operations. Bushveld is studying the potential for battery storage plus renewable energy solutions to supplement grid power supplies to Vanchem. We also analyse the impact if Vanchem production was to remain flat at 2023 levels.

Figure 10: We model flat production at Vametco, and rising production towards the bottom of the group target range at Vanchem in our base case, but also consider a sensitivity case of flat production at Vanchem

Gross production forecasts for Vametco and Vanchem

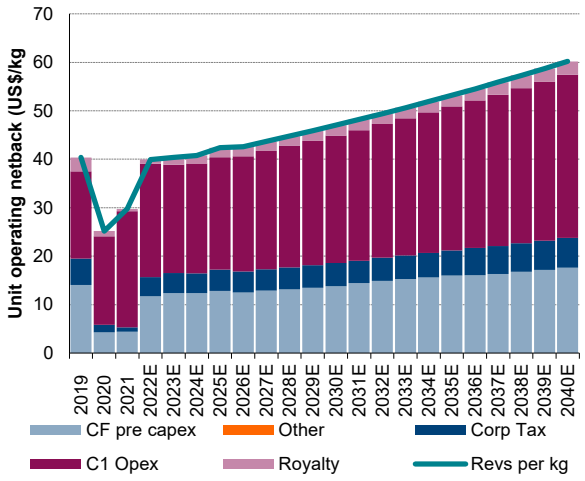


Source: Company, BNP Paribas Exane estimates

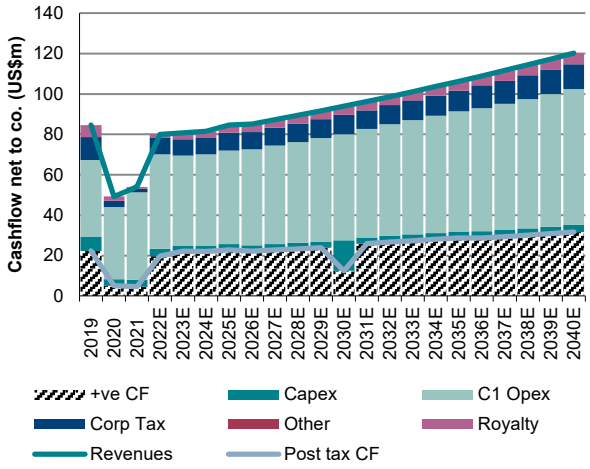
We forecast cash netbacks returning towards 2019 levels at Vametco driven by the improvement in the vanadium price seen since the COVID lows and steady production rates. We model C1 cash costs for Vametco at the top of the 2023 guidance range and are inflating costs and prices at 2.5% pa.

Figure 11: We forecast netbacks at Vametco returning towards 2019 levels in 2023, driving cash generation

Vametco unit operating netback breakdown



Vametco cash-flow forecast breakdown

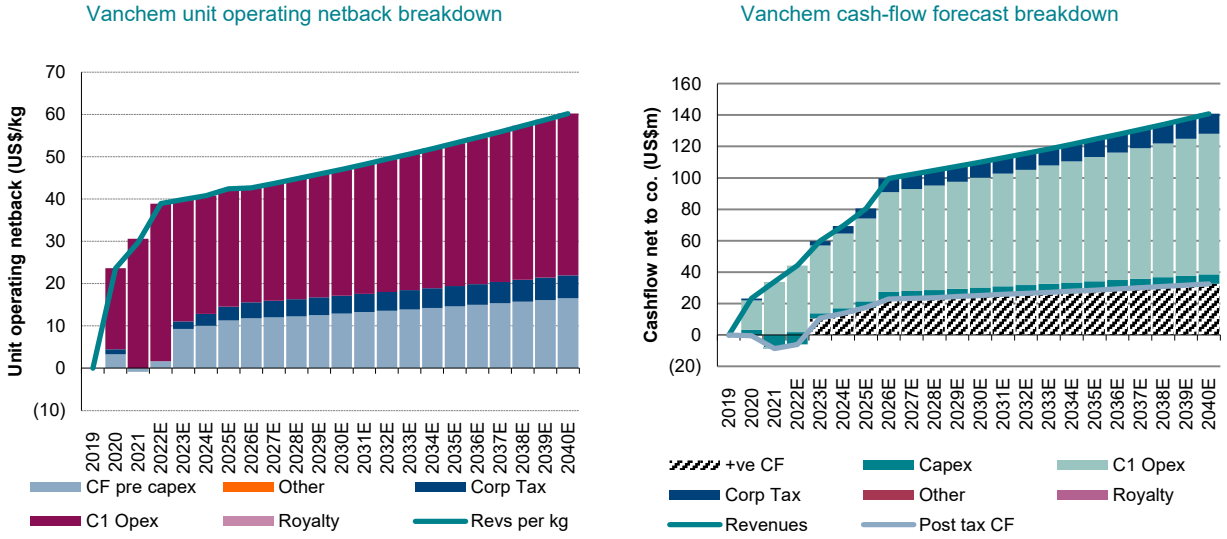


Source: BNP Paribas Exane estimates

At Vanchem the forecast increase in production is anticipated to return the operation to positive cash generation, increasing volumes and reducing unit costs. We model C1 cash costs for Vanchem at the top of the 2023 guidance range, with the same inflation assumptions as for Vametco (2.5% pa).

The impact of the recent agreement to reduce the impact of scheduled load shedding on Eskom, and the degree to which unscheduled load-shedding persists in 2023, will impact production and profitability at Vanchem.

Figure 12: Rising production, driving down unit costs, is anticipated to return Vanchem to cash generation in 2023



Source: BNP Paribas Exane estimates

Can Bushveld turn the corner in 2023?

The above analysis demonstrates that Bushveld can, if it delivers production at the bottom end of guidance and costs at the top end of guidance, begin to turn the corner in 2023.

Vametco appears to have achieved stability post investments in reliability. If the revised agreement on power supply at Vanchem combined with the new ore supply agreement can deliver much needed stability to operations, and if production optimisation of kiln 3 can proceed, the lower end of the group's production guidance range should be within reach.

Successful completion of the refinancing is key to the outlook

Bushveld announced on 5th May 2023 it had entered into a non-binding, investment committee approved term sheet with Orion Mine Finance to refinance its existing convertible loan note. The details of the existing Orion financing and the proposed refinancing are provided in the appendix to this report and are summarised below.

Summary of existing Orion financing packaged

The existing Orion financing package, agreed in 2020, comprises a US$35m convertible loan note and a US$30m Production Financing Agreement (PFA).

The existing convertible, plus accrued interest, is anticipated to total ~US$45m at maturity in November 2023. The existing convertible is out of the money (17p/sh conversion price) and Bushveld does not have the financial resources to repay the debt.

The US$30m PFA was issued in exchange for a royalty on the asset base (based upon volumes of product sold and revenues realised). The PFA does not have a fixed interest rate.

We have modelled the PFA payments, based upon our assumptions for production and revenues, and have split it into notional interest and principal repayment portions based upon the accounting treatment. Taking the notional interest portions and apportioning them over the life of the facilities we estimate an effective interest rate of ~15.8% pa for the PFA.

Summary of convertible refinancing

The existing ~US$45m convertible debt, including accrued interest, will be refinanced with:

- A new US$27m 3-year term loan
- A new US$13.5m convertible loan
- Conversion of US$4.5m of the existing convertible loan notes into shares at 6p/sh
- A supplemental production financing agreement (PFA), which is essentially a royalty on gross revenues

The refinancing transaction is conditional on several items and completion is not guaranteed on the agreed terms, however, it has been approved by Orion's investment committee and both Bushveld management and Orion are confident of completing the transaction.

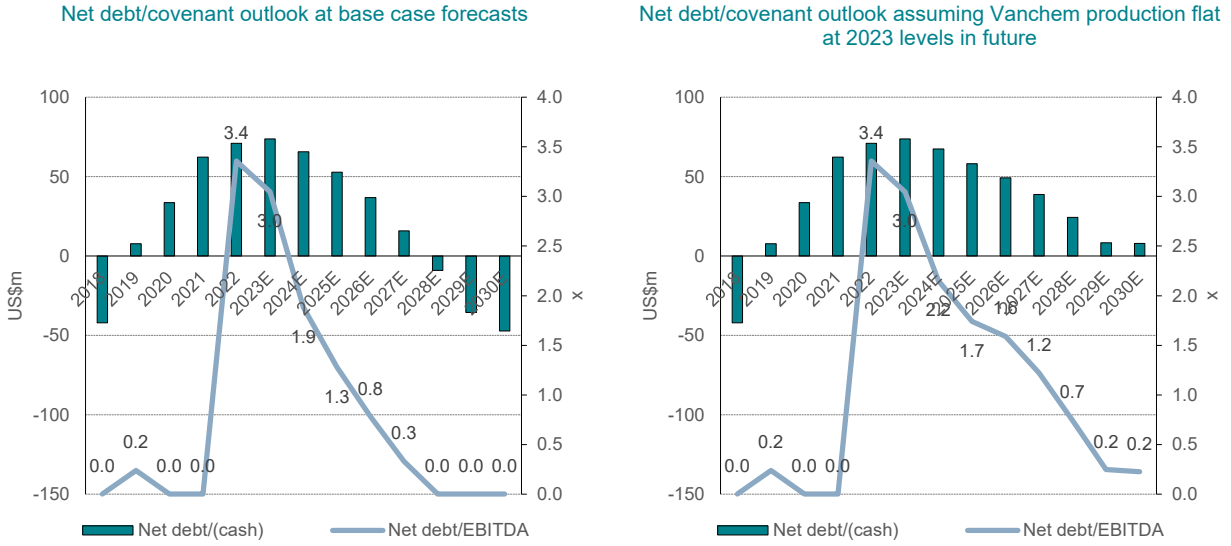
Can the business support current levels of debt?

The chart below shows our net debt forecast at our base case assumptions (at the conservative end of 2023 guidance on production and costs), and in the case Vanchem production does not advance above the bottom end of the 2023 guidance range.

We forecast a substantial improvement in covenant metrics, with net debt:EBITDA falling to ~1.9x by year-end 2024. The position continues to improve thereafter, even in the sensitivity case where production at Vanchem does not rise above forecast 2023 levels.

Subject to the caveats noted above relating to the relatively concentrated portfolio and modest cash-flows, at our base case forecasts the business appears to have capacity to support forecast levels of debt post the refinancing at our forecast vanadium price.

Figure 13: Covenant metric forecast to improve significantly from 2024; forecasts assume 2023 delivery at conservative end of guidance



Source: Company, BNP Paribas Exane estimates. Note the business was EBITDA -ve in 2020/21 and our EBITDA calculation may not be identical to that used by lending institutions.

What is the cost of capital for this business?

We adopt our mining team's approach in deriving the cost of capital for Bushveld, taking account of market risk free rates and equity risk premia, the country risk premium and debt costs. Reflecting these factors we estimate a WACC of 16.2% for Bushveld but include sensitivities to this in our report.

Valuation range of 4.8-6.8p/sh

We set our valuation range at 4.8-6.8p/sh, offering c. 28%-81% upside versus the current share price.

The bottom end of our valuation range is set in-line with our Core producing asset NAV at our base case assumptions, assuming the convertible refinancing is completed on the agreed terms.

The upper end of our valuation range incorporates risked value for the potential expansion cases at Vametco and Vanchem, incorporating an assessment of risking around the possibility the projects do not proceed as per our modelled assumptions. We have scheduled the various investments required so they can be funded once operating cash-flows begin to reduce debt, with expansion capex incurred over the period 2026-2031. We expect the near-term focus, for management and investors, to be on the performance of the existing producing assets which we believe is key to the equity story.

We also include in the upper end of our range risked value for Bushveld Minerals' VRFB-related investments, which are being spun-out into a listed SPAC (Mustang Energy).

We do not attribute value to the Brits or Mokopane vanadium deposits, which could potentially be developed in future.

Risked NAV methodology

We model and value companies with a relatively concentrated portfolio of mining assets using a Risked Net Asset Value (Risked NAV) approach. We believe this captures the growth potential of the business, and the associated capital investment required along with funding costs.

We calculate two NAV's and present the un-risked potential of the portfolio:

- Core NAV: NAV of producing assets (Vametco and Vanchem) post balance sheet adjustments and the NPV of the PFA (Production Financing Agreement payments). We attribute a 100% chance of success to Vametco since it is operating at steady-state, and a 90% chance of success for Vanchem since further process optimisation is required to increase production in-line with our forecasts. The are no currently sanctioned development/expansion projects to include in our Core NAV.
- Growth projects NAV: Comprises our Core NAV plus the risked value of the proposed expansion projects at Vametco and Vanchem after the associated incremental PFA payments, and a risked assessment of value for the Mustang Energy stake.
- Un-risked upside NAV: Comprises our valuation for the Core assets plus the expansion at a 100% chance of success, i.e. the full value of the asset base assuming all projects are executed in-line with our forecasts.

We construct a detailed cash-flow model for each asset in our Core NAV. This model incorporates our production forecast, along with realised prices, and the associated operating and capital costs, for recovery of the resource base. We model the associated cash-flows under the specific fiscal terms which apply, to generate semi-annual cash-flow forecasts over the life of each asset.

These cash-flow forecasts form the basis of our corporate level financial forecasts, and are also discounted to calculate our gross asset values (as of 01/01/2023).

We have also constructed detailed cash-flow models for the expansion cases.

To the gross asset value we deduct the net debt position, corporate overheads and any other cash adjustments (eg. our estimate of future payments associated with historic acquisitions). We also incorporate the impact of the conversion of US$4.5m of debt to equity at 6p/sh, part of the announced convertible debt refinancing, to generate our Net Asset Value.

Evaluating Bushveld's VRFB investments

Bushveld has announced the planned spin-out of its VRFB investments into Mustang Energy. In our evaluation of the business we have taken the announced US$19.4m of shares to be received by Bushveld Energy at an assumed price of 20p/sh, adjusted this for Bushveld Mineral's 85% interest in Bushveld Energy, and applied a 50% chance of success to reflect that the required transactions have yet to be completed, including an equity raise within Mustang, and Mustang Energy stock needs to return to trading on the LSE having been suspended since 2021. We include this potential value in our 'Growth projects NAV', with no contribution from the VRFB investments to our 'Core NAV'.

For comparison listed VRFB peer Invinity Energy systems has deployed or contracted for installation 65MWh of VRFB storage projects across 70 projects in 14 countries, compared to 75MWh for CellCube. Bushveld is anticipated to own a ~21-23% stake in CellCube upon completion of the ongoing spin-out. Invinity is currently EBITDA loss making and consensus forecasts indicate the business should turn profitable in 2025. Invinity has a market cap of ~£76m and consensus estimates forecast the business will sustain a net cash position through to 2024. Invinity recently raised £21.5m, which management stated was sufficient to meet its working capital requirements through H2 2024.

We do not have visibility around the financial performance of CellCube to performe a more detailed evaluation of the business.

Other assets not evaluated at this time

BELCO electrolyte plant

Bushveld holds a 55% interest in the BELCO electrolyte plant being constructed in South Africa, near East London. The plant is currently being commissioned, a process which is expected to complete in H1 2023. No production guidance has been provided for the facility, which has the potential to increase capacity to 8 million litres pa/200MW, and potentially beyond, over time.

To date there have been no contract awards for the plant, with an electrolyte qualification process ongoing with VRFB manufacturers. Initial production rates will depend upon sales and off-take contracts to be signed with OEMs.

Bushveld Minerals intends to retain its interest in the BELCO electrolyte plant in the event Bushveld Energy is carved out as a standalone entity.

Mini-grid

A mini-grid project, comprising solar PV generation and storage, is under development at Vametco which is intended to contribute a maximum of just under 10% of Vametco's power consumption at any given time. Bushveld Energy has provided 40% of the financing with NESA Capital providing the other 60% and taking the majority of the project. The project is expected to be complete in H1 2023 at a total cost of ~US$7.1m and is structured as an independent PPA, however, we do not have visibility around the economics of the project to Bushveld.

Bushveld has identified potential for up to 120MW solar PV generation and 180MWh storage capacity across the Bushveld Minerals group, and it seems likely the model could have application for other industrial groups in South Africa (and potentially elsewhere) given the ongoing issues around power generation in South Africa.

This appears to be a business model offering scalability with access to funding for the supply of renewable energy in a business environment suffering power shortages. Solar power generation projects typically offer high single digit returns, and a modest return on a much lower cost of capital than that currently available for Bushveld Minerals. The separation of Bushveld Energy from Bushveld Minerals makes sense in this context, however, we have no visibility on project economics at this stage.

Base case risked Core NAV of 4.8/sh rising to 6.8p/sh including growth projects

The table below provides a detailed breakdown of our risked NAV for Bushveld Minerals.

Our Core NAV stands at 4.8p/sh and including risked potential from growth projects this rises to 6.8p/sh. Our un-risked NAV, including growth projects, stands at 12.7p/sh.

Figure 14: Risked NAV - detail

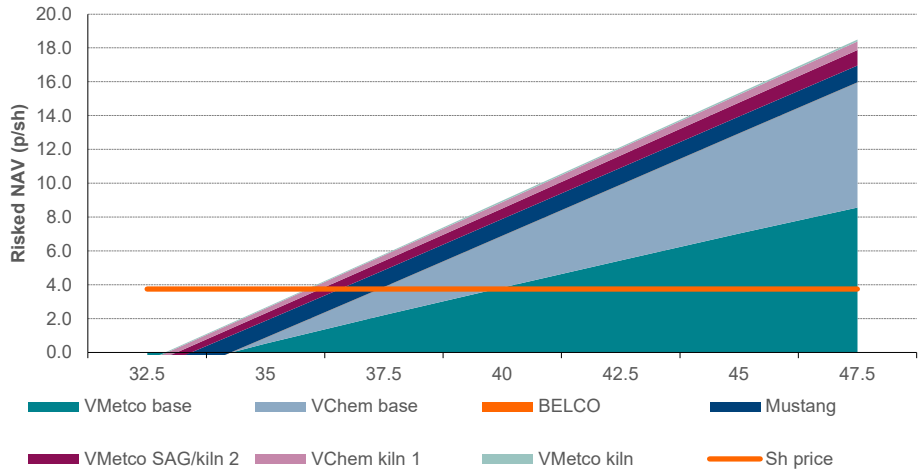
Country	Asset	Gross resource modelled (mt V)	Int. %	W.I. Res/vols processed (mtV)	CoS (%)	NAV@ 16.2% as of 1st Jan				
						$m	$/kg V (net)	£m	p/sh	Unrisked p/sh
Production										
South Africa	Vametco	62.1	74%	45.95	100%	164	3.6	133	9.8	9.8
South Africa	Vanchem	51.9	100%	51.90	90%	128	2.7	103	7.7	8.5
South Africa	NPV of PFA payments				100%	(38)		-31	(2.3)	(2.3)
Total producing		**114.0**		**97.9**		**253**	**2.7**	**205**	**15.2**	**16.1**
NPV of overheads (incl selling costs, post tax)						-140		-114	(8.4)	(8.4)
Net cash (debt) excl PFA & restr cash, incl lease liabs						-37		-30	(2.2)	(2.2)
Cash in from future equity raises						4		3	0.3	0.3
Cash return completed post B/S date								0	0.0	0.0
Proceeds from/deferred payments for disposals/acqns					100%	-1		-1	(0.1)	(0.1)
Core NAV - Prod		**114.0**		**97.9**		**79**		**64**	**4.8**	**5.6**
Development										
Total development		**0.0**		**0.0**		**0**	**0.0**	**0**	**0.0**	**0.0**
Core NAV - Prod & Dev		**114.0**		**97.9**		**79**		**64**	**4.8**	**5.6**
Growth projects										
SA/Global	BELCO					Ltd financial detail upon which to ascribe value at this time				
SA/Global	Bushveld Energy/Mustang Energy spin out				50%	16		13	1.0	2.0
South Africa	Vametco SAG mill & Vanchem refurb kiln 2	15.8	100%	15.8	30%	11	2.4	9	0.7	2.3
South Africa	Vanchem refurb kiln 1	12.6	100%	12.6	20%	7	2.8	6	0.4	2.1
South Africa	Vametco kiln expansion	8.4	74%	6.2	10%	1	2.3	1	0.1	0.8
South Africa	Risked NPV of PFA payments for expansion programs				100%	-3		-2	(0.2)	(0.2)
Total growth projects		**36.8**		**34.7**		**33**	**4.2**	**27**	**2.0**	**7.0**
Growth projects NAV		**150.8**		**132.5**		**113**	**14.3**	**91**	**6.8**	**12.7**
Share price									**3.8**	**3.8**
Core NAV up/(down)side vs share price									**27%**	**50%**
Expansion program NAV up/(down)side vs share price									**81%**	**238%**

Source: BNP Paribas Exane estimates

The charts below show the sensitivity of this base case risked NAV to the long-term vanadium price outlook and WACC.

Figure 15: Base case Core Producing risked NAV sensitivity to vanadium price

p/sh



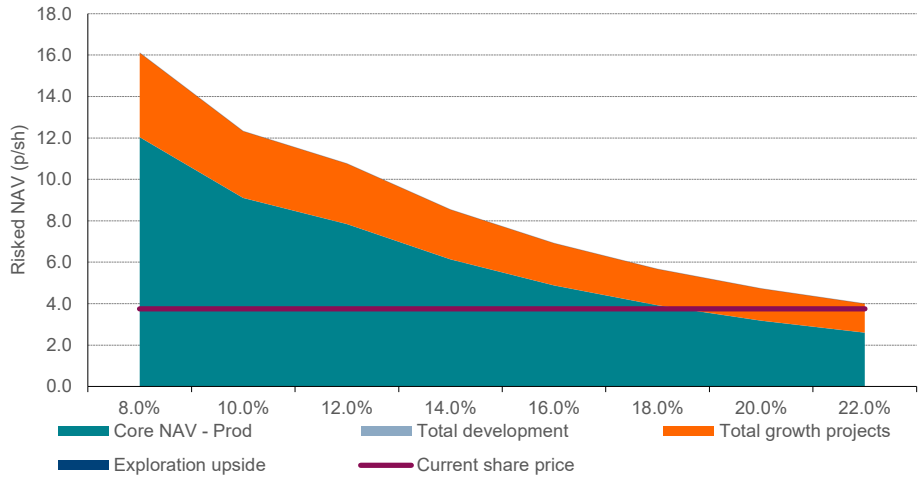
Source: BNP Paribas Exane estimates

We use a consistent approach to calculating discount rates across our mining coverage, incorporating the risk-free rate and equity risk premium with a country risk premium for the country of operations. This, combined with our assumption of a 15.8% debt cost for Bushveld (above the 12% rate on the new convertible but consistent with the ~15.8% implied rate on the production financing agreement), results in a 16.2% WACC.

In addition to the outlook for vanadium prices the cost of capital is a key sensitivity for Bushveld, given its long asset lives. The chart below shows a significant increase in our risked NAV at lower discount rates.

Figure 16: Base case Core Producing risked NAV sensitivity to discount rate

p/sh



Source: BNP Paribas Exane estimates. The non-linearity around 8p/sh relates to the conversion price of the convertible debt

The table overleaf provides a detailed breakdown of our risked NAV at a range of vanadium prices.

Figure 17: Risked NAV sensitivity to vanadium price - detail

Country Asset	CoS (%)	NAV@ 16.2% as of 1st Jan							
		Base	32.5	35	37.5	40	42.5	45	47.5
Production									
South Africa Vametco	100%	9.8	6.2	7.8	9.4	11.1	12.7	14.3	15.9
South Africa Vanchem	100%	7.7	3.8	5.5	7.1	8.8	10.4	12.1	13.7
South Africa NPV of PFA payments	100%	(2.3)	(2.2)	(2.2)	(2.3)	(2.3)	(2.4)	(2.4)	(2.4)
Total producing		**15.2**	**7.9**	**11.1**	**14.3**	**17.5**	**20.8**	**24.0**	**27.2**
NPV of overheads (incl selling costs, post tax)		(8.4)	(7.9)	(8.2)	(8.4)	(8.6)	(8.8)	(9.0)	(9.3)
Net cash (debt) excl PFA & restr cash, incl lease liabs		(2.2)	(2.2)	(2.2)	(2.2)	(2.2)	(2.2)	(2.2)	(2.2)
Cash in from future equity raises		0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Cash return completed post B/S date		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Proceeds from/deferred payments for disposals/acqns	100%	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)
Core NAV - Prod		**4.8**	**(2.1)**	**0.9**	**3.9**	**6.9**	**9.9**	**13.0**	**16.0**
Development									
		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total development		**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Core NAV - Prod & Dev		**4.8**	**(2.1)**	**0.9**	**3.9**	**6.9**	**9.9**	**13.0**	**16.0**
Growth projects									
SA/Global BELCO	30%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SA/Global Bushveld Energy/Mustang Energy spin out	30%	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
South Africa Vametco SAG mill & Vanchem refurb kiln 2	30%	0.7	0.4	0.5	0.6	0.7	0.8	0.9	1.0
South Africa Vanchem refurb kiln 1	20%	0.4	0.3	0.4	0.4	0.4	0.5	0.5	0.6
South Africa Vametco kiln expansion	10%	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
South Africa Risked NPV of PFA payments for expansion p	10%	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)
Total growth projects		**2.0**	**1.6**	**1.8**	**1.9**	**2.1**	**2.2**	**2.4**	**2.5**
Growth projects NAV		**6.8**	**(0.5)**	**2.7**	**5.8**	**9.0**	**12.2**	**15.3**	**18.5**
Share price		**3.8**	**3.8**	**3.8**	**3.8**	**3.8**	**3.8**	**3.8**	**3.8**
Core NAV up/(down)side vs share price		**27%**	**(156%)**	**(76%)**	**4%**	**84%**	**165%**	**246%**	**326%**
Expansion program NAV up/(down)side vs share price		**81%**	**(112%)**	**(29%)**	**55%**	**139%**	**224%**	**309%**	**393%**
Upside NAV up/(down)side vs share price		**81%**	**(112%)**	**(29%)**	**55%**	**139%**	**224%**	**309%**	**393%**

Source: BNP Paribas Exane estimates

Summary of operations

The figure below provides a succinct overview of Bushveld's operations across its key operating sites.

From late 2021 through 2022 some ore was sourced from the Upper Seam at Vametco for processing at Vanchem, however, this introduced some operational challenges. Third party ore with a lower silicon content, which is better suited for processing at Vanchem, has been sourced at no additional cost and is expected to comprise the bulk of processed ore at Vanchem from 2Q 2023.

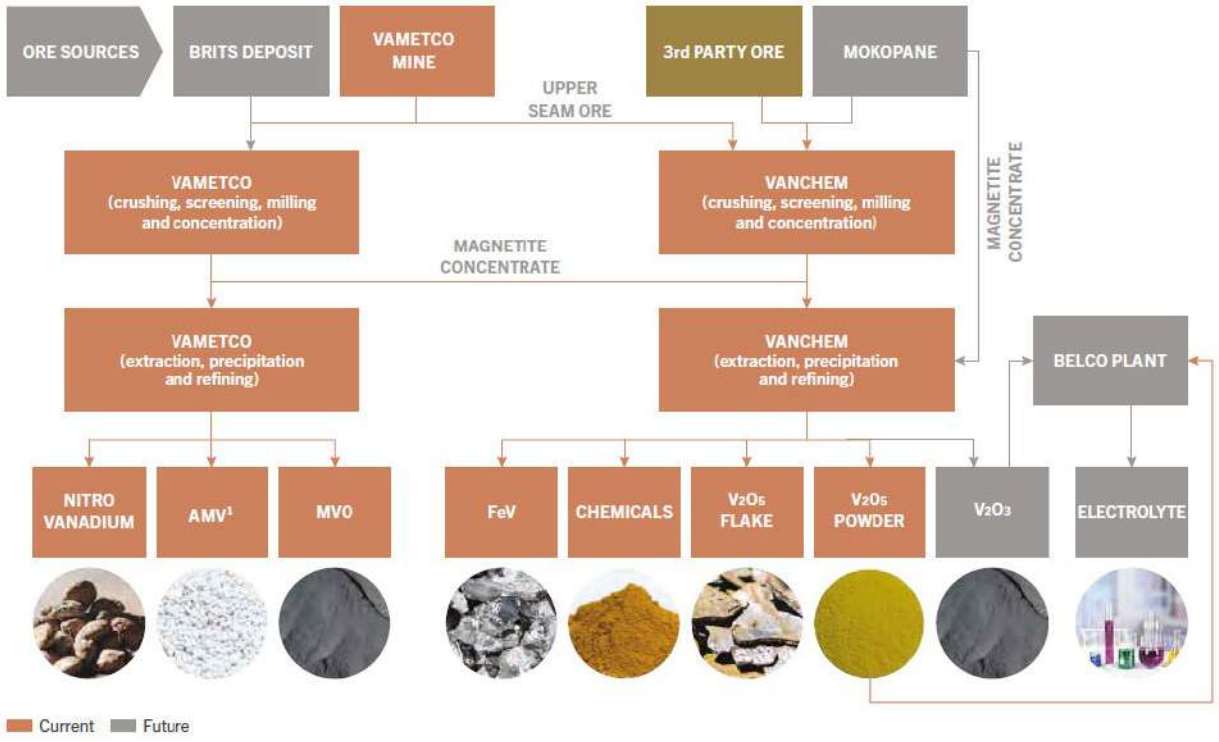
Magnetite concentrate can be switched between Vanchem and Vametco as required to meet product requirements.

Vanchem produces a wider range of vanadium products providing greater diversity to sales and ability to optimise production in response to market pricing.

Any future development of the Brits or Mokopane deposits could be monetised through these facilities, however, we have not considered this potential in our analysis. There is no firm timeframe for development of either resource, and existing Vametco resources appear sufficient to supply operations through to 2051 (and potentially beyond).

The BELCO plant (under construction) will be able to take V_2O_3 from Vanchem and produce up to 8m litres pa electrolyte for VRFBs.

Figure 18: Summary of Bushveld's operations



Source: Company. Note Vametco's AMV can be sent to Vanchem to produce FeV and V2O5, and Vanchem's AMV can sent to Vametco to produce Nitro Vanadium.

Vanadium market overview

Physical properties and uses

Vanadium is a grey, soft, ductile metal which exists in four 'oxidation states' (II, III, IV and V). It exists naturally as a component of minerals, rather than in its pure form, and as an impurity within hydrocarbons and bauxites.

It is used primarily in steel production, as a catalyst in the chemicals industry, in the manufacture of ceramics, glasses and pigments, and increasingly in Vanadium Redox Flow Batteries (VRFBs).

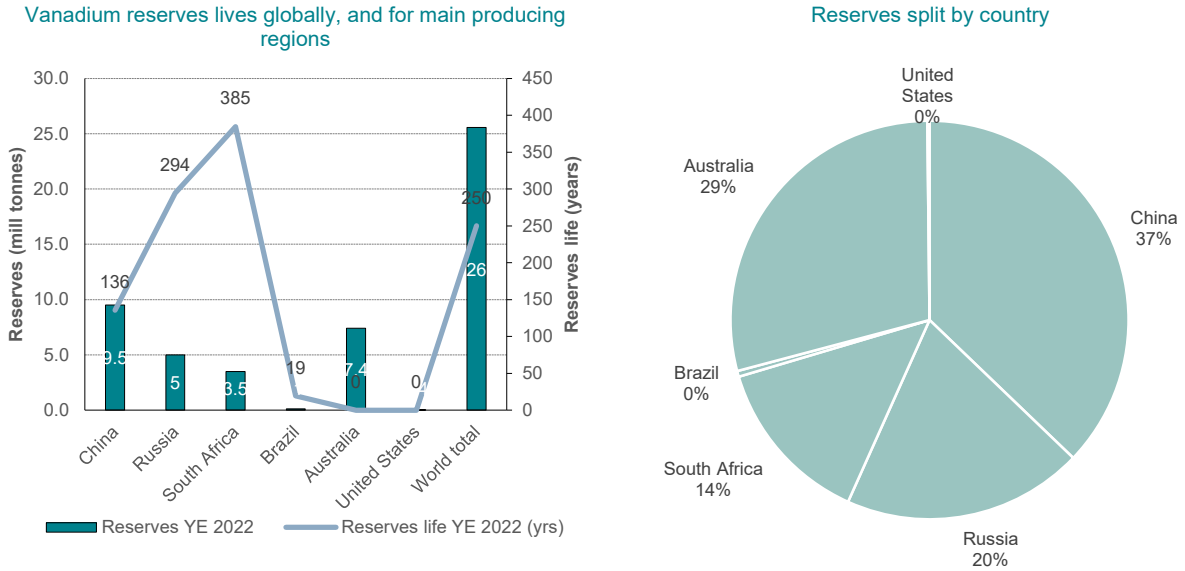
Global reserves and resources

Vanadium resources exceed 63 million metric tons at year-end 2022, of which ~26 million metric tons are classified as reserves.

China holds ~37% of global reserves, Russia ~20% and South Africa ~14%. Around 29% of global reserves are located in Australia where there is currently no production, but projects have been under study for a number of years.

At 2022 production rates global vanadium reserves offer a reserves life of ~250 years. Reserves lives vary significantly by country, from >130 years in China to just under 400 years in South Africa. Since the bulk of vanadium production occurs as a coproduct or by-product reserves are likely underestimated.

Figure 19: China and Russia hold >half of total reserves, but South Africa has large reserves base relative to production



Source: USGS, BNP Paribas Exane estimates

Three principal production methods

Vanadium is produced through three principal methods:

- **Co-production:** as a by-product of steel making.
- **Primary production:** mining and processing ores of vanadium, the method undertaken by Bushveld.
- **Secondary production:** from residues and waste materials.

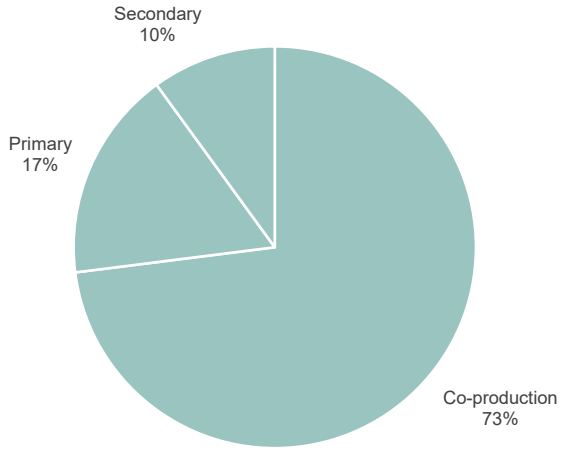
As shown below the majority of vanadium produced globally is via co-production in steel furnaces using vanadiferous iron ore. This process results in the production of a vanadium slag, which is converted to vanadium pentoxide and ferrovanadium.

Iron ore with a higher vanadium content offers more favourable economics for co-production, and in general terms iron ore from China, Russia and South Africa are particularly well suited to this approach. The bulk of China and Russia's vanadium production, and therefore global vanadium production, comes from co-production.

Secondary production methods involve the recovery of vanadium from catalysts used in the refining/petrochemicals industries, vanadium containing ash from oil and coal fired power stations, and residues from the production of uranium, alumina and some hydrocarbons.

Figure 20: Co-production accounts for the bulk of global vanadium production

2021 global vanadium production by source



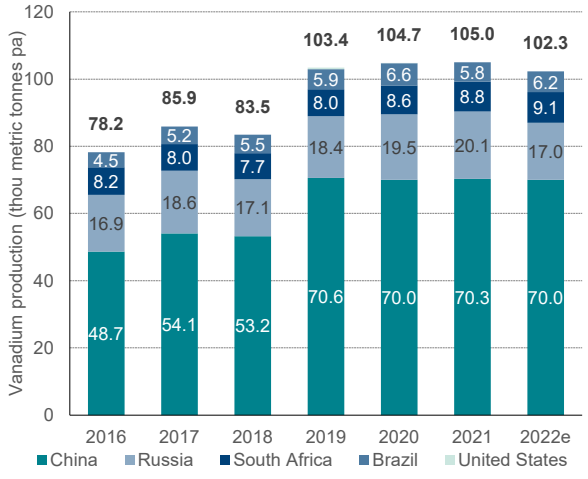
Source: Company, BNP Paribas Exane estimates

Production is geographically concentrated in three countries

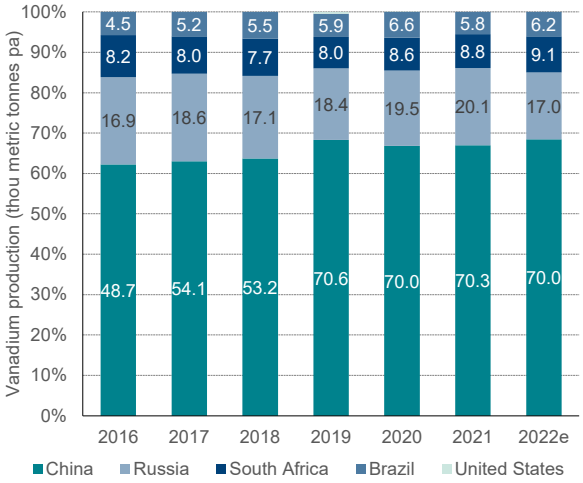
The bulk of global vanadium production is sourced from China, Russia, South Africa and Brazil, with China and Russia together accounting for ~85% of global production.

Figure 21: Global vanadium production dominated by China and Russia

Global vanadium production (absolute)



Global vanadium production (proportionate)



Source: USGS, BNP Paribas Exane estimates

Chinese vanadium production has remained relatively flat over the last four years and Russian production is expected to have declined marginally in 2022, with modest increases anticipated in South Africa and Brazil. Global vanadium production has declined from recent peaks in 2020/21.

EU sanctions were introduced on Russian mining operations in December 2022, however, vanadium mining is exempt from these measures. The bulk of Russia's vanadium output comes via co-production during steel manufacturing. The bulk of Russian vanadium oxide production is exported to Czechia for processing by Russian-owned Evraz group. The USGS states trade of vanadium pentoxide between Russia and Czechia has been relatively unaffected by the conflict and exports from Czechia of ferrovanadium products have also suffered limited disruption.

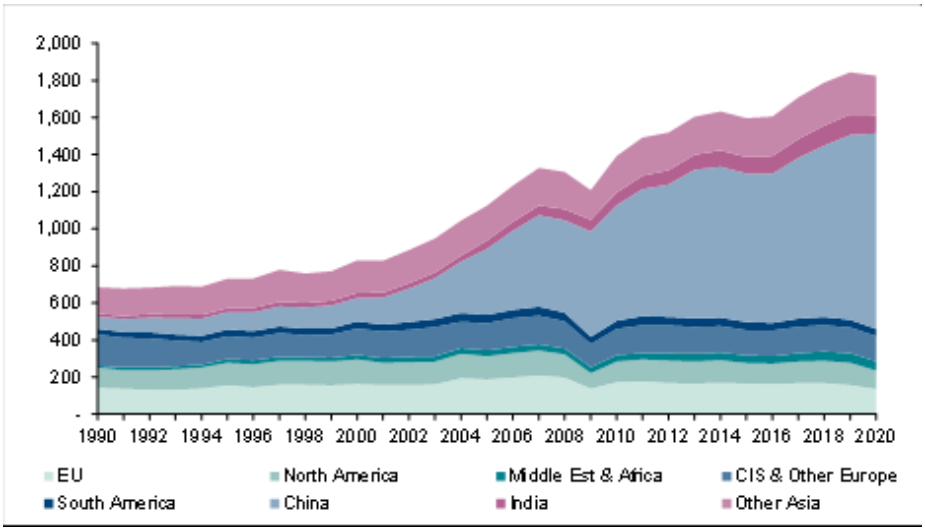
Global vanadium demand outlook linked to steel

Vanadium is predominantly used in the production of carbon steel, full alloy and high strength low alloy steels, which accounted for ~92% of global vanadium demand in 2021. Vanadium demand is, therefore, expected to be driven by overall levels of steel demand, but also the proportion of vanadium incorporated in steel grades.

Regionally China accounts for ~60% of global vanadium demand, driven by its position as the world's largest steel producer (the bulk of Chinese vanadium production is via co-production), with a >50% market share.

Figure 22: China still represents ~58% of the world steel production

Crude Steel Production by Region (mt)



Source: BNP Paribas Exane, NBS

Although China is lifting covid restrictions our steel team forecasts a 1.6% contraction in Chinese steel demand this year (vs a 1.9% decline in 2022). This is driven by a deeper, lingering decline in construction demand and moderating infrastructure investment. Businesses are benefitting from a clear shift in government policy to support growth, with credit more readily available, however, our team believes it will take longer for confidence to return to the housing market. The infrastructure binge of 2022 looks harder to repeat in 2023 since local governments will need fresh funding that can no longer be sourced from land sales, and export demand is expected to remain weak.

Global steel production forecast to return towards ~2% pa growth rate, but declining in China

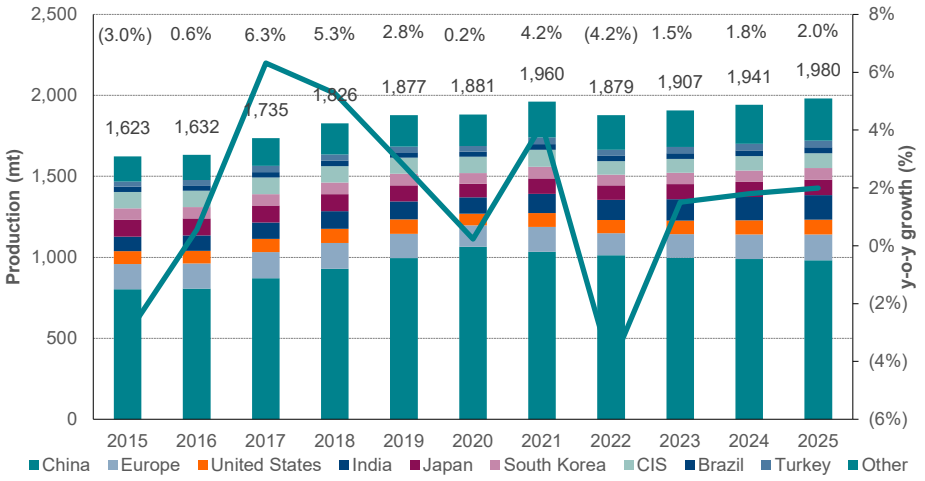
The chart below shows BNPPE steel team's forecasts for global steel production.

Following a sharp ~4.2% pullback in production during 2022, split across most regions (with the exception of India) global steel production growth is expected to return towards ~2% pa over the coming years.

Notably our team expects Chinese steel production to decline each year through to 2025. As noted previously China accounts for ~2/3 of global vanadium production, with the bulk of this produced via co-production with steel. Lower steel production volumes should, therefore, equate to lower vanadium production in China.

Figure 23: Global steel production growth forecast to return towards ~2% pa

Global steel production (incl forecasts) by country



Source: BNP Paribas Exane estimates

Global vanadium intensity of steel production is expected by consultants Wood Mackenzie to rise from 56.4g/t in 2021 to 70.7g/t in 2050, which should drive incremental demand for vanadium above steel demand growth rates.

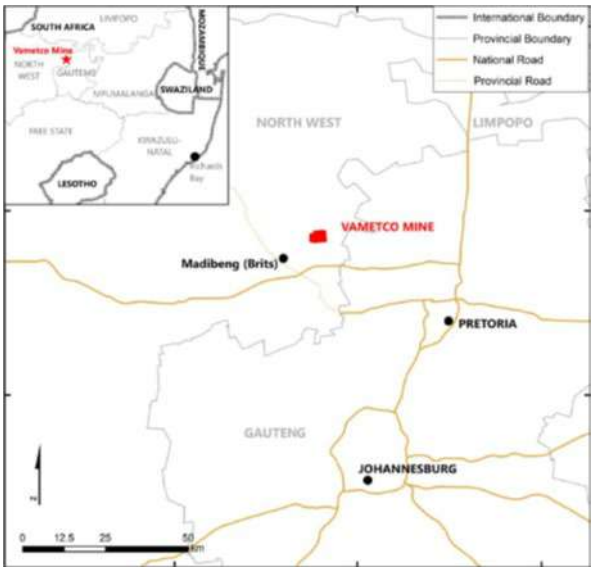
Vametco mine and processing facilities

Vametco is an integrated mining and processing plant located to the north of Johannesburg, in the North West Province of South Africa.

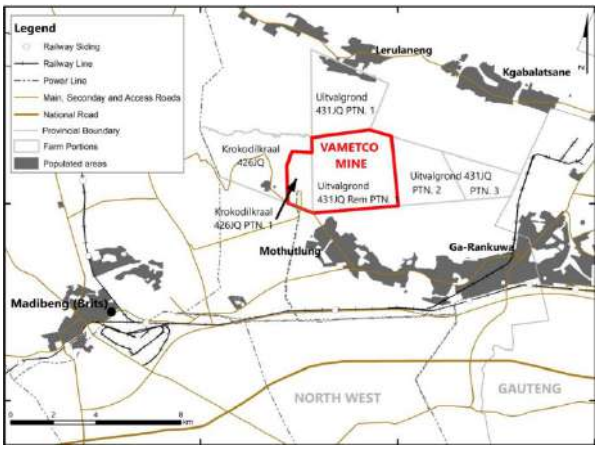
This mine is situated ~6.5km to the north-east of the town of Madibeng (formerly known as Brits). This mine is located near two villages, Mmakau and Rankotea, which are ~0.5km to the south and west of the operations respectively, and lies ~1km north of the town of Mothutlung, 5km NW of Ga-Rankuwa, and 4km south of Lerulaneng.

Figure 24: Maps showing location of Vametco mine

Vametco mine location in regional context



Location of Vametco mine relative to nearby settlements

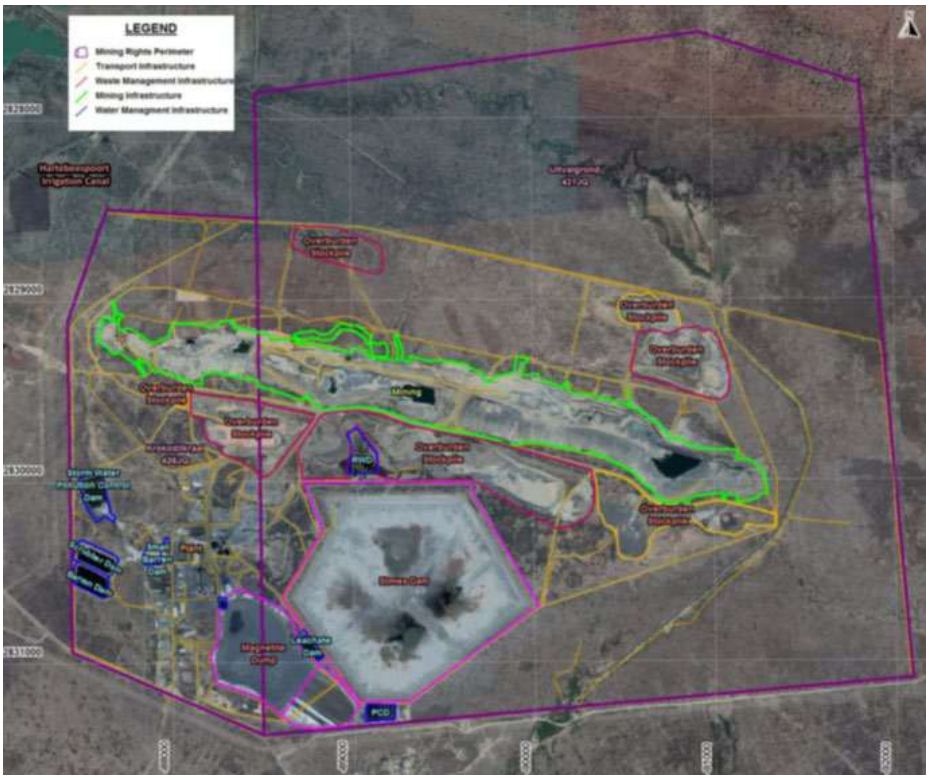


Source: Company

The open pit mine supplies ore to its vanadium processing plant located on the same properties. The open pit is ~3.5km long (E-W) and the target horizons are magnetite layers near the basal contact of the Upper Zone of the Bushveld Igneous Complex.

The image overleaf shows an aerial view of the mine facilities.

Figure 25: Vametco – aerial view of mine infrastructure



Source: Company

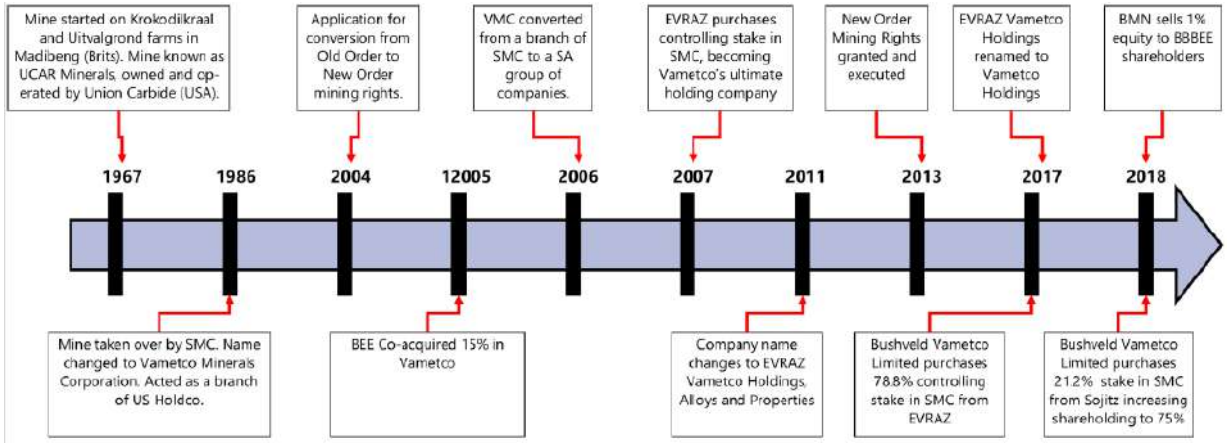
In operation since 1967 sufficient reserves to operate until 2051

Mining operations have been ongoing since 1967; the new order mining right was granted in 2013 and runs for 25 years, expiring on 23 April 2038. Reserves are sufficient to continue operations beyond this date and we model extensions to the mining right with mining operations continuing until 2051.

Current operations lie on parts of the Krokodilkraal and Uitvalgrond farms, which have been owned by Historically Disadvantaged South Africans (HDSAs) since 1912. Long term lease agreements were signed in 1998 for 25 years, i.e. to 2013, until the conversion of the Old Order Mining Right to the New Order Mining Right.

The figure below summarises key steps in the evolution of the mine over the last 55 years.

Figure 26: Vametco mine and processing facilities timeline of key events



Source: Company

74% interest acquired through two transactions in 2017-2018

Bushveld Minerals holds an effective 74% interest in Vametco, with 26% held by BBBEE (Broad-Based Black Economic Empowerment) groups. Vametco is 100% consolidated in Bushveld's accounts. Bushveld acquired its interest through two deals in 2017 and 2018.

History of mine ownership

Mining operations commenced in 1967 under the ownership of Union Carbide and in 1986 the mine was acquired by SMC.

In 2005 BEE Strategic Partners acquired a 15% interest in the operations from SMC and in 2006 the mine was converted from an American subsidiary of SMC to a South African Company (Vametco Holdings) with a further 10% transferred to a BEE group.

EVRAZ acquired a controlling shareholding in SMC in 2007 and in 2017 Bushveld Minerals, in partnership with Yellow Dragon SMC, acquired EVRAZ' 78.8% interest in SMC (SMC held a 75% interest in the Vametco mine and facilities, owned 45% Bushveld/55% Yellow Dragon). Later that year Bushveld Minerals acquired Yellow Dragon's 55% share, taking its effective interest to 59.1%.

In 2018 Bushveld acquired the remaining 21.22% interest in SMC from Sojitz, increasing its effective shareholding the mine and facilities to 75%. Later that year a 1% stake was sold to the two Broad Based Black Economic Empowerment shareholders taking the BBBEE shareholding to 26% and leaving Bushveld Minerals with a 74%, the maximum ownership permitted under the South African Mining Charter.

Overview of geology

The Vametco mine sits within the Rustenburg Layered Suite of the Bushveld Complex.

Mineralisation occurs in vanadium-bearing titaniferous magnetite-rich layers within the Upper Zone of the Rustenberg Layered Suite; both the Main and Upper Zones occur in the Vametco mining area. The magnetite-rich layers are continuous along strike and down-dip with and are of variable thickness. The layers are east-west striking with an average dip of 19° to the north.

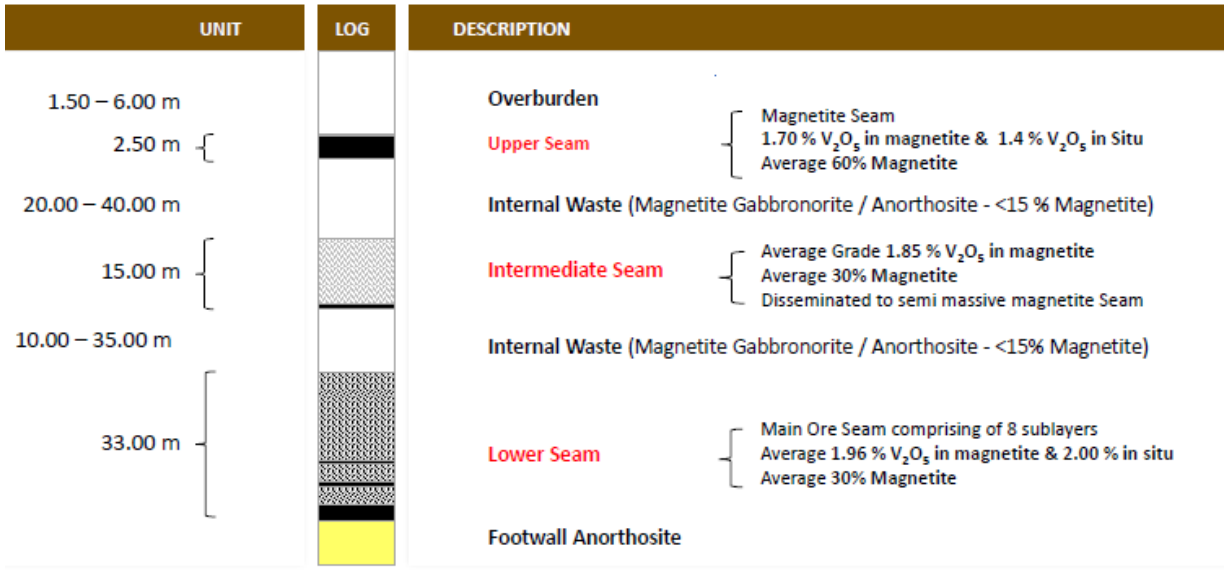
Groups of magnetite-rich layers at Vametco are separated into three seams, the Upper, Intermediate and Lower. All three seams have been exposed by open pit mining at Vametco.

The Upper Seam Mineral Resource extends ~4km along strike and ~230m down-dip, the Intermediate Seam Mineral Resource extends ~2.6km along strike and ~290m down-dip and the Lower Seam Mineral Resource extends ~3.9km along strike and ~230m down-dip.

The mineral resource has been limited to ~150m below surface, however, the mineralisation is open down-dip.

The stratigraphy summarised below.

Figure 27: Stratigraphy of Vametco Mine & Brits Vanadium Project



Source: Company

Vametco reserves, resources and mining operations

The Vametco processing plant is fed ore from the adjacent Vametco open pit mine.

The ore body is well defined and continuous with gross inferred and indicated mineral resources assessed at 181.5 Mt (YE 2022) at an average grade of 1.98% V_2O_5 in magnetite, for total resources of 699.0 kt vanadium in magnetite.

Figure 28: Vametco gross mineral resource at YE 2022

Mineral resources at cut-off grade of 20% magnetite

Class	Seam Name	Millions tonnes whole rock	V2O5 grade of whole rock (%)	Magnetite grade of whole rock (%)	V2O5 grade in magnetite (%)	V2O5 in magnetite (thou tonnes)	V in magnetite (thou tonnes)
Indicated	Upper	5.4	1.44	65.9	1.78	62.7	35.1
	Intermediate	27.6	0.67	32.9	1.91	173.1	97.0
	Lower	105.9	0.72	32.4	2.03	697.2	390.4
	Total	**139.0**	**0.74**	**33.8**	**2.00**	**933.0**	**522.5**
Inferred	Upper	10.2	1.46	63.6	1.75	113.3	63.5
	Intermediate	7.0	0.67	32.1	1.92	43.4	24.3
	Lower	25.4	0.74	31.3	2.00	158.4	88.7
	Total	**42.6**	**0.90**	**39.1**	**1.93**	**315.2**	**176.5**
Indicated and Inferred	Upper	15.5	1.45	64.4	1.76	176.0	98.6
	Intermediate	34.7	0.67	32.7	1.91	216.5	121.3
	Lower	131.3	0.72	32.1	2.03	855.6	479.2
	Total	**181.5**	**0.77**	**35.0**	**1.98**	**1,248.2**	**699.0**

Source: Company

Of this total 46.4 Mt is assessed as probable reserves on a gross basis (there are no proven reserves), with vanadium grades of 1.99% V_2O_5 in magnetite equating to 148.2 kt vanadium in magnetite.

Figure 29: Vametco gross probable ore reserves at YE 2022

Seam	Millions tonnes whole rock	V2O5 grade of whole rock	Magnetite grade of whole rock	V2O5 grade in magnetite	V2O5 in magnetite (thou tonnes)	V in magnetite (thou tonnes)
Upper	1.9	1.07%	50.20%	1.77%	16.7	9.3
Intermediate	8.3	0.57%	26.70%	1.87%	41.3	23.1
Lower	36.2	0.62%	28.10%	2.03%	206.7	115.7
Total	**46.4**	**0.63%**	**28.70%**	**1.99%**	**264.6**	**148.2**

Source: Company

A conventional drill, blast, load and haul mining cycle is employed at Vametco, incorporating a combination of strip and open mining owing to the stratified nature of the ore deposit. A number of contractors are employed in the mining operations.

The probable reserves base is sufficient for our modelling of the base and expansion case production profiles at Vametco.

Vametco process

The Vametco processing facilities historically produced vanadium products from vanadium bearing magnetite ore, or vanadium containing slag. Since 2016, various debottlenecking initiatives have been undertaken to increase magnetite production volumes to maintain final product volumes without contribution from slag.

Vametco employs the standard salt roast and leach process to produce a trademark vanadium carbon nitride (VCN) product called Nitrovan™. The Vametco beneficiation process involves the following sequential sections:

- crushing
- milling and magnetic separation concentration
- salt-roasting of concentrate (~1,150°C)
- leach separation of water soluble sodium vanadate
- precipitation separation and purification to produce Modified Vanadium Oxide ("MVO")
- Nitro Vanadium production in Nitrovan furnaces

Below we present a mass balance for the Vametco process at our modelled long-term production rate in our base case. The overall recovery from primary mill to Nitrovan product equates to ~71%.

Figure 30: Simplified vanadium mass balance for Vametco plant

Based upon 14.2 Mt pa RoM to deliver our base case steady-state 2023+ production rate and 2019 CPR recovery assumptions

Section	Material	Monthly Feed (tpm)	Magnetite Grade (%)	Vanadium Tonnes per annum (tpa)	Recovery (%)	Grade (%)	Production (mtV p.a.)	Recovery (%)
Secondary crusher	RoM	1,200,167						
Tertiary crusher and screens	RoM	1,200,167						
Primary Mill	RoM	1,200,167	28.00%	336,047		1.130%	3,797	
Secondary Mill magseps	magnetite			330,804	98.44%	1.130%	3,738	98.44%
Non-magnetic tailings	waste	869,362	0.603%	5,242		0.007%	74	
Kiln	magnetite			330,804		1.130%	3,738	83.50%
Leach Mill	calcine	330,804					3,121	
Leach Filter	residue	327,877					2,928	93.80%
Precipitation Dryer	AMV						2,825	96.50%
MVO Reactors	MVO						2,783	98.50%
Mix plant recovery	MVO						2,727	98.00%
Nitrovan Reactors	NV						2,700	99.00%
						Overall Recovery from primary mill to Nitrovan		**71.10%**

Source: Company, BNP Paribas Exane estimates

Concentration – crushing and milling

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.

The three crushing stages reduce ~1,000mm boulders to ~10mm sized particles, with the undersize fed to the milling circuit. Three ball mills reduce the particle size further to ~70% <150 microns (typically 20% passing 75 microns).

The ball mills operate in a closed circuit, with cyclone separators incorporating magnetic separators on the overflows. The concentrated magnetite, with typical remaining impurities including silicon, calcium and aluminium is fed to the kiln with the slimes and gangue pumped to the slimes tailing dam. Water is recovered and recycled.

Salt roasting kiln

The concentrate is mixed with measured amounts of sodium carbonate (Na_2CO_3) and sodium sulphate (Na_2SO_4) before being roasted in a 4.2m diameter, 90m long rotary kiln. The kiln is coal-fired to temperatures of ~1,150°C. The vanadium reacts to form water soluble sodium vanadates.

Secondary reactions also occur in the kiln, including the conversion of silicon (as SiO_2) to silicates, which can affect the operability of the kiln if significant levels of silicates cause restrictions owing to accumulations of glass. If this occurs operations need to be halted to remove the accumulations.

High levels of silicon (SiO_2) in the magnetite concentrate also scavenges sodium ions to form sodium silicates. These can be 'sticky' in the hot zone of the kiln, and their formation also reduces the availability of sodium ions to form water soluble sodium vanadates – a necessary step to ensure high recoveries of vanadium. Adding increased amounts of sodium salts to the kiln feed in an attempt to counteract the impact of higher silicon content only exacerbates the build-up of glass accumulations in the kiln, and increases the sodium load in the next stage of the process.

Maximising the separation of magnetite from silicon compounds in the milling stage minimises the potential for secondary reactions involving silicon compounds to impact operations.

Solids exit the rotary kiln at ~900°C and pass directly into an air-cooled rotary cooler with hot air recycled to the kiln.

Kiln off gases are scrubbed to remove dust and SO_2 prior to release to atmosphere, with solids from the scrubber settled in a thickener, dewatered and returned to the kiln feed. The thickener overflow is transferred to lined scrubber dams for further settling, prior to reuse in the scrubbing circuit.

Extraction: leach milling & purification

The cooled calcine is transferred to a wet ball mill which grinds the agglomerated material with recovered process water for improved leaching. This initial milling stage also acts as the first stage of leaching.

The leaching process continues in a three-stage circuit, with counter current washing over a large belt filter. The discharged slurry from the final stage is transferred to a thickener where flocculent and aluminium sulphate ($AlSO_4$) is added to precipitate the co-leached silica and clarify the pregnant leach liquor solution.

The thickener overflow (which is predominantly sodium sulphate and sodium metavanadate in solution) is pumped to the precipitation circuit and the underflow is pumped to a wash circuit to maximise recovery of the vanadium rich solution from the calcine tailings. Calcine tailings are conveyed to the tailings disposal facility.

Ammonium Metavanadate (AMV) precipitation

Ammonium sulphate ($[NH4]_2SO_4$) is added to the vanadium-bearing leach liquor in a multistage precipitation circuit, resulting in the precipitation of ammonium metavanadate (AMV, NH_4VO_3).

The slurry is transferred to a thickener, with the thickened underflow filtered on a belt filter to produce an AMV cake, which is dried in an oil fired calciner at a temperature below that at which ammonium would be driven off. The vanadium is in the +5 oxidation state in the AMV product.

The overflow, which contains residual ammonium sulphate and sodium sulphate produced during the precipitation process, is transferred to the barren dam at the salt recovery plant (SRP).

Modified Vanadium Oxide (MVO) production

The AMV filter cake is dried in a rotary dryer and thereafter transferred to the MVO Rotary Calciners, which are two parallel kilns operating at 900°C. In these kilns the AMV (NH_4VO_3) decomposes to produce modified vanadium oxide (MVO, V_2O_3). This reaction occurs in a reducing atmosphere, caused by the decomposition of the ammonia molecules, released from the AMV, to nitrogen and hydrogen.

The MVO product is sealed in drums to prevent re-oxidation, and is the feedstock for the production of Nitrovan and vanadium electrolytes.

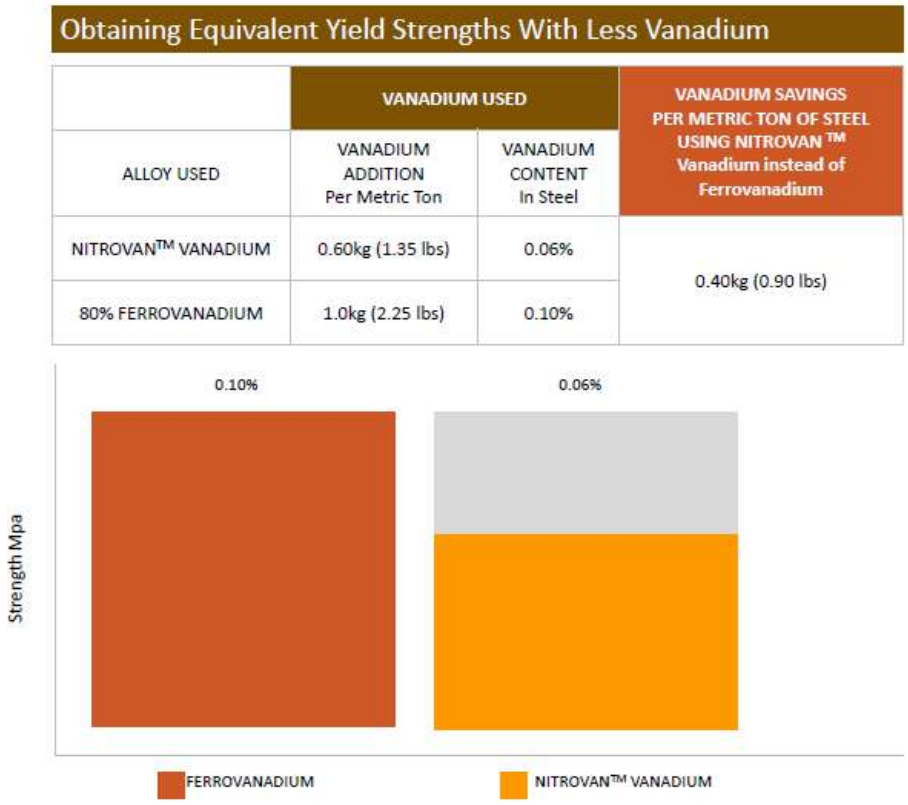
Nitrovan shaft furnace

MVO is mixed with carbon and a starch binder in a dry-ball mixing process, with different proportions corresponding to different grades of Nitrovan (NV 12 and NV 16, with the number referring to the percentage content of nitrogen in the final product).

This mixture is briquetted and fed into a nitrogen purged induction shaft furnace which runs on electricity, where nitrogen substitutes some of the carbon to produce Nitrovan, a trademarked vanadium carbon nitride (VCN) product. The elements in the product are in a solid solution state.

Nitrovan is a vanadium-nitrogen produce used as a micro-alloy in steel production. It strengthens steel more efficiently than ferrovanadium allowing steelmakers to use less vanadium in high-strength low alloy steels and reduce vanadium costs by as much as 40%.

Figure 31: Nitrovan permits steelmakers to achieve equivalent yield strengths with less vanadium



Source: Company

Salt recovery plant (SRP)

The remaining solution from the precipitation stages, which contains residual ammonium sulphate and sodium sulphate, is transferred to the SRP. The solutions are concentrated through evaporation, resulting in the crystallisation of sodium sulphate which is recovered by belt filtration for return to the kiln. Excess sodium sulphate which does not meet sales specification is stockpiled.

The remaining solution, containing concentrated levels of ammonium sulphate, is returned to the AMV precipitation process.

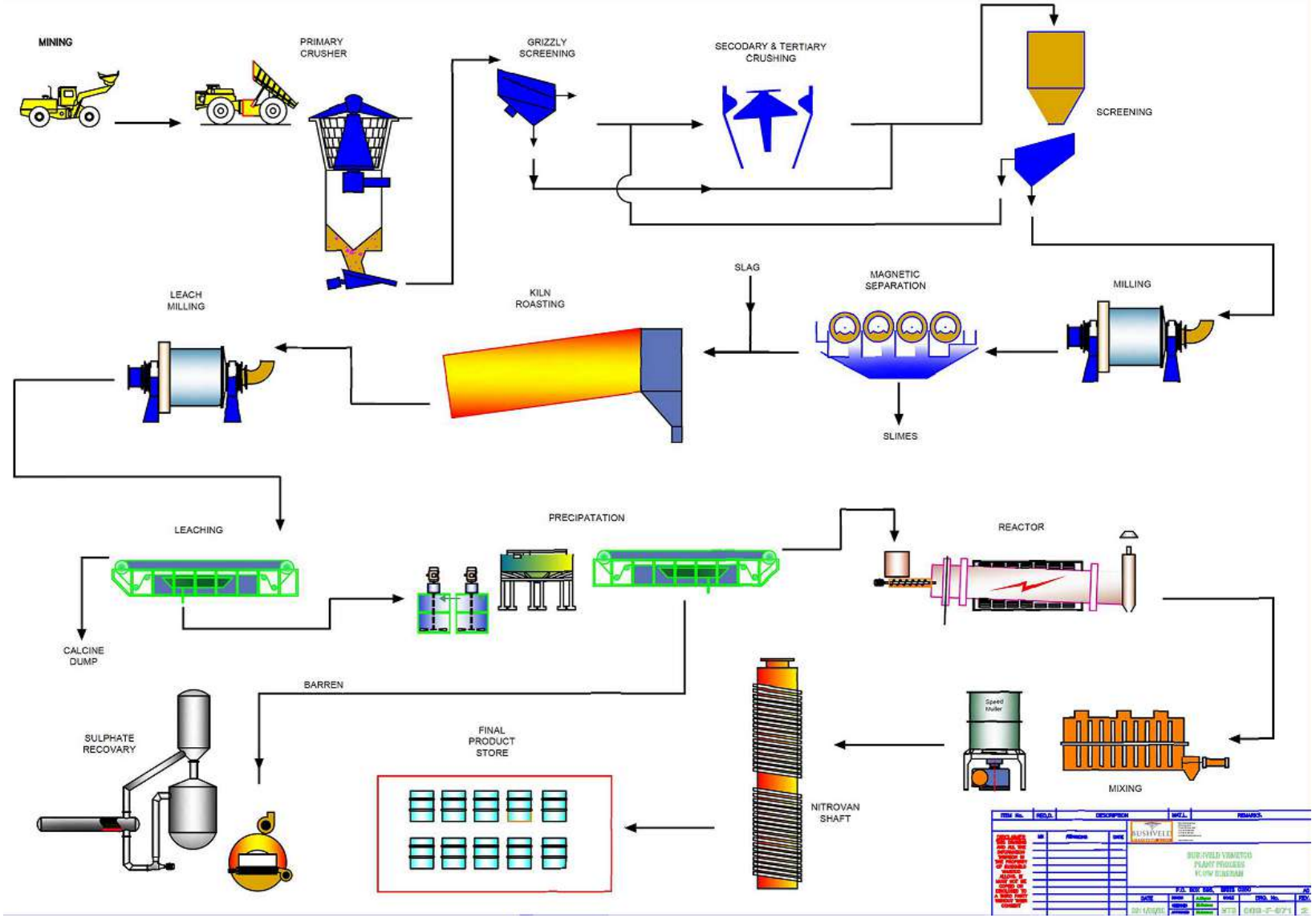
Moderate impact of load-shedding at Vametco compared to Vanchem

During periods of load shedding on the South African grid, power supply to Vametco is curtailed, rather than cut-off. The mine and plant operators plan to reduce power consumption to the curtailment limit during these periods, which is preferable to a complete cut-off. This permits, for example, critical items of equipment such as the kiln to be maintained at operating temperature, reducing temperature cycling and stress on the refractory lining.

Detailed cash-flow analysis underpins our analysis

The figure overleaf summarises the Vametco process and following this we present the summary output from our detailed cash-flow analysis for Vametco in US$ and ZAR terms.

Figure 32: Simplified overall process flow diagram for the Vametco Project indicating the key operational components



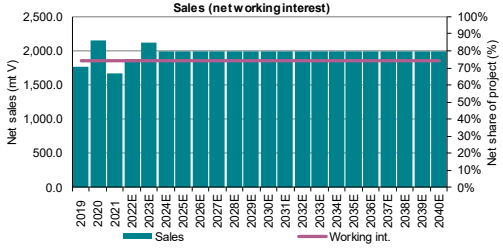
Source: Company

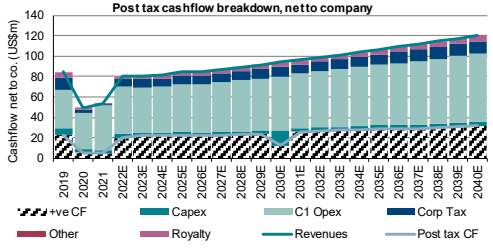
Figure 33: Vametco base case cash-flow analysis in US$

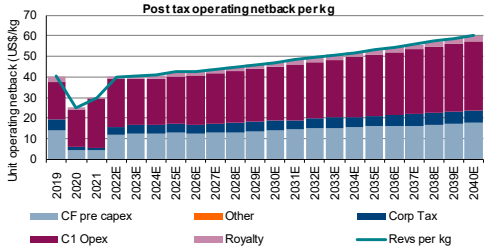
	Gross mine/processing facility												Country: South Africa		Vametco Base - net to company											Discount rate: 16.0%	
													Working interest basis														
Year	LMB V price	Price as % of LMB	Realised V price	Prod pre losses mtV	Production	Sales as % of prod	Sales	Revenues	Royalty	Capex	C1 Opex	Working int.	Production	Sales	Revenues	Revs per kg	Royalty	Royalty	C1 Opex	C1 Opex	Capex	Corp Tax	Corp Tax	Other	Other	Post tax CF	Post tax CF	CF pre capex	Rem. NPV (1st Jan)	Rem. NPV (1st Jan)
	US$/kg	%	US$/kg	mt V	mt V	%	mt V	US$m	US$m	US$m	US$m	%	mt V	mt V	US$m	US$/kg	US$m	US$/kg	US$m	US$/kg	US$m	US$m	US$/kg	US$m	US$/kg	US$m	US$/kg	US$/kg	US$m	US$/kg
2019	42.3	116%	49.0	3,984	2,833	84%	2,392	114.3	-8.0	-9.7	-51.1	74.0%	2,096	1,770	84.6	40.4	-5.9	-2.8	-37.9	-18.1	-7.2	-11.3	-5.4	0.0	0.0	22.3	10.6	14.1	135.7	2.1
2020	25.0	95%	23.7	3,721	2,646	110%	2,901	66.6	-2.9	-4.4	-48.3	74.0%	1,958	2,147	49.3	25.2	-2.1	-1.1	-35.7	-18.2	-3.3	-3.1	-1.6	0.0	0.0	5.1	2.6	4.3	131.7	2.1
2021	34.5	93%	32.2	3,450	2,453	92%	2,248	73.0	-1.2	-4.5	-58.7	74.0%	1,815	1,663	54.0	29.7	-0.9	-0.5	-43.4	-23.9	-3.3	-1.7	-1.0	0.0	0.0	4.6	2.5	4.4	147.2	2.4
2022E	39.2	109%	42.8	3,803	2,704	94%	2,532	108.0	-2.4	-5.1	-63.2	74.0%	2,001	1,873	79.9	40.0	-1.8	-0.9	-46.7	-23.4	-3.8	-8.0	-4.0	0.0	0.0	19.7	9.8	11.7	165.6	2.8
2023E	35.0	108%	37.8	3,797	2,700	106%	2,875	109.1	-4.2	-3.8	-60.3	74.0%	1,998	2,128	80.7	40.4	-3.1	-1.5	-44.7	-22.3	-2.8	-8.2	-4.1	0.0	0.0	22.0	11.0	12.4	169.6	2.9
2024E	38.5	106%	40.8	3,797	2,700	100%	2,700	110.2	-4.5	-3.9	-61.2	74.0%	1,998	1,998	81.5	40.8	-3.3	-1.7	-45.3	-22.7	-2.9	-8.1	-4.1	0.0	0.0	21.9	10.9	12.4	171.6	3.1
2025E	40.7	104%	42.4	3,797	2,700	100%	2,700	114.4	-5.2	-4.0	-62.7	74.0%	1,998	1,998	84.7	42.4	-3.9	-1.9	-46.4	-23.2	-2.9	-8.7	-4.4	0.0	0.0	22.7	11.4	12.8	174.0	3.2
2026E	41.8	102%	42.6	3,797	2,700	100%	2,700	115.0	-5.3	-4.0	-64.3	74.0%	1,998	1,998	85.1	42.6	-3.9	-2.0	-47.6	-23.8	-3.0	-8.5	-4.3	0.0	0.0	22.1	11.1	12.6	175.8	3.4
2027E	42.8	102%	43.7	3,797	2,700	100%	2,700	117.9	-5.3	-4.1	-65.9	74.0%	1,998	1,998	87.2	43.7	-3.9	-2.0	-48.8	-24.4	-3.0	-8.8	-4.4	0.0	0.0	22.7	11.4	12.9	178.6	3.6
2028E	43.9	102%	44.8	3,797	2,700	100%	2,700	120.8	-5.4	-4.2	-67.6	74.0%	1,998	1,998	89.4	44.8	-4.0	-2.0	-50.0	-25.0	-3.1	-9.1	-4.5	0.0	0.0	23.2	11.6	13.2	181.1	3.8
2029E	45.0	102%	45.9	3,797	2,700	100%	2,700	123.9	-5.6	-4.3	-69.3	74.0%	1,998	1,998	91.7	45.9	-4.1	-2.1	-51.3	-25.7	-3.1	-9.3	-4.7	0.0	0.0	23.8	11.9	13.5	183.5	4.0
2030E	46.1	102%	47.0	3,797	2,700	100%	2,700	127.0	-5.7	-20.7	-71.0	74.0%	1,998	1,998	94.0	47.0	-4.3	-2.1	-52.5	-26.3	-15.3	-9.6	-4.8	0.0	0.0	12.3	6.2	13.8	185.5	4.2
2031E	47.3	102%	48.2	3,797	2,700	100%	2,700	130.1	-5.9	-4.3	-72.8	74.0%	1,998	1,998	96.3	48.2	-4.4	-2.2	-53.8	-27.0	-3.2	-9.1	-4.6	0.0	0.0	25.8	12.9	14.5	201.3	4.8
2032E	48.4	102%	49.4	3,797	2,700	100%	2,700	133.4	-5.7	-4.4	-74.6	74.0%	1,998	1,998	98.7	49.4	-4.2	-2.1	-55.2	-27.6	-3.2	-9.5	-4.7	0.0	0.0	26.6	13.3	14.9	204.0	5.1
2033E	49.6	102%	50.6	3,797	2,700	100%	2,700	136.7	-5.9	-4.5	-76.5	74.0%	1,998	1,998	101.2	50.6	-4.3	-2.2	-56.6	-28.3	-3.3	-9.7	-4.9	0.0	0.0	27.3	13.6	15.3	206.1	5.4
2034E	50.9	102%	51.9	3,797	2,700	100%	2,700	140.1	-6.0	-4.5	-78.4	74.0%	1,998	1,998	103.7	51.9	-4.5	-2.2	-58.0	-29.0	-3.4	-10.0	-5.0	0.0	0.0	27.9	14.0	15.7	207.8	5.8
Totals				thou t	thou t		thou t	US$m	US$m	US$m	US$m		tonnes	tonnes	US$m	US$/kg	US$m	US$/kg	US$m	US$/kg	US$m	US$m	US$/kg	US$m	US$/kg	US$m	US$/kg	US$/kg	US$m	US$/kg
2022E+				113,925	81,004		81,007	4,583.9	-203.2	-163.4	-2,563.6		59,943	59,945	3,392.1	56.6	-150.4	-2.5	-1,897.1	-31.6	-120.9	-343.4	-5.7	0.00	0.0	880.3	14.7	16.7	165.6	2.8
2035+				64,555	45,900		45,900	2,997.2	-136.1	-91.6	-1,675.9		33,966	33,966	2,217.9	65.3	-100.7	-3.0	-1,240.2	-36.5	-67.8	-226.8	-6.7	0.0	0.0	582.4	17.1	19.1		

Notes: Gross cashflows are for Vametco Holdings, which holds a 100% interest in the Vametco mine/processing facility and in which Bushveld Minerals holds a 74% stake.

	Gross	Opex	Capex
	US$/kg	-29.9	-1.9







1st Jan NAV sensitivity to discount rate

	US$m	p/sh	US$/kg
12.0%	217	13.1	3.63
14.0%	188	11.3	3.14
16.0%	166	10.0	2.77
18.0%	148	8.9	2.47
20.0%	134	8.1	2.24

NAV sensitivity to 2023+ V price				IRR sensy
US$/kg	US$m	p/sh	US$/kg	(%)
25	22	1.3	0.37	
30	76	4.6	1.27	
35	130	7.8	2.17	
40	184	11.1	3.07	
45	238	14.3	3.97	

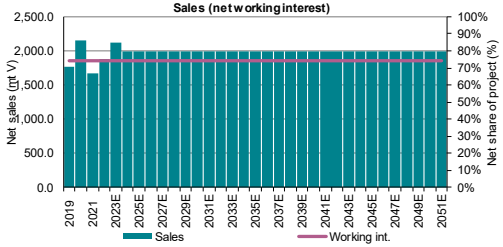
Source: BNP Paribas Exane estimates

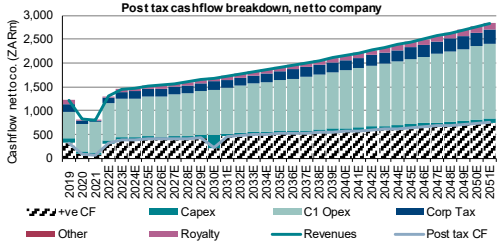
Figure 34: Vametco base case cash-flow analysis in ZAR

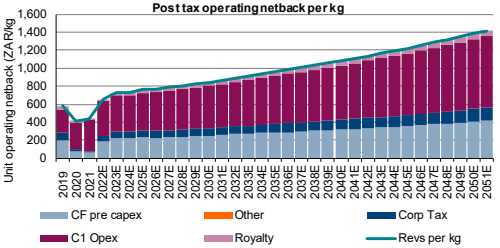
	Gross mine/processing facility												Country: South Africa		Vametco Base - net to company												Discount rate: 16.0%	
													Working interest basis															
Year	LMB V price	Price as % of LMB	Realised V price	Prod pre losses mtV	Production	Sales as % of prod	Sales	Revenues	Royalty	Capex	C1 Opex	Working int.	Production	Sales	Revenues	Revs per kg	Royalty	Royalty	C1 Opex	C1 Opex	Capex	Corp Tax	Corp Tax	Other	Other	Post tax CF	Post tax CF	CF pre capex	Rem. NPV (1st Jan)	Rem. NPV (1st Jan)
	US$/kg	%	US$/kg	mtV	mt V	%	mt V	ZARm	ZARm	ZARm	ZARm	%	mt V	mt V	ZARm	ZAR/kg	ZARm	ZAR/kg	ZARm	ZAR/kg	ZARm	ZARm	ZAR/kg	ZARm	ZAR/kg	ZARm	ZAR/kg	ZAR/kg	ZARm	ZAR/kg
2019	42.3	116%	49.0	3,984	2,833	84%	2,392	1,643	-115	-140	-739	74.0%	2,096	1,770	1,216	580	-85	-41	-547	-261	-104	-162	-77	0	0	318	152	201	2,315	35
2020	25.0	95%	23.7	3,721	2,646	110%	2,901	1,098	-47	-72	-793	74.0%	1,958	2,147	812	415	-35	-18	-587	-300	-54	-51	-26	0	0	86	44	71	2,320	36
2021	34.5	93%	32.2	3,450	2,453	92%	2,248	1,082	-18	-67	-870	74.0%	1,815	1,663	801	441	-13	-7	-644	-355	-49	-26	-14	0	0	69	38	65	2,596	42
2022E	39.2	109%	42.8	3,803	2,704	94%	2,532	1,762	-39	-85	-1,040	74.0%	2,001	1,873	1,304	652	-29	-14	-770	-385	-63	-128	-64	0	0	314	157	188	2,937	49
2023E	35.0	108%	37.8	3,797	2,700	106%	2,875	1,960	-75	-68	-1,084	74.0%	1,998	2,128	1,450	726	-55	-28	-802	-401	-51	-148	-74	0	0	395	198	223	3,048	53
2024E	38.5	106%	40.8	3,797	2,700	100%	2,700	1,979	-81	-71	-1,100	74.0%	1,998	1,998	1,465	733	-60	-30	-814	-407	-52	-146	-73	0	0	393	197	223	3,083	55
2025E	40.7	104%	42.4	3,797	2,700	100%	2,700	2,056	-94	-71	-1,127	74.0%	1,998	1,998	1,521	761	-69	-35	-834	-418	-53	-157	-79	0	0	408	204	231	3,126	58
2026E	41.8	102%	42.6	3,797	2,700	100%	2,700	2,066	-95	-72	-1,155	74.0%	1,998	1,998	1,529	765	-70	-35	-855	-428	-54	-153	-77	0	0	397	199	226	3,158	61
2027E	42.8	102%	43.7	3,797	2,700	100%	2,700	2,118	-95	-74	-1,184	74.0%	1,998	1,998	1,567	784	-70	-35	-876	-439	-55	-158	-79	0	0	408	204	232	3,208	64
2028E	43.9	102%	44.8	3,797	2,700	100%	2,700	2,171	-98	-75	-1,214	74.0%	1,998	1,998	1,607	804	-72	-36	-898	-450	-56	-163	-82	0	0	417	209	237	3,254	68
2029E	45.0	102%	45.9	3,797	2,700	100%	2,700	2,225	-101	-76	-1,244	74.0%	1,998	1,998	1,647	824	-75	-37	-921	-461	-57	-167	-84	0	0	428	214	242	3,296	72
2030E	46.1	102%	47.0	3,797	2,700	100%	2,700	2,281	-103	-372	-1,275	74.0%	1,998	1,998	1,688	845	-76	-38	-944	-472	-275	-172	-86	0	0	221	111	248	3,333	76
2031E	47.3	102%	48.2	3,797	2,700	100%	2,700	2,338	-106	-77	-1,307	74.0%	1,998	1,998	1,730	866	-78	-39	-967	-484	-57	-164	-82	0	0	463	232	261	3,617	86
2032E	48.4	102%	49.4	3,797	2,700	100%	2,700	2,396	-102	-79	-1,340	74.0%	1,998	1,998	1,773	888	-75	-38	-992	-496	-58	-170	-85	0	0	478	239	269	3,664	92
2033E	49.6	102%	50.6	3,797	2,700	100%	2,700	2,456	-106	-80	-1,374	74.0%	1,998	1,998	1,818	910	-78	-39	-1,016	-509	-59	-174	-87	0	0	490	245	275	3,702	98
2034E	50.9	102%	51.9	3,797	2,700	100%	2,700	2,518	-108	-82	-1,408	74.0%	1,998	1,998	1,863	933	-80	-40	-1,042	-521	-60	-179	-90	0	0	502	251	281	3,733	104
Totals				thou t	thou t		thou t	ZARm	ZARm	ZARm	ZARm		tonnes	tonnes	ZARm	ZAR/kg	ZARm	ZAR/kg	ZARm	ZAR/kg	ZARm	ZARm	ZAR/kg	ZARm	ZAR/kg	ZARm	ZAR/kg	ZAR/kg	ZARm	ZAR/kg
2022E+				**113,925**	**81,004**		**81,007**	**82,173**	**-3,646**	**-2,929**	**-45,962**		**59,943**	**59,945**	**60,808**	**1,014**	**-2,698**	**-45**	**-34,012**	**-567**	**-2,167**	**-6,155**	**-103**	**0**	**0**	**15,776**	**263**	**299**	**2,937**	**49**
2035+				64,555	45,900		45,900	53,846	-2,445	-1,647	-30,109		33,966	33,966	39,846	1,173	-1,809	-53	-22,280	-656	-1,218	-4,075	-120	0	0	10,463	308	344		

Notes: Gross cashflow s are for Vametco Holdings, w hich holds a 100% interest in the Vametco mine/processing facility and in w hich Bushveld Minerals holds a 74% stake.

	Gross	Opex	Capex
	ZAR/kg	-526	-34







1st Jan NAV sensitivity to discount rate

	ZARm	p/sh	ZAR/kg
12.0%	3,905	13.1	65.14
14.0%	3,382	11.4	56.42
16.0%	2,979	10.0	49.70
18.0%	2,662	9.0	44.42
20.0%	2,409	8.1	40.19

NAV sensitivity to 2023+ V price				**IRR sensy**
US$/kg	**ZARm**	**p/sh**	**ZAR/kg**	**(%)**
25	397	1.3	0.01	
30	1,366	4.6	0.02	
35	2,335	7.9	0.04	
40	3,305	11.1	0.06	
45	4,274	14.4	0.07	

Source: BNP Paribas Exane estimates

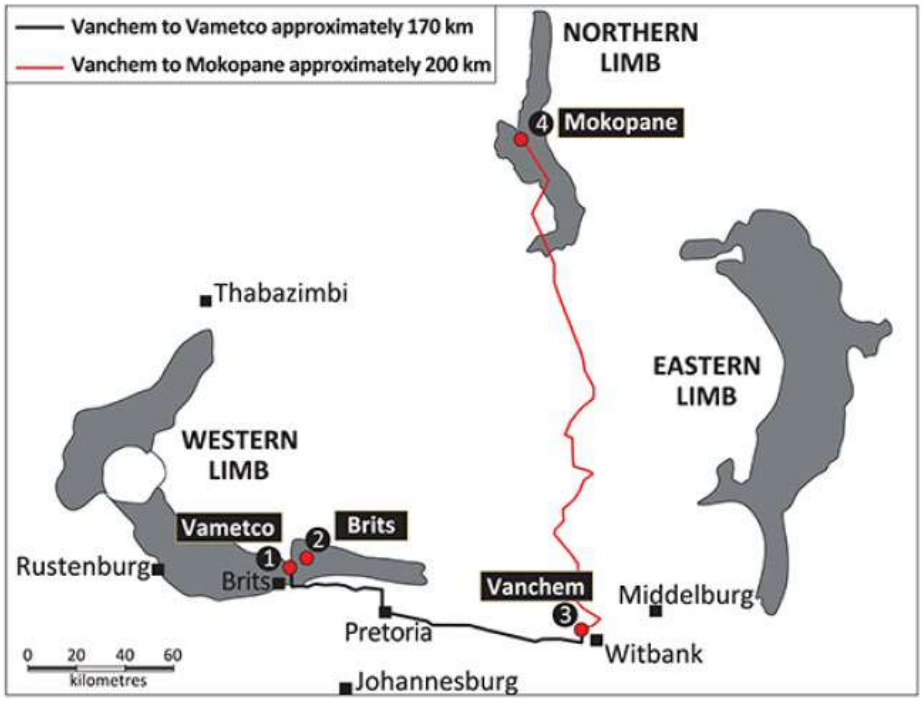
Vanchem – processing facilities

Vanchem is a primary vanadium production facility with a beneficiation plant capable of producing a range of vanadium products. These include ferrovanadium, vanadium pentoxide, vanadium trioxide and vanadium chemicals. The vanadium chemicals produced are key to Bushveld's steps into the emerging stationary energy storage business (vanadium redox flow batteries – VRFBs).

Located ~170km from Vametco

Vanchem is located at Ferrobank Industrial Park in Emalahleni Local Municipality, Mpumalanga Province, in South Africa. The facility lies ~170km east by road from the Vametco mine and processing facilities, and ~200km south of the company's Mokopane resource. Vanchem has a rail siding for delivery of ore to the processing plant.

Figure 35: Map showing location of Vanchem in relation to Vametco, Brits and Mokopane vanadium deposits



Source: Company

Key advantages of the Vanchem acquisition

The acquisition of Vanchem enables Bushveld to further grow vanadium production and sales, with the addition of separate, complementary, production capacity.

Vanchem diversifies Bushveld's production operations, both through adding an additional site, but also through the addition of parallel processing stages. For example the three kilns at Vanchem can, post refurbishment, be run in parallel, and offer redundancy and flexibility when it comes to maintenance planning.

By virtue of its ability to produce a range of Vanadium products, Vanchem further diversifies the product portfolio, offering exposure to a greater range of end markets and prices.

The vanadium chemical plant and its high purity vanadium oxide production facility are key inputs for the manufacture of vanadium electrolyte for VRFBs.

The Vanchem facility could eventually take milled ore from the Mokopane deposit, thus creating a second integrated vanadium business from mine to product. Development options for Mokopane are currently under study.

History: operating since the 1970s

The Vanchem processing facilities have been operating since the late 1970s, processing ore from the Mapochs vanadium mine and slag from the Highveld Steel & Vanadium plant, located ~10km from Vanchem. Following the cessation of production from the Mapochs mine in 2015, which fed both the Vanchem and Highveld operations, Vanchem entered into Business Rescue in November 2015.

In 3Q 2018 production partially restarted, fed by ore from third parties and existing stockpiles. Milled magnetite concentrates from the Upper Seam at Vametco, which is higher grade than previously used third party ore, were fed to the plant from 3Q 2021. However higher than anticipated levels of clay/silica in the ore resulted in kiln ring formation and unplanned downtime for removal.

The upper seam resource was expected to be sufficient to supply Vanchem through to mid-2024, after which third party ore would be used until the installation of a new semi-autogeneous mill at Vametco. It has now been decided to use third party ore indefinitely at Vanchem, which can be sourced for a similar cost to the Upper Seam at Vametco, but is better suited to the Vanchem process.

Bushveld acquired the Vanchem business from Duferco in November 2019 for a total consideration of US$53.5m (US$30.5m cash with the remaining US$23m paid in convertible loan notes, of which US$9m was converted into Bushveld shares in October 2021 with the remainder repaid in cash).

Facilities: similar to Vametco, but with expanded product offering

The Vanchem process incorporates a salt roast beneficiation plant, similar to that employed at Vametco. Vanchem is one of only four such operational vanadium processing plants in the world (and one of three in South Africa), with Bushveld owning two (Vanchem and Vametco).

The Vanchem process consists of five key stages; the first three of which are similar to processes at Vametco. Ore is not crushed at Vanchem.

1) Milling and magnetic separation to produce a magnetite concentrate with average grades of approximately 1.65% V_2O_5 in-magnetite.

2) Salt-roasting of the concentrate with sodium salts in a kiln at approximately 1,150°C, to form a water-soluble sodium vanadate material

3) Leaching and purification, involving dissolution of roasted vanadium concentrate in water, purification and precipitation of vanadium through the addition of ammonium sulphate, followed by drying and then processing in a reducing environment to produce an APV product

4) Vanadium oxide production: the APV is de-ammoniated and melted to produce vanadium tri and pentoxide

5) The APV is also used in other processes to produce a spectrum of vanadium chemicals

6) Vanadium oxides are reduced in the presence of iron to produce ferrovanadium (FeV) – a primary product.

Salt roasting process – three kilns at Vanchem

At the time of production restart in 2018 only one of Vanchem's three kilns (kiln 1) was in operation. Kiln 3 has subsequently been refurbished and was commissioned in H2 2022, however, it has not yet ramped up to full capacity.

Of the three kilns at Vanchem kiln 3 has similar characteristics to the Vametco kiln, at 90m long with a 4.0m diameter. Kiln 3 accounts for around half of the installed kiln capacity at Vanchem, with kilns 2 and 3 each accounting for ~25% of capacity.

It became apparent kiln 1 was approaching the end of its life in early 2022 and was taken offline upon completion of the kiln 3 refurb in July 2022. Stages two and three of the four-phase expansion programs for Vametco and Vanchem involve the refurbishment of kiln 2 and 1 to further increase overall production rates.

The salt roast process is broadly similar to that employed at Vametco, using sodium containing reagents and operating at ~1,150°C. As at Vametco, process interruptions can occur; as noted above higher than expected clay and silica content in the Vametco ore resulted in kiln ring formation which required an unplanned shutdown for removal.

The Vanchem kiln outlet differs from Vametco in that Vametco incorporates a 10m cooling section at the end of the kiln, whereas Vanchem discharges almost directly into the leach plant. This necessitates careful management of roast temperatures at Vanchem, since the kiln outlet temperature impacts the recovery from the leach stage.

Leach plant, with a portion of product fed to the APV precipitation stage

Leach dams/vats are employed to leach the water-soluble sodium vanadates produced in the kiln, in a similar process to that at Vametco. The pregnant leachate is then split between the vanadium oxide section of the plant and the chemical plant.

APV precipitation and vanadium oxide reactors

The pregnant leachate is fed to the Ammonium Polyvanadate (APV) precipitation stage. As part of the phase 2 expansion at Vanchem a new AMV plant will be constructed, similar to the plant at Vametco.

The dried APV precipitate is then split to produce vanadium trioxide (V_2O_3) and vanadium pentoxide (V_2O_5) flake.

- APV (NH_4VO_3) is reacted with ammonia gas in the V_2O_3 reactor, with the product transferred to the FeV site, or used to produce electrolyte for VRFBs.
- In the V_2O_5 reactor the APV (NH_4VO_3) is de-ammoniated and then smelted in gas fired or electric powered fusion furnaces. The product can then be flaked and packed for sale as V_2O_5 flakes – a primary product used in aerospace applications and in coatings for steel used in auto manufacturing, or converted to FeV. V_2O_5 powder can also be used to produce electrolyte for VRFBs.

Vanadium chemicals production, the key difference compared to Vametco

A portion of the pregnant leachate is transferred to the chemicals plant to produce a variety of vanadium chemicals, including V_2O_5 powders, electrolyte and vanadyl oxalate (C_2O_5V).

V_2O_3 product from Vanchem can be used to manufacture electrolyte for VRFBs at Bushveld's BELCO battery electrolyte plant which is expected to commence operations in H1 2023.

The broader range of products enables Bushveld to tailor its output across a broader range of end markets, optimising production to meet demand trends.

Ferrovanadium (FeV) production

The ferrovanadium (FeV) facilities are located at the Highveld site and are situated approximately 10 km from the Vanchem plant.

FeV is produced via reacting vanadium oxides in the presence of iron in two separate processes:

- V_2O_3 is converted to FeV in an electric smelting furnace
- V_2O_5 is converted to FeV in an alumina-thermic reaction process

Investments to date – initial plan to increase capacity to 4,200 mt V at a cost of ~US$45m

Management put together an initial three phase plan following the acquisition, to increase production at Vanchem to ~4,200 mtV pa by 2025 at a total cost of ~ZAR 760m (~US$45m at the time) with the bulk of this spend being Rand denominated. Estimated costs have, however, subsequently increased reflecting the outcome of more detailed studies, and the more general inflationary cost environment affecting companies across a number of industries.

The first phase of this plan was completed in 2020/21, with the expansion of the calcine dump and the waste disposal facility, upgrades to the electrical reticulation system and the construction of a storm water treatment facility for a total cost of ~ZAR55m in 2020 and ~ZAR130m in 2021.

Load shedding has disproportionately impacted Vanchem, but new power supply agreement should reduce the impact

Vanchem has been particularly badly affected by load shedding since it is connected via the municipal grid and, prior to 2023, suffered total power loss during load shedding periods. Vametco, on the other hand, has a direct connection to the grid and although it is required to reduce consumption during periods of load shedding, it does not lose all power.

This difference is important since activities at Vametco can be planned around anticipated power availability to minimise the overall operational impact. At Vanchem auxiliary generators needed be used during periods of power loss to ensure kiln temperatures could be maintained, thus minimising the potential for premature failure of the refractory linings owing to temperature cycling.

At the end of January 2023 Bushveld announced an agreement had been reached with the local municipality responsible for power supply to Vanchem. The agreement on load shedding should prevent total power loss during scheduled periods of load shedding across the grid. Instead power should be curtailed enabling key processing units to remain at operating temperature, or potentially in operation. During unscheduled load shedding it is anticipated Vanchem will continue to suffer complete power loss.

The impact of this arrangement will therefore be partly dependent upon the extent to which Eskom (the South African state-owned power utility which has been under financial and operational stress for years) can avoid unscheduled load shedding.

Although some impact from grid instability is still likely, it is anticipated this new agreement should reduce the impact of load shedding on operations at Vanchem. Management noted that during 1Q 2023 the agreement has provided more reliable feed of electricity, contributing to improved operational stability in the months of March and April.

Load shedding expected to be an ongoing problem in South Africa

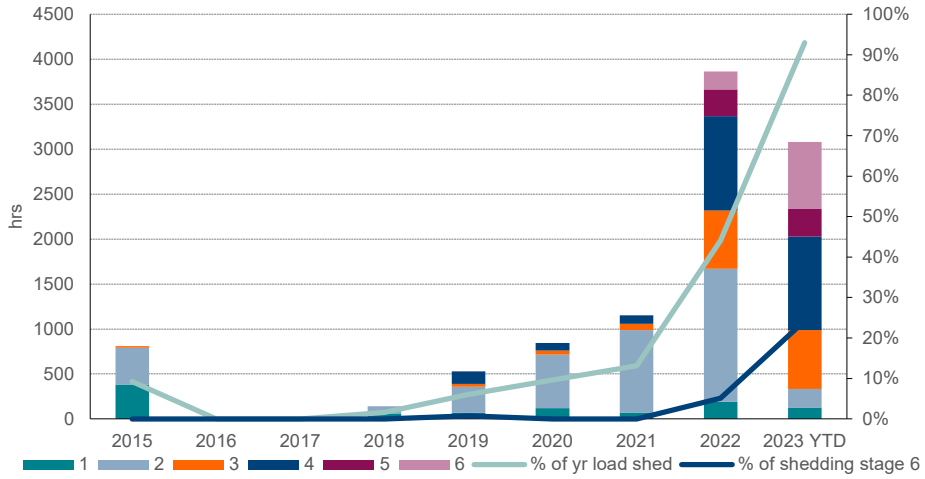
Eskom's CEO stated in October 2022 the country should be prepared for another 18 months of regular load shedding, until sufficient generating capacity has been added to the grid to meet demand. He went on to say "we're going to go through a tough time over the next year and a half".

Subsequent to this the CEO of Eskom has resigned, suffered an attempted cyanide poisoning, and conducted an interview highlighting corruption and the activities of organised crime gangs in extracting money from the utility.

In May 2023 Eskom warned load shedding may need to increase beyond the maximum level enacted to date of Stage 6, in which 6GW is shed from the grid, to stage 8, which would require 8GW of load shedding. This equates to 16hr outages over a 32hr cycle.

Figure 36: Load shedding continuing to get worse

Load shedding by year and stage, with stage 6 being the worst



Source: EskomSEPush, BNP Paribas Exane estimates

Generation capacity remains below requirements

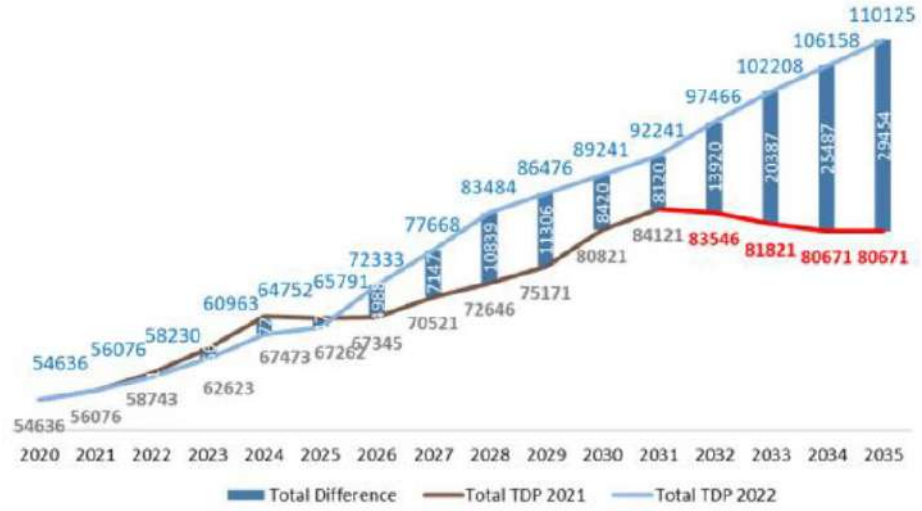
Current South African power generation capacity is estimated to be 4-6GW below that required to ensure stable supplies. In addition to this the continued operation of South Africa's ageing coal fired power plants is not compatible with the nation's climate goals. Power generation has historically accounted for ~42% of South Africa's national greenhouse gas emissions, and under the Paris Agreement South Africa has pledged that greenhouse gas emissions will plateau from 2025 before declining from 2036. Meeting these targets will require changes to the power generation mix, however, progress to date has been slow with suggestions vested interests are against the transition to renewable energy

Considerable investments required in both generation and the grid

The existing coal fired plant could be retrofitted with abatement equipment to reduce emissions, but with an estimated cost of ZAR300bn for the first six plants, this would be too costly. Eskom instead intends to retire polluting coal fired stations when they reach the end of their lives and replace them with lower emission, or zero-emission, technologies. In total 5.4GW of coal generation capacity is planned to be retired by 2022, increasing to 10.5GW by 2030.

Eskom's 2022 Transmission Development Plan (TDP) update calls for an additional 53GW of generation capacity, particularly renewable (wind, solar) to be added to the grid by 2032 to ensure energy security. This figure is significantly higher than the 2021 estimate of 30GW of capacity additions by 2030 (itself based upon the 2019 Integrated Resource Plan policy document which is being updated).

Figure 37: Total generation capacity forecast increased substantially



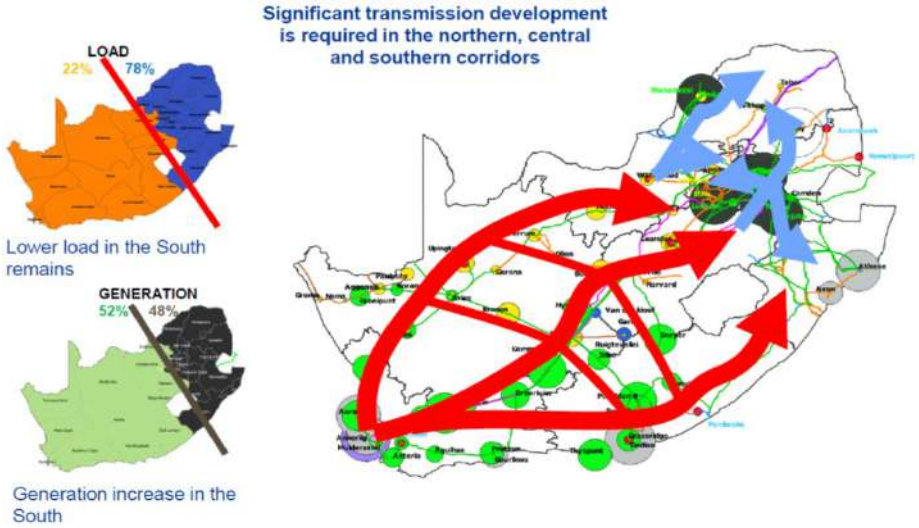
Source: Eskom 2022 Transmission Development Plan

In addition 14,200km of extra-high voltage power lines and 170 transformers would also need to be installed to accommodate the increased generation capacity, including the integration of the aggressive renewables expansion program.

Historically the grid was built to transmit significant amounts of power from coal-fired generation located near coal mines in the north-east of the country, to load centres in the south and southwest. The solar resource is, however, highest in the Northern Cape (NW of the country) with significant wind resource in the Eastern Cape (towards the middle of the southern coast). This will require investment in the grid to supply increasing proportions of renewable power to demand centres in the NE of the country.

Figure 38: Investment in transmission network required to balance demand centres in NE with generation capacity expansion in the SW

Northern Cape (in west of country) has most efficient solar resource



Source: Eskom 2022 Transmission Development Plan

Expansion of storage likely required if renewable energy displaces coal

Current storage capacity is predominantly pumped storage (~2.7GW) with ~300MW of solar thermal (CSP), which was designed to meet the evening peak demand period.

The plans call for increased reliance upon battery storage to time shift power generation, particularly from renewable generation capacity, to match demand patterns. Eskom's battery procurement approach is technology agnostic, however, it is not clear to what extent VRFBs will be adopted.

Eskom has a battery test facility at its Research & Innovation Centre to test the effectiveness of different technologies. The facility has the ability to test five 200kW/1.2MWh units under identical discharge profiles at real operating conditions. The facility was created to identify the best technology for different applications, to establish the operating life of each technology under real conditions, and the charge/discharge efficiencies of different technologies.

Bushveld Energy and IDC (Industrial Development Corporation, a South African national development financing institution) ordered a VRFB from UniEnergy Technologies, which was delivered towards the end of 2Q 2018. The electrolyte was unfortunately contaminated whilst filling the VRFB which made the system inoperable. With no ability to filter the electrolyte in country this needed to be replaced, along with certain contaminated system components. The VRFB subsequently passed acceptance tests in Jan/Feb 2019 after which a number of upgrades were recommended (and paid for) by the manufacturer. Unfortunately the test program was not completed owing to a change in technology focus at the battery supplier.

Eskom embarked on a battery storage systems project targeting 200MW/800MWh of storage capacity in phase 1 and 160MW/640MWh in phase 2. The original plan was to have phase one in place by December 2019, and phase two in December 2021, however, implementation has taken longer than initially planned.

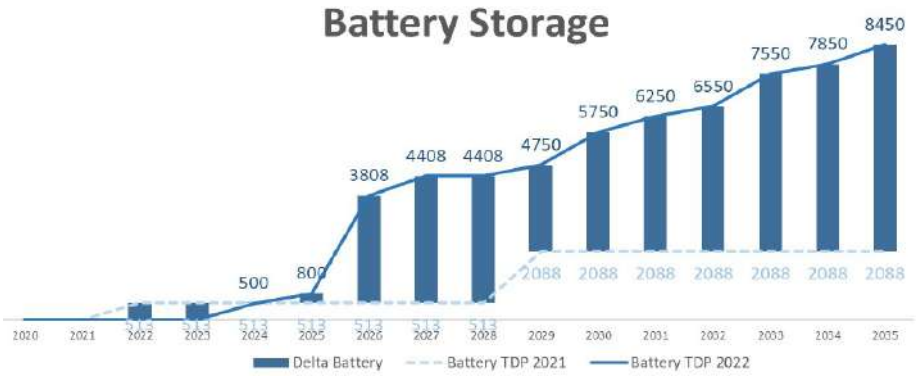
In summer 2022 Eskom confirmed the award of two contracts to South Korea's Hyosung Heavy Industries and Chinese company Pinggao Grp for 343MW of BESS with four-hour duration, i.e. total capacity of 1,440MWh. The systems will be built in two phases, with phase 1 comprising 199MW/833MWh across eight sites. These systems will range in capacity from 1.54MW/6.16MWh to 80MW/320MWh, and are expected to be commissioned by the end of June 2023.

Phase 2 comprises installations at four sites, ranging from 17MW/68MWh to 70MW/280MWh, for completion by December 2024.

In April 2022 Hyosung revealed that it had also received a letter of acceptance from Eskom for a separate 48MW/192MWh project near the city of Durban.

The updated 2022 TDP envisages a significantly larger build-out of renewable power generation, and incorporates substantially higher battery storage requirements post 2026, rising to 8.45GW by 2035.

Figure 39: Significant increase in forecast battery storage requirements (MW)



Source: Eskom 2022 Transmission Development Plan

Over the first five years of this program investments of ~ZAR72bn (~US$4bn) are estimated to be required to expand and strengthen the grid alone (for the addition of 2,890km extra high voltage lines and the installation of 60 transformers).

Climate grants and loans for US$8.5bn, from the US and European nations including the UK, were agreed at the COP26 climate summit in 2021 to help fund the transition. Significant additional financing will, however, be required to implement the changes.

It remains to be seen if Eskom will be able to enact these plans, with the former CEO alleging criminal gangs are against any move to renewables.

On the generation side Eskom is leasing land to independent power producers for the development of renewable energy projects located adjacent to existing power plants, with additional projects to follow.

In the face of the ongoing power supply problems it seems likely consumers will be receptive to additional sources of power supply, including renewable energy, potentially with battery storage.

Self-generation and storage options being explored at Vanchem

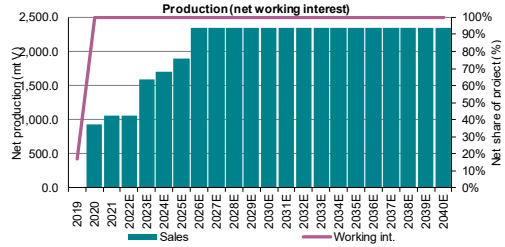
Work is also underway to explore self-generation options, potentially with energy storage, to supplement power requirements. This could potentially take a similar form to the mini-grid project at Vametco.

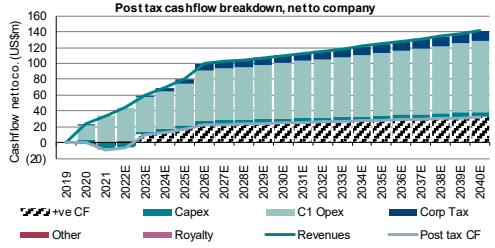
Figure 40: Vanchem cash-flow analysis in US$

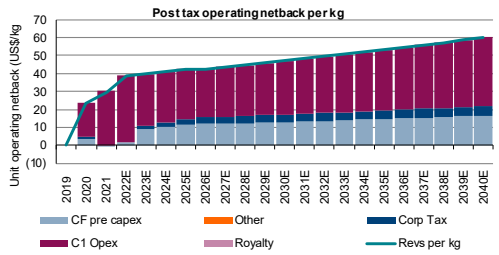
	Gross processing facility											Country: South Africa		Vanchem Base - net to company												Discount rate: 16.0%	
												Working interest basis															
Year	LMB V price	Price as % of LMB	Realised V price		Production	Sales as % of prod	Sales	Revenues	Royalty	Capex	C1 Opex	Working int.	Production	Sales	Revenues	Revs per kg	Royalty	Royalty	C1 Opex	C1 Opex	Capex	Corp Tax	Corp Tax	Other	Other	Post tax CF	Post tax CF	CF pre capex	Rem. NPV (1st Jan)	Rem. NPV (1st Jan)
	US$/kg	%	US$/kg		mt V	%	mt V	US$m	US$m	US$m	US$m	%	mt V	mt V	US$m	US$/kg	US$m	US$/kg	US$m	US$/kg	US$m	US$m	US$/kg	US$m	US$/kg	US$m	US$/kg	US$/kg	US$m	US$/kg
2019	42.3	116%	49.0		0	#DIV/0!	0	0	0	0	0	16.7%	0	0	0	0.0	0	0	0	0.0	0	0	0.0	0	0.0	0	0.0	0.0	70	1.3
2020	25.0	95%	23.7		986	94%	930	23	0	-4	-19	100.0%	986	930	23	23.6	0	0	-19	-19.1	-4	-1	-1.2	0	0.0	0	-0.4	3.3	81	1.5
2021	34.5	93%	32.2		1,139	94%	1,066	34	0	-8	-35	100.0%	1,139	1,066	34	29.8	0	0	-35	-30.6	-8	0	0.0	0	0.0	-9	-7.6	-0.9	95	1.8
2022E	39.2	109%	42.8		1,137	93%	1,052	44	0	-8	-42	100.0%	1,137	1,052	44	38.9	0	0	-42	-37.2	-8	0	0.0	0	0.0	-6	-5.3	1.7	121	2.3
2023E	35.0	108%	37.8		1,500	106%	1,586	60	0	-3	-43	100.0%	1,500	1,586	60	39.9	0	0	-43	-28.8	-3	-3	-1.8	0	0.0	10	7.0	9.3	147	2.8
2024E	38.5	106%	40.8		1,700	100%	1,700	69	0	-4	-48	100.0%	1,700	1,700	69	40.8	0	0	-48	-28.0	-4	-5	-2.8	0	0.0	13	7.9	10.0	159	3.2
2025E	40.7	104%	42.4		1,900	100%	1,900	81	0	-4	-53	100.0%	1,900	1,900	81	42.4	0	0	-53	-27.8	-4	-6	-3.3	0	0.0	17	9.2	11.3	169	3.5
2026E	41.8	102%	42.6		2,340	100%	2,340	100	0	-5	-63	100.0%	2,340	2,340	100	42.6	0	0	-63	-27.1	-5	-9	-3.7	0	0.0	23	9.7	11.8	176	3.8
2027E	42.8	102%	43.7		2,340	100%	2,340	102	0	-5	-65	100.0%	2,340	2,340	102	43.7	0	0	-65	-27.7	-5	-9	-3.9	0	0.0	23	9.8	12.0	178	4.0
2028E	43.9	102%	44.8		2,340	100%	2,340	105	0	-5	-67	100.0%	2,340	2,340	105	44.8	0	0	-67	-28.4	-5	-9	-4.1	0	0.0	23	10.0	12.3	180	4.3
2029E	45.0	102%	45.9		2,340	100%	2,340	107	0	-5	-68	100.0%	2,340	2,340	107	45.9	0	0	-68	-29.1	-5	-10	-4.1	0	0.0	24	10.3	12.6	182	4.6
2030E	46.1	102%	47.0		2,340	100%	2,340	110	0	-5	-70	100.0%	2,340	2,340	110	47.0	0	0	-70	-29.9	-5	-10	-4.2	0	0.0	25	10.6	13.0	184	4.9
2031E	47.3	102%	48.2		2,340	100%	2,340	113	0	-6	-72	100.0%	2,340	2,340	113	48.2	0	0	-72	-30.6	-6	-10	-4.3	0	0.0	26	10.9	13.3	185	5.3
2032E	48.4	102%	49.4		2,340	100%	2,340	116	0	-6	-73	100.0%	2,340	2,340	116	49.4	0	0	-73	-31.4	-6	-10	-4.4	0	0.0	26	11.2	13.6	185	5.6
2033E	49.6	102%	50.6		2,340	100%	2,340	118	0	-6	-75	100.0%	2,340	2,340	118	50.6	0	0	-75	-32.2	-6	-11	-4.5	0	0.0	27	11.5	14.0	184	6.1
2034E	50.9	102%	51.9		2,340	100%	2,340	121	0	-6	-77	100.0%	2,340	2,340	121	51.9	0	0	-77	-33.0	-6	-11	-4.6	0	0.0	28	11.8	14.3	183	6.5
Totals					thou t		thou t	US$m	US$m	US$m	US$m		tonnes	tonnes	US$m	US$/kg	US$m	US$/kg	US$m	US$/kg	US$m	US$m	US$/kg	US$m	US$/kg	US$m	US$/kg	US$/kg	US$m	US$/kg
2022E+					19,359		19,359	2,800	0	-140	-1,804		53,037	53,038	2,800	52.8	0	0.0	-1,804	-34.0	-140	-242	-4.6	0	0.0	615	11.6	14.2	121	2.3
2035+					9,395		9,395	1,554	0	-72	-987		25,740	25,740	1,554	60.4	0	0.0	-987	-38.4	-72	-140	-5.4	0	0.0	355	13.8	16.6		

Notes:

	Gross	Opex	Capex
	US$/kg	-92.2	-7.5







1st Jan NAV sensitivity to discount rate

	US$m	ked p/sh	US$/kg
12.0%	189	11.3	3.56
14.0%	164	9.8	3.08
16.0%	144	8.6	2.71
18.0%	128	7.7	2.40
20.0%	114	6.9	2.16

NAV sensitivity to 2023+ V price				IRR sensy
US$/kg	US$m	p/sh	US$/kg	(%)
25	-32	-1.9	-0.61	
30	40	2.4	0.76	
35	101	6.1	1.91	
40	163	9.8	3.06	
45	224	13.4	4.22	

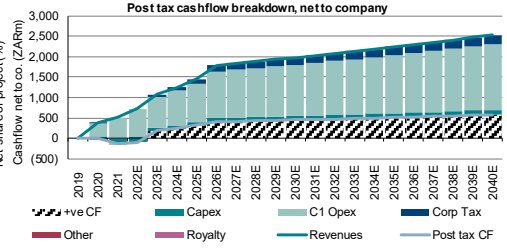
Source: BNP Paribas Exane estimates

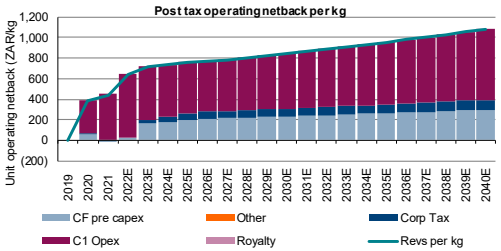
Figure 41: Vanchem cash-flow analysis in ZAR

	Gross processing facility											Country: South Africa		Vanchem Base - net to company											Discount rate: 16.0%	
												Working interest basis														
Year	LMB V price	Price as % of LMB	Realised V price		Production	Sales as % of prod	Sales	Revenues	Royalty	Capex	C1 Opex	Working int.	Production	Sales	Revenues	Revs per kg	Royalty	Royalty	C1 Opex	C1 Opex	Capex	Corp Tax	Corp Tax	Other	Other	Post tax CF	Post tax CF	CF pre capex	Rem. NPV (1st Jan)	Rem. NPV (1st Jan)
	US$/kg	%	US$/kg		mt V	%	mt V	ZARm	ZARm	ZARm	ZARm	%	mt V	mt V	ZARm	ZAR/kg	ZARm	ZAR/kg	ZARm	ZAR/kg	ZARm	ZARm	ZAR/kg	ZARm	ZAR/kg	ZARm	ZAR/kg	ZAR/kg	ZARm	ZAR/kg
2019	42.3	116%	49.0		0	#DIV/0!	0	0	0	0	0	16.7%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,285	23
2020	25.0	95%	23.7		986	94%	930	381	0	-59	-309	100.0%	986	930	381	386	0	0	-309	-314	-59	-19	-20	0	0	-7	-7	53	1,493	27
2021	34.5	93%	32.2		1,139	94%	1,066	501	0	-114	-516	100.0%	1,139	1,066	501	440	0	0	-516	-453	-114	0	0	0	0	-129	-113	-13	1,743	32
2022E	39.2	109%	42.8		1,137	93%	1,052	729	0	-130	-699	100.0%	1,137	1,052	729	641	0	0	-699	-615	-130	0	0	0	0	-100	-88	27	2,175	41
2023E	35.0	108%	37.8		1,500	106%	1,586	1,075	0	-61	-776	100.0%	1,500	1,586	1,075	717	0	0	-776	-517	-61	-49	-33	0	0	189	126	166	2,643	51
2024E	38.5	106%	40.8		1,700	100%	1,700	1,246	0	-64	-855	100.0%	1,700	1,700	1,246	733	0	0	-855	-503	-64	-86	-51	0	0	242	142	180	2,852	57
2025E	40.7	104%	42.4		1,900	100%	1,900	1,447	0	-72	-949	100.0%	1,900	1,900	1,447	761	0	0	-949	-500	-72	-113	-59	0	0	312	164	202	3,033	62
2026E	41.8	102%	42.6		2,340	100%	2,340	1,791	0	-91	-1,138	100.0%	2,340	2,340	1,791	765	0	0	-1,138	-486	-91	-157	-67	0	0	406	173	212	3,162	68
2027E	42.8	102%	43.7		2,340	100%	2,340	1,836	0	-92	-1,166	100.0%	2,340	2,340	1,836	785	0	0	-1,166	-498	-92	-164	-70	0	0	413	177	216	3,202	72
2028E	43.9	102%	44.8		2,340	100%	2,340	1,882	0	-94	-1,195	100.0%	2,340	2,340	1,882	804	0	0	-1,195	-511	-94	-170	-73	0	0	422	180	220	3,241	77
2029E	45.0	102%	45.9		2,340	100%	2,340	1,929	0	-96	-1,225	100.0%	2,340	2,340	1,929	824	0	0	-1,225	-524	-96	-173	-74	0	0	434	186	227	3,275	82
2030E	46.1	102%	47.0		2,340	100%	2,340	1,977	0	-98	-1,256	100.0%	2,340	2,340	1,977	845	0	0	-1,256	-537	-98	-177	-75	0	0	447	191	233	3,301	88
2031E	47.3	102%	48.2		2,340	100%	2,340	2,026	0	-99	-1,287	100.0%	2,340	2,340	2,026	866	0	0	-1,287	-550	-99	-181	-77	0	0	459	196	239	3,317	94
2032E	48.4	102%	49.4		2,340	100%	2,340	2,077	0	-101	-1,319	100.0%	2,340	2,340	2,077	888	0	0	-1,319	-564	-101	-185	-79	0	0	471	201	245	3,321	101
2033E	49.6	102%	50.6		2,340	100%	2,340	2,129	0	-103	-1,352	100.0%	2,340	2,340	2,129	910	0	0	-1,352	-578	-103	-190	-81	0	0	483	207	251	3,311	109
2034E	50.9	102%	51.9		2,340	100%	2,340	2,182	0	-105	-1,386	100.0%	2,340	2,340	2,182	933	0	0	-1,386	-592	-105	-195	-83	0	0	496	212	257	3,286	117
Totals					thou t		thou t	ZARm	ZARm	ZARm	ZARm		tonnes	tonnes	ZARm	ZAR/kg	ZARm	ZAR/kg	ZARm	ZAR/kg	ZARm	ZARm	ZAR/kg	ZARm	ZAR/kg	ZARm	ZAR/kg	ZAR/kg	ZARm	ZAR/kg
2022E+					**19,359**		**19,359**	**50,246**	**0**	**-2,499**	**-32,341**		**53,037**	**53,038**	**50,246**	**947**	**0**	**0**	**-32,341**	**-609.8**	**-2,499**	**-4,348**	**-82**	**0**	**0**	**11,059**	**209**	**256**	**2,175**	**41**
2035+					9,395		9,395	27,921	0	-1,294	-17,737		25,740	25,740	27,921	1,085	0	0	-17,737	-689.1	-1,294	-2,507	-97	0	0	6,384	248	298		

Notes:

	Gross	Opex	Capex
	ZAR/kg	-1,647	-133





1st Jan NAV sensitivity to discount rate

	ZARm	p/sh	ZAR/kg
12.0%	3,387	11.4	63.87
14.0%	2,938	9.9	55.39
16.0%	2,580	8.7	48.64
18.0%	2,291	7.7	43.20
20.0%	2,055	6.9	38.74

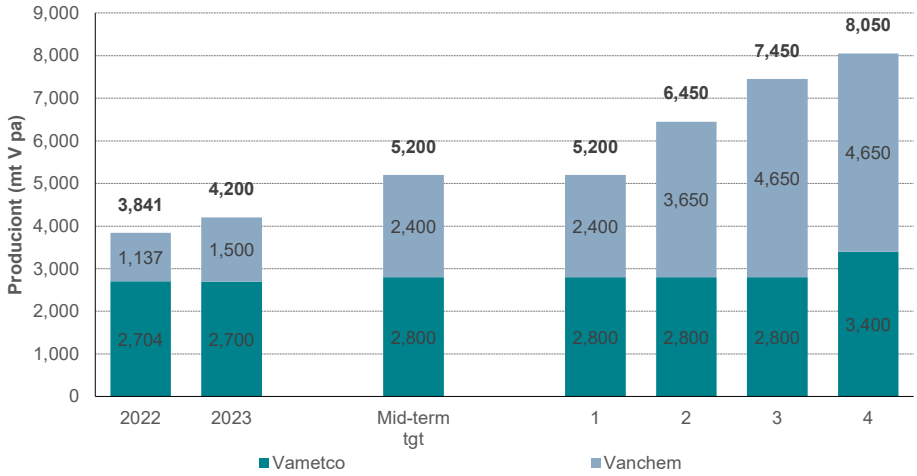
NAV sensitivity to 2023+ V price				IRR sensy
US$/kg	ZARm	p/sh	ZAR/kg	(%)
25	-582	-2.0	-0.01	
30	726	2.4	0.01	
35	1,823	6.1	0.03	
40	2,920	9.8	0.06	
45	4,017	13.5	0.08	

Source: BNP Paribas Exane estimates

Expansion options at Vametco and Vanchem

Four phases of expansion have been identified at Vametco and Vanchem which could more than double production from 2022 levels to ~8,000 mtV pa.

Figure 42: 2022/23 production estimates, mid-term targets and the four-phase expansion programs for Vameto and Vanchem



Source: BNP Paribas Exane estimates

Feasibility and pre-feasibility studies have been undertaken for these projects, however, there is no firm timeline for implementation. A precursor for any additional expansion stages is the attainment of steady-state operations and funding. Management also intends to obtain third party validation of project economics ahead of sanction.

The first expansion phase at Vametco will not result in any increase in overall throughput, but is required to ensure Vametco can reliably supply concentrate feedstock to both the Vanchem and Vametco operations. The first two phases are, therefore, expected to be executed back-to-back.

The phases are summarised below, including estimated capex and details of the proposed program. We have modelled these cases and show overleaf cash-flow summaries for each, however, we expect the market to be focused on the core producing assets in the near-term.

Figure 43: Details of the proposed expansion phases at Vametco and Vanchem, including estimated costs

Phase	Gross finished prod (mtV pa)	Gross capex (ZARm)	(ZAR/kg incr V prod)	Capex (US$m)	(US$m/kg incr V prod)	Timeframe (months)	Notes
1	2800	503	n/a	32.9	n/a	24	Establish permanent/reliable supply of feedstock sufficient to deliver up to 6,800mt V pa from both plants through installation of SAG mill and upgrades to balance of plant at concentrate section. Eskom upgrades on critical path. No direct increase in production.
2	3600-3700	810	648	53	69	18-24	Refurb of kiln 2. Capex/kg includes both Vametco ph1 + Vanchem ph2 capex on Vanchem ph prod inc
3	4600-4700	566	566	37	37	18-24	Refurb of kiln 1
4	3400	431	719	28.2	47	12-18	Increase single kiln capacity to 3,400 mtV pa

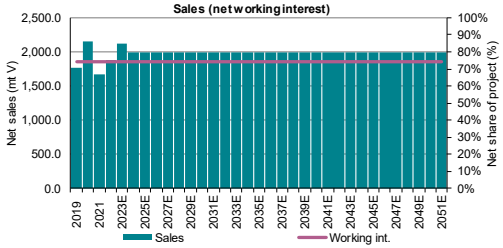
Source: Company, BNP Paribas Exane estimates

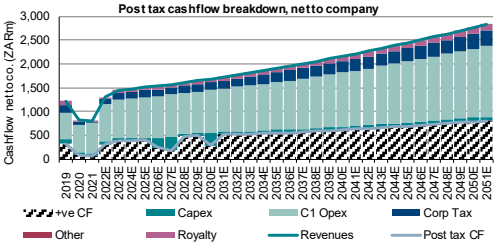
Figure 44: Vametco SAG mill expansion case cash-flow analysis in ZAR

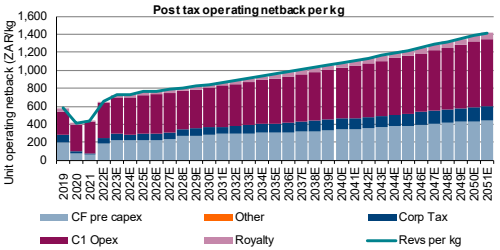
	Gross mine/processing facility												Country: South Africa				Vametco SAG mill - net to company											Discount rate: 16.0%	
						Sales as						Working	Working interest basis														Post	Post tax	CF pre	Rem. NPV	Rem. NPV
Year	LMB V price	Price as % of LMB	Realised V price	Prod pre losses mtV	Production mt V	% of prod %	Sales mt V	Revenues ZARm	Royalty ZARm	Capex ZARm	C1 Opex ZARm	int. %	Production mt V	Sales mt V	Revenues ZARm	Revs per kg ZAR/kg	Royalty ZARm	Royalty ZAR/kg	C1 Opex ZARm	C1 Opex ZAR/kg	Capex ZARm	Corp Tax ZARm	Corp Tax ZAR/kg	Other ZARm	Other ZAR/kg	tax CF ZARm	CF ZAR/kg	capex ZAR/kg	(1st Jan) ZARm	(1st Jan) ZAR/kg
	US$/kg	%	US$/kg	thou t	mt V	%	mt V	ZARm	ZARm	ZARm	ZARm	%	mt V	mt V	ZARm	ZAR/kg	ZARm	ZAR/kg	ZARm	ZAR/kg	ZARm	ZARm	ZAR/kg	ZARm	ZAR/kg	ZARm	ZAR/kg	ZAR/kg	ZARm	ZAR/kg
2019	42.3	116%	49.0	3,984	2,833	84%	2,392	1,643	-115	-140	-739	74.0%	2,096	1,770	1,216	580	-85	-41	-547	-261	-104	-162	-77	0	0	318	152	201	2,278	35
2020	25.0	95%	23.7	3,721	2,646	110%	2,901	1,098	-47	-72	-793	74.0%	1,958	2,147	812	415	-35	-18	-587	-300	-54	-51	-26	0	0	85	44	71	2,277	36
2021	34.5	93%	32.2	3,450	2,453	92%	2,248	1,082	-18	-67	-870	74.0%	1,815	1,663	801	441	-13	-7	-644	-355	-49	-26	-14	0	0	69	38	65	2,547	41
2022E	39.2	109%	42.8	3,803	2,704	94%	2,532	1,762	-39	-85	-1,040	74.0%	2,001	1,873	1,304	652	-29	-15	-770	-385	-63	-128	-64	0	0	314	157	188	2,880	48
2023E	35.0	108%	37.8	3,797	2,700	106%	2,875	1,960	-75	-68	-1,095	74.0%	1,998	2,128	1,450	726	-55	-28	-810	-406	-51	-145	-73	0	0	389	195	220	2,981	51
2024E	38.5	106%	40.8	3,797	2,700	100%	2,700	1,979	-79	-71	-1,123	74.0%	1,998	1,998	1,465	733	-58	-29	-831	-416	-52	-142	-71	0	0	382	191	217	3,013	54
2025E	40.7	104%	42.4	3,797	2,700	100%	2,700	2,056	-91	-71	-1,151	74.0%	1,998	1,998	1,521	761	-67	-34	-851	-426	-53	-153	-76	0	0	397	199	225	3,057	57
2026E	41.8	102%	42.6	3,797	2,700	100%	2,700	2,066	-93	-274	-1,179	74.0%	1,998	1,998	1,529	765	-69	-34	-873	-437	-202	-147	-73	0	0	239	119	221	3,091	60
2027E	42.8	102%	43.7	3,797	2,700	100%	2,700	2,118	-91	-376	-1,209	74.0%	1,998	1,998	1,567	784	-67	-34	-895	-448	-278	-143	-71	0	0	185	93	232	3,315	66
2028E	43.9	102%	44.8	3,797	2,700	100%	2,700	2,171	-88	-75	-1,140	74.0%	1,998	1,998	1,607	804	-65	-33	-843	-422	-56	-160	-80	0	0	483	242	269	3,636	76
2029E	45.0	102%	45.9	3,797	2,700	100%	2,700	2,225	-99	-76	-1,168	74.0%	1,998	1,998	1,647	824	-73	-37	-865	-433	-57	-163	-81	0	0	490	245	274	3,664	80
2030E	46.1	102%	47.0	3,797	2,700	100%	2,700	2,281	-101	-372	-1,198	74.0%	1,998	1,998	1,688	845	-75	-37	-886	-444	-275	-167	-84	0	0	285	142	280	3,689	84
2031E	47.3	102%	48.2	3,797	2,700	100%	2,700	2,338	-104	-77	-1,227	74.0%	1,998	1,998	1,730	866	-77	-38	-908	-455	-57	-162	-81	0	0	526	263	292	3,956	94
2032E	48.4	102%	49.4	3,797	2,700	100%	2,700	2,396	-102	-79	-1,258	74.0%	1,998	1,998	1,773	888	-75	-38	-931	-466	-58	-177	-89	0	0	532	266	295	3,985	100
2033E	49.6	102%	50.6	3,797	2,700	100%	2,700	2,456	-111	-80	-1,290	74.0%	1,998	1,998	1,818	910	-82	-41	-954	-478	-59	-191	-95	0	0	532	266	296	4,013	106
2034E	50.9	102%	51.9	3,797	2,700	100%	2,700	2,518	-117	-82	-1,322	74.0%	1,998	1,998	1,863	933	-87	-43	-978	-490	-60	-195	-98	0	0	543	272	302	4,046	112
Totals				thou t	thou t		thou t	ZARm	ZARm	ZARm	ZARm		tonnes	tonnes	ZARm	ZAR/kg	ZARm	ZAR/kg	ZARm	ZAR/kg	ZARm	ZARm	ZAR/kg	ZARm	ZAR/kg	ZARm	ZAR/kg	ZAR/kg	ZARm	ZAR/kg
2022E+				113,925	81,004		81,007	82,173	-3,817	-3,432	-43,668		59,943	59,945	60,808	1,014	-2,824	-47	-32,315	-539	-2,540	-6,490	-108	0	0	16,639	278	320	2,880	48
2035+				64,555	45,900		45,900	53,846	-2,629	-1,647	-28,269		33,966	33,966	39,846	1,173	-1,945	-57	-20,919	-616	-1,218	-4,418	-130	0	0	11,345	334	370		

Notes: Gross cashflows are for Vametco Holdings, which holds a 100% interest in the Vametco mine/processing facility and in which Bushveld Minerals holds a 74% stake.

	Gross	Opex	Capex
	ZAR/kg	-502	-39







1st Jan NAV sensitivity to discount rate

	ZARm	p/sh	ZAR/kg
12.0%	3,893	13.1	64.94
14.0%	3,340	11.2	55.72
16.0%	2,917	9.8	48.66
18.0%	2,586	8.7	43.14
20.0%	2,323	7.8	38.76

NAV sensitivity to 2023+ V price				IRR sensy
US$/kg	ZARm	p/sh	ZAR/kg	(%)
25	332	1.1	0.01	
30	1,302	4.4	0.02	
35	2,271	7.6	0.04	
40	3,241	10.9	0.05	
45	4,210	14.2	0.07	

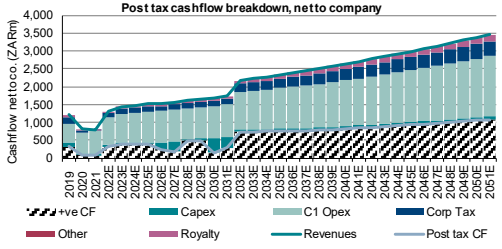
Source: BNP Paribas Exane estimates

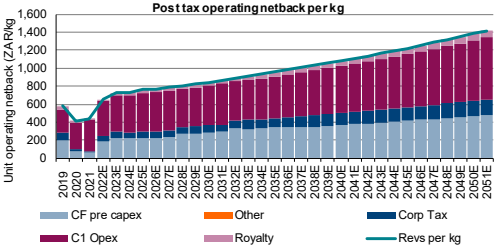
Figure 45: Vametco SAG mill + kiln expansion case cash-flow analysis in ZAR

	Gross mine/processing facility												Country: South Africa		Vametco SAG mill & kiln expansion - net to company												Discount rate: 16.0%	
													Working interest basis															
Year	LMB V price	Price as % of LMB	Realised V price	Prod pre losses mtV	Production	Sales as % of prod	Sales	Revenues	Royalty	Capex	C1 Opex	Working int.	Production	Sales	Revenues	Revs per kg	Royalty	Royalty	C1 Opex	C1 Opex	Capex	Corp Tax	Corp Tax	Other	Other	Post tax CF	Post tax CF	CF pre capex	Rem. NPV (1st Jan)	Rem. NPV (1st Jan)
	US$/kg	%	US$/kg	mtV	mt V	%	mt V	ZARm	ZARm	ZARm	ZARm	%	mt V	mt V	ZARm	ZAR/kg	ZARm	ZAR/kg	ZARm	ZAR/kg	ZARm	ZARm	ZAR/kg	ZARm	ZAR/kg	ZARm	ZAR/kg	ZAR/kg	ZARm	ZAR/kg
2019	42.3	116%	49.0	3,984	2,833	84%	2,392	1,643	-115	-140	-739	74.0%	2,096	1,770	1,216	580	-85	-41	-547	-261	-104	-162	-77	0	0	318	152	201	2,421	32
2020	25.0	95%	23.7	3,721	2,646	110%	2,901	1,098	-47	-72	-793	74.0%	1,958	2,147	812	415	-35	-18	-587	-300	-54	-51	-26	0	0	85	44	71	2,444	34
2021	34.5	93%	32.2	3,450	2,453	92%	2,248	1,082	-18	-67	-870	74.0%	1,815	1,663	801	441	-13	-7	-644	-355	-49	-26	-14	0	0	69	38	65	2,740	39
2022E	39.2	109%	42.8	3,803	2,704	94%	2,532	1,762	-39	-85	-1,040	74.0%	2,001	1,873	1,304	652	-29	-15	-770	-385	-63	-128	-64	0	0	314	157	188	3,104	45
2023E	35.0	108%	37.8	3,797	2,700	106%	2,875	1,960	-75	-68	-1,095	74.0%	1,998	2,128	1,450	726	-55	-28	-810	-406	-51	-145	-73	0	0	389	195	220	3,242	49
2024E	38.5	106%	40.8	3,797	2,700	100%	2,700	1,979	-79	-71	-1,123	74.0%	1,998	1,998	1,465	733	-58	-29	-831	-416	-52	-142	-71	0	0	382	191	217	3,316	51
2025E	40.7	104%	42.4	3,797	2,700	100%	2,700	2,056	-91	-71	-1,151	74.0%	1,998	1,998	1,521	761	-67	-34	-851	-426	-53	-153	-76	0	0	397	199	225	3,410	54
2026E	41.8	102%	42.6	3,797	2,700	100%	2,700	2,066	-93	-274	-1,179	74.0%	1,998	1,998	1,529	765	-69	-34	-873	-437	-202	-147	-73	0	0	239	119	221	3,501	58
2027E	42.8	102%	43.7	3,797	2,700	100%	2,700	2,118	-91	-376	-1,209	74.0%	1,998	1,998	1,567	784	-67	-34	-895	-448	-278	-143	-71	0	0	185	93	232	3,790	64
2028E	43.9	102%	44.8	3,797	2,700	100%	2,700	2,171	-88	-75	-1,140	74.0%	1,998	1,998	1,607	804	-65	-33	-843	-422	-56	-160	-80	0	0	483	242	269	4,189	74
2029E	45.0	102%	45.9	3,797	2,700	100%	2,700	2,225	-99	-76	-1,168	74.0%	1,998	1,998	1,647	824	-73	-37	-865	-433	-57	-163	-81	0	0	490	245	274	4,307	79
2030E	46.1	102%	47.0	3,797	2,700	100%	2,700	2,281	-101	-547	-1,198	74.0%	1,998	1,998	1,688	845	-75	-37	-886	-444	-405	-166	-83	0	0	156	78	281	4,435	84
2031E	47.3	102%	48.2	3,797	2,700	100%	2,700	2,338	-103	-407	-1,227	74.0%	1,998	1,998	1,730	866	-76	-38	-908	-455	-301	-152	-76	0	0	293	147	297	4,972	98
2032E	48.4	102%	49.4	4,641	3,300	100%	3,300	2,929	-116	-79	-1,423	74.0%	2,442	2,442	2,167	888	-86	-35	-1,053	-431	-58	-230	-94	0	0	741	303	327	5,437	111
2033E	49.6	102%	50.6	4,641	3,300	100%	3,300	3,002	-142	-81	-1,458	74.0%	2,442	2,442	2,222	910	-105	-43	-1,079	-442	-60	-241	-99	0	0	736	301	326	5,458	118
2034E	50.9	102%	51.9	4,641	3,300	100%	3,300	3,077	-148	-83	-1,495	74.0%	2,442	2,442	2,277	933	-110	-45	-1,106	-453	-61	-248	-101	0	0	752	308	333	5,486	125
Totals				**thou t**	**thou t**		**thou t**	**ZARm**	**ZARm**	**ZARm**	**ZARm**		**tonnes**	**tonnes**	**ZARm**	**ZAR/kg**	**ZARm**	**ZAR/kg**	**ZARm**	**ZAR/kg**	**ZARm**	**ZARm**	**ZAR/kg**	**ZARm**	**ZAR/kg**	**ZARm**	**ZAR/kg**	**ZAR/kg**	**ZARm**	**ZAR/kg**
2022E+				**130,802**	**93,004**		**93,007**	**95,777**	**-4,742**	**-4,065**	**-47,877**		**68,823**	**68,825**	**70,875**	**1,030**	**-3,509**	**-51**	**-35,429**	**-515**	**-3,008**	**-8,122**	**-118**	**0**	**0**	**20,807**	**302**	**346**	**3,104**	**45**
2035+				78,900	56,100		56,100	65,812	-3,478	-1,773	-31,971		41,514	41,514	48,701	1,173	-2,574	-62	-23,659	-570	-1,312	-5,905	-142	0	0	15,251	367	399		

Notes: Gross cashflow s are for Vametco Holdings, w hich holds a 100% interest in the Vametco mine/processing facility and in w hich Bushveld Minerals holds a 74% stake.

	Gross	Opex	Capex
	ZAR/kg	-485	-41





1st Jan NAV sensitivity to discount rate

	ZARm	p/sh	ZAR/kg
12.0%	4,377	14.7	63.60
14.0%	3,693	12.4	53.66
16.0%	3,177	10.7	46.16
18.0%	2,779	9.4	40.38
20.0%	2,467	8.3	35.85

NAV sensitivity to 2023+ V price				IRR sensy
US$/kg	ZARm	p/sh	ZAR/kg	(%)
25	409	1.4	0.01	
30	1,442	4.9	0.02	
35	2,475	8.3	0.04	
40	3,508	11.8	0.05	
45	4,541	15.3	0.07	

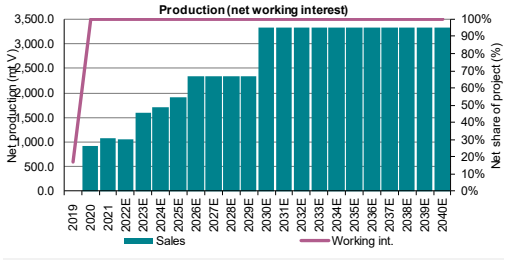
Source: BNP Paribas Exane estimates

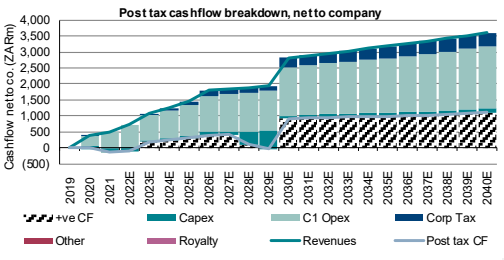
Figure 46: Vanchem kiln 2 refurb case cash-flow analysis in ZAR

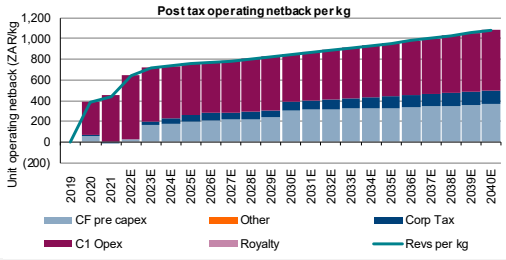
	Gross processing facility											Country: South Africa		Vanchem Refurb kiln 2 - net to company												Discount rate: 16.0%	
												Working interest basis															
Year	LMB V price	Price as % of LMB	Realised V price		Production	Sales as % of prod	Sales	Revenues	Royalty	Capex	C1 Opex	Working int.	Production	Sales	Revenues	Revs per kg	Royalty	Royalty	C1 Opex	C1 Opex	Capex	Corp Tax	Corp Tax	Other	Other	Post tax CF	Post tax CF	CF pre capex	Rem. NPV (1st Jan)	Rem. NPV (1st Jan)
	US$/kg	%	US$/kg		mt V	%	mt V	ZARm	ZARm	ZARm	ZARm	%	mt V	mt V	ZARm	ZAR/kg	ZARm	ZAR/kg	ZARm	ZAR/kg	ZARm	ZARm	ZAR/kg	ZARm	ZAR/kg	ZARm	ZAR/kg	ZAR/kg	ZARm	ZAR/kg
2019	42.3	116%	49.0		0	#DIV/0!	0	0	0	0	0	16.7%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,712	24
2020	25.0	95%	23.7		986	94%	930	381	0	-59	-309	100.0%	986	930	381	386	0	0	-309	-314	-59	-19	-20	0	0	-7	-7	53	1,990	28
2021	34.5	93%	32.2		1,139	94%	1,066	501	0	-114	-516	100.0%	1,139	1,066	501	440	0	0	-516	-453	-114	0	0	0	0	-129	-113	-13	2,320	33
2022E	39.2	109%	42.8		1,137	93%	1,052	729	0	-130	-699	100.0%	1,137	1,052	729	641	0	0	-699	-615	-130	0	0	0	0	-100	-88	27	2,845	41
2023E	35.0	108%	37.8		1,500	106%	1,586	1,075	0	-61	-776	100.0%	1,500	1,586	1,075	717	0	0	-776	-517	-61	-49	-33	0	0	189	126	166	3,422	51
2024E	38.5	106%	40.8		1,700	100%	1,700	1,246	0	-64	-855	100.0%	1,700	1,700	1,246	733	0	0	-855	-503	-64	-86	-51	0	0	242	142	180	3,757	57
2025E	40.7	104%	42.4		1,900	100%	1,900	1,447	0	-72	-949	100.0%	1,900	1,900	1,447	761	0	0	-949	-500	-72	-113	-59	0	0	312	164	202	4,085	63
2026E	41.8	102%	42.6		2,340	100%	2,340	1,791	0	-91	-1,138	100.0%	2,340	2,340	1,791	765	0	0	-1,138	-486	-91	-157	-67	0	0	406	173	212	4,383	70
2027E	42.8	102%	43.7		2,340	100%	2,340	1,836	0	-92	-1,166	100.0%	2,340	2,340	1,836	785	0	0	-1,166	-498	-92	-164	-70	0	0	413	177	216	4,622	77
2028E	43.9	102%	44.8		2,340	100%	2,340	1,882	0	-418	-1,195	100.0%	2,340	2,340	1,882	804	0	0	-1,195	-511	-418	-166	-71	0	0	102	44	222	4,890	84
2029E	45.0	102%	45.9		2,340	100%	2,340	1,929	0	-582	-1,225	100.0%	2,340	2,340	1,929	824	0	0	-1,225	-524	-582	-148	-63	0	0	-27	-12	237	5,564	100
2030E	46.1	102%	47.0		3,330	100%	3,330	2,813	0	-98	-1,513	100.0%	3,330	3,330	2,813	845	0	0	-1,513	-454	-98	-293	-88	0	0	909	273	302	6,496	122
2031E	47.3	102%	48.2		3,330	100%	3,330	2,884	0	-101	-1,551	100.0%	3,330	3,330	2,884	866	0	0	-1,551	-466	-101	-301	-90	0	0	931	280	310	6,493	130
2032E	48.4	102%	49.4		3,330	100%	3,330	2,956	0	-103	-1,590	100.0%	3,330	3,330	2,956	888	0	0	-1,590	-477	-103	-310	-93	0	0	953	286	317	6,463	139
2033E	49.6	102%	50.6		3,330	100%	3,330	3,030	0	-106	-1,629	100.0%	3,330	3,330	3,030	910	0	0	-1,629	-489	-106	-324	-97	0	0	971	292	323	6,403	148
2034E	50.9	102%	51.9		3,330	100%	3,330	3,105	0	-108	-1,670	100.0%	3,330	3,330	3,105	933	0	0	-1,670	-502	-108	-353	-106	0	0	974	292	325	6,312	158
Totals					thou t		thou t	ZARm	ZARm	ZARm	ZARm		tonnes	tonnes	ZARm	ZAR/kg	ZARm	ZAR/kg	ZARm	ZAR/kg	ZARm	ZARm	ZAR/kg	ZARm	ZAR/kg	ZARm	ZAR/kg	ZAR/kg	ZARm	ZAR/kg
2022E+					25,140		25,140	66,456	0	-3,412	-37,326		68,877	68,878	66,456	965	0	0	-37,326	-542	-3,412	-7,244	-105	0	0	18,474	268	318	2,845	41
2035+					13,370		13,370	39,734	0	-1,386	-21,370		36,630	36,630	39,734	1,085	0	0	-21,370	-583	-1,386	-4,779	-130	0	0	12,199	333	371		

Notes:

	Gross	Opex	Capex
	ZAR/kg	-1,472	-138







1st Jan NAV sensitivity to discount rate

	ZARm	p/sh	ZAR/kg
12.0%	4,682	15.8	67.97
14.0%	3,933	13.2	57.10
16.0%	3,350	11.3	48.63
18.0%	2,889	9.7	41.94
20.0%	2,521	8.5	36.60

NAV sensitivity to 2023+ V price				IRR sensy
US$/kg	ZARm	p/sh	ZAR/kg	(%)
25	-928	-3.1	-0.01	
30	1,139	3.8	0.02	
35	2,428	8.2	0.04	
40	3,717	12.5	0.05	
45	5,006	16.8	0.07	

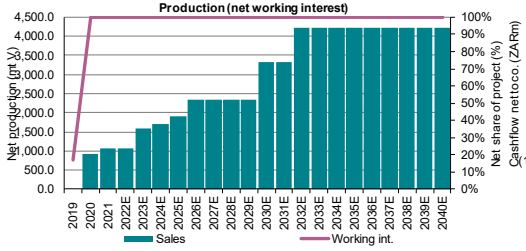
Source: BNP Paribas Exane estimates

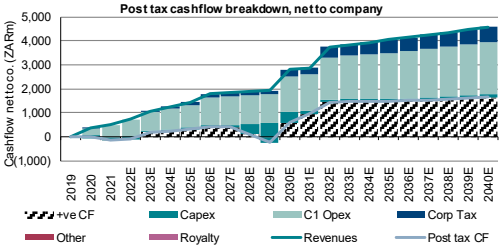
Figure 47: Vanchem kiln 2 + 1 refurb case cash-flow analysis in ZAR

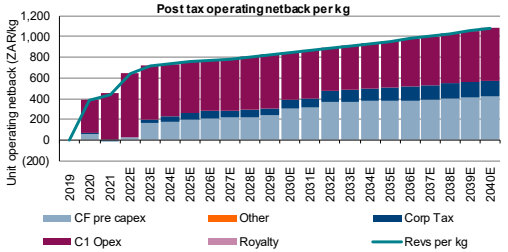
	Gross processing facility											Country: South Africa		Vanchem Refurb kiln 2 + 1 - net to company												Discount rate: 16.0%	
												Working interest basis															
Year	LMB V price	Price as % of LMB	Realised V price		Production	Sales as % of prod	Sales	Revenues	Royalty	Capex	C1 Opex	Working int.	Production	Sales	Revenues	Revs per kg	Royalty	Royalty	C1 Opex	C1 Opex	Capex	Corp Tax	Corp Tax	Other	Other	Post tax CF	Post tax CF	CF pre capex	Rem. NPV (1st Jan)	Rem. NPV (1st Jan)
	US$/kg	%	US$/kg		mt V	%	mt V	ZARm	ZARm	ZARm	ZARm	%	mt V	mt V	ZARm	ZAR/kg	ZARm	ZAR/kg	ZARm	ZAR/kg	ZARm	ZARm	ZAR/kg	ZARm	ZAR/kg	ZARm	ZAR/kg	ZAR/kg	ZARm	ZAR/kg
2019	42.3	116%	49.0		0	#DIV/0!	0	0	0	0	0	16.7%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,068	25
2020	25.0	95%	23.7		986	94%	930	381	0	-59	-309	100.0%	986	930	381	386	0	0	-309	-314	-59	-19	-20	0	0	-7	-7	53	2,403	29
2021	34.5	93%	32.2		1,139	94%	1,066	501	0	-114	-516	100.0%	1,139	1,066	501	440	0	0	-516	-453	-114	0	0	0	0	-129	-113	-13	2,801	34
2022E	39.2	109%	42.8		1,137	93%	1,052	729	0	-130	-699	100.0%	1,137	1,052	729	641	0	0	-699	-615	-130	0	0	0	0	-100	-88	27	3,404	42
2023E	35.0	108%	37.8		1,500	106%	1,586	1,075	0	-61	-776	100.0%	1,500	1,586	1,075	717	0	0	-776	-517	-61	-49	-33	0	0	189	126	166	4,071	51
2024E	38.5	106%	40.8		1,700	100%	1,700	1,246	0	-64	-855	100.0%	1,700	1,700	1,246	733	0	0	-855	-503	-64	-86	-51	0	0	242	142	180	4,511	57
2025E	40.7	104%	42.4		1,900	100%	1,900	1,447	0	-72	-949	100.0%	1,900	1,900	1,447	761	0	0	-949	-500	-72	-113	-59	0	0	312	164	202	4,961	64
2026E	41.8	102%	42.6		2,340	100%	2,340	1,791	0	-91	-1,138	100.0%	2,340	2,340	1,791	765	0	0	-1,138	-486	-91	-157	-67	0	0	406	173	212	5,402	72
2027E	42.8	102%	43.7		2,340	100%	2,340	1,836	0	-92	-1,166	100.0%	2,340	2,340	1,836	785	0	0	-1,166	-498	-92	-164	-70	0	0	413	177	216	5,806	80
2028E	43.9	102%	44.8		2,340	100%	2,340	1,882	0	-418	-1,195	100.0%	2,340	2,340	1,882	804	0	0	-1,195	-511	-418	-166	-71	0	0	102	44	222	6,266	89
2029E	45.0	102%	45.9		2,340	100%	2,340	1,929	0	-808	-1,225	100.0%	2,340	2,340	1,929	824	0	0	-1,225	-524	-808	-145	-62	0	0	-250	-107	239	7,162	105
2030E	46.1	102%	47.0		3,330	100%	3,330	2,813	0	-438	-1,513	100.0%	3,330	3,330	2,813	845	0	0	-1,513	-454	-438	-276	-83	0	0	587	176	308	8,613	131
2031E	47.3	102%	48.2		3,330	100%	3,330	2,884	0	-101	-1,551	100.0%	3,330	3,330	2,884	866	0	0	-1,551	-466	-101	-270	-81	0	0	963	289	319	9,326	149
2032E	48.4	102%	49.4		4,230	100%	4,230	3,755	0	-103	-1,762	100.0%	4,230	4,230	3,755	888	0	0	-1,762	-416	-103	-454	-107	0	0	1,436	339	364	9,719	164
2033E	49.6	102%	50.6		4,230	100%	4,230	3,848	0	-106	-1,806	100.0%	4,230	4,230	3,848	910	0	0	-1,806	-427	-106	-472	-112	0	0	1,465	346	371	9,625	175
2034E	50.9	102%	51.9		4,230	100%	4,230	3,945	0	-108	-1,851	100.0%	4,230	4,230	3,945	933	0	0	-1,851	-438	-108	-509	-120	0	0	1,476	349	375	9,482	187
Totals					thou t		thou t	ZARm	ZARm	ZARm	ZARm		tonnes	tonnes	ZARm	ZAR/kg	ZARm	ZAR/kg	ZARm	ZAR/kg	ZARm	ZARm	ZAR/kg	ZARm	ZAR/kg	ZARm	ZAR/kg	ZAR/kg	ZARm	ZAR/kg
2022E+					29,739		29,739	79,652	0	-3,977	-40,169		81,477	81,478	79,652	978	0	0	-40,169	-493	-3,977	-9,984	-123	0	0	25,520	313	362	3,404	42
2035+					16,983		16,983	50,473	0	-1,386	-23,684		46,530	46,530	50,473	1,085	0	0	-23,684	-509	-1,386	-7,124	-153	0	0	18,279	393	423		

Notes:

	Gross	Opex	Capex
	ZAR/kg	-1,343	-136







1st Jan NAV sensitivity to discount rate

	ZARm	ked p/sh	ZAR/kg
12.0%	323	19.4	3.96
14.0%	266	16.0	3.26
16.0%	222	13.4	2.73
18.0%	188	11.3	2.31
20.0%	161	9.7	1.98

NAV sensitivity to 2023+ V price				IRR sensy
US$/kg	ZARm	p/sh	ZAR/kg	(%)
25	2	0.1	0.02	
30	86	5.1	1.05	
35	164	9.9	2.02	
40	243	14.6	2.99	
45	322	19.4	3.96	

Source: BNP Paribas Exane estimates

Other assets: Bushveld Energy, Brits and Mokopane

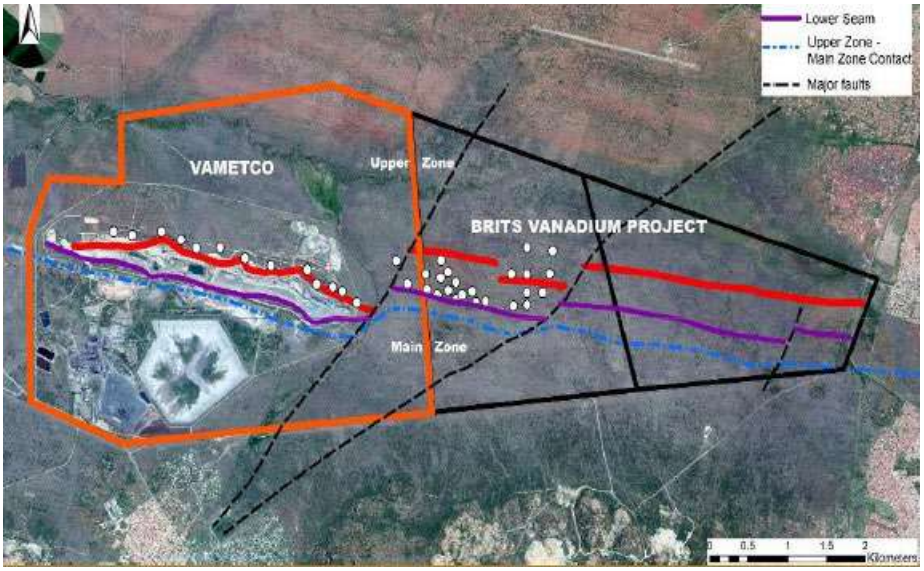
Brits could provide additional resource for future expansions, but not required in near-term

Brits is an outcropping, strike extension of the Vametco mine with similar characterstics. It could provide additional resource for future expansions of processing capacity at Vametco, or Vanchem, subject to construction of the semi-autogeneous mill (SAG mill) planned as part of the phase 1 expansion at Vanchem.

Brits hosts high-grade vanadium mineralisation in several magnetite layers. This mineralisation is an outcropping extension to the Vametco strike. Drilling has demonstrated weighted average grades for the Lower Seam of 0.6%-1.6% V_2O_5 in magnetite, amongst the highest grades in the world.

Brits is not, however, required to deliver current plans and we have not assessed the project in more detail.

Figure 48: Location of Brits extension to Vametco resource



Source: Company

Mokopane could provide ore for additional expansion/extension at Vanchem, but not required in near-term

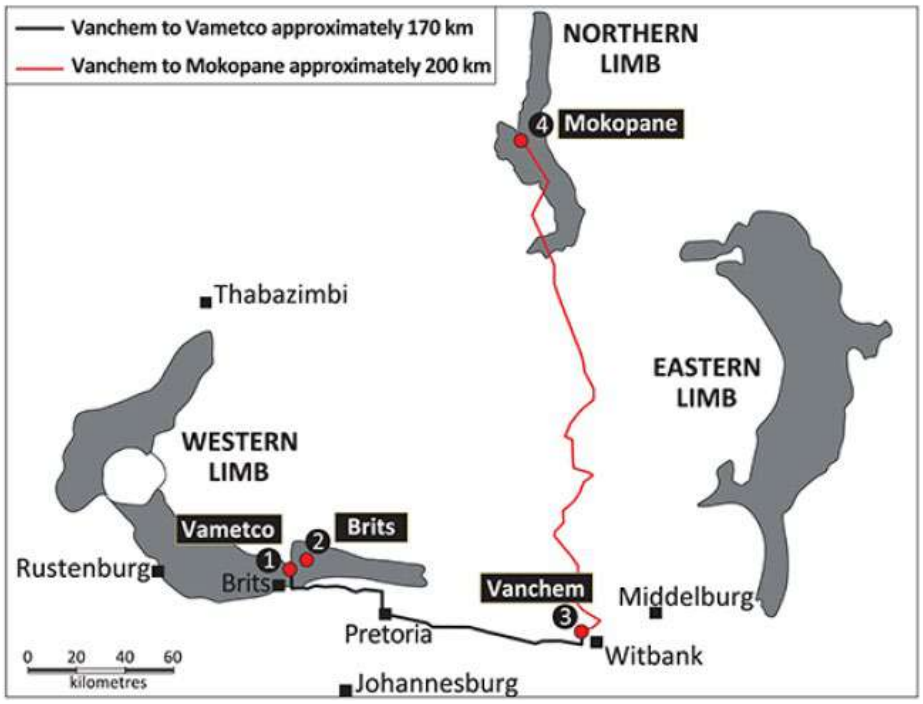
Mokopane is located on the central portion of the Northern Limb of the Bushveld Complex, to the north of Vanchem and could be developed in future to provide feedstock to Vanchem.

The project includes one of the world's largest primary vanadium resources, with an average grade of 1.8% V_2O_5 in magnetite.

A 30-year mining right was awarded in January 2020.

Bushveld is committed to adhering to Mining Charter III regulations for Mokopane (although it is only subject to Mining Charter II regulations) and will transfer 5% of the equity to the Bakenberg community and 5% to an Employee Share Ownership Scheme. Consequently Bushveld's stake will reduce from 64% to 57.6% (pro rata for partner Izingwe's shareholding which will reduce from 36% to 32.4%).

Figure 49: Map showing location of Vanchem in relation to Vametco, Brits and Mokopane vanadium deposits



Source: Company

The deposit is a layered orebody along a 5.5km N-S strike, dipping to the west at 18-24°. The project comprises three adjacent and parallel magnetite layers which hold JORC Compliant Mineral Resources of 298 Mt with grades ranging from 1.6% to >2.0%. A mineable reserves of 28.56 Mt V was estimated as mineable supporting a minimum 30-year mine life.

A pre-feasibility study, completed in 2016, indicated capex of US$300m for a mine and plant producing 5,300 mtV pa from a deposit grading an average of 1.75% V_2O_5.

The Mokopane reserves are not required in the near-medium term to support planned developments and we have not assessed the project further.

Bushveld Energy

Bushveld Energy comprises the group's investments in VRFB (Vanadium Redox Flow Battery) storage technology and projects. Bushveld Minerals currently holds an 84% interest in Bushveld Energy but announced with its 2021 results its intention to carve out Bushveld Energy as a separate business. Subsequent announcements indicated this process was underway targeting completion by year-end 2022, with the intention of crystallising value and attracting the appropriate investors with a greater understanding of the energy transition. Completion is now anticipated in H2 2023 with Bushveld Minerals retaining a substantial share in the business post carve-out.

Key objectives of the business include:

- Electrolyte manufacturing
- Renting vanadium electrolyte to battery users
- Assembly of VRFBs, through third parties in which Bushveld Energy may have an ownership position
- Direct selling of VRFBs in African markets
- Developing and investing in African energy storage projects

Brief history of the business

- The business was incorporated in 2016 as an 84% owned subsidiary of Bushveld Minerals, and a cooperation agreement was signed with IDC (Industrial Development Corporation) to determine the economic viability of VRFB's for use and manufacture in South Africa.
- In 2018 development of the first commercial PV and VRFB mini grid commenced.
- The first battery rental contract was signed in 2019 with Avalon Battery Corp, investments in VRFB businesses were made, taking an 8.71% stake in Invinity Energy Systems through funding a convertible loan, and an initial stake in CellCube (formerly Enerox).
- Vanadium rental partnerships were entered into with Invinity during 2020, and the Bushveld Electrolyte company (BELCO) was established to supply electrolyte to VRFB manufacturers.
- Construction of BELCO's electrolyte plant got underway in 2021. Bushveld Energy also increased its indirect interest in Cellcube to 25.25% during the year, and monetised its investment in Invinity Energy Systems, realising proceeds of ~US$13m.
- Financial close was achieved for the Vametco mini-grid in 2022 and funding secured for the development.

Reorganisation for spin-out ongoing

Bushveld Minerals is transferring the bulk of its investments within Bushveld Energy, with the exception of its interest in the BELCO electrolyte plant, to Mustang Energy. Mustang is a SPAC, which listed in 2019 after raising £0.75m, and which has been suspended from trading since 27 April 2021 in conjunction with the reorganisation. The carve out process is now expected to be completed during H2 2023 with readmission of Mustang to trading.

It is intended that Bushveld Minerals will hold a 21-23% interest in Mustang, with the final shareholding dependent upon the amount of money raised by Mustang in conjunction with its readmission to trading.

At readmission, Mustang will own 100% of VRFB Holdings (VRFB-H), which will own 100% of Enerox Holdings Ltd (EHL). EHL owns 100% of the share capital of Enerox GmbH, which itself owns the CellCube brand.

Mustang is acquiring the VRFB-H interests in three stages:

- Conditional acquisition of 22.1% announced on 26 April 2021 through participation in a VRFB-H funding round
- Conditional acquisition of 27.4% interest from Acacia Resources announced 3 August 2022

– Conditional acquisition of the remaining 50.5% interest from Bushveld Energy an 85% owned subsidiary of Bushveld Minerals, announced 28 November 2022. Bushveld Energy will receive US$19.4m in new Mustang shares, priced at 20p/sh, and will have the right to appoint two new directors.

VRFB-H is acquiring a 50.5% interest in EHL from Garnet, taking its ownership to 100%:

– Conditional acquisition announced 12 April 2023 and expected to complete at the same time as the above deals

Mustang is in the process of preparing a prospectus to raise a minimum of US$15m in new capital in conjunction with a relisting of Mustang's shares on the LSE.

CellCube investment

Bushveld invested a total of US$12m to obtain a 25.25% indirect interest in Austrian VRFB manufacturer CellCube, which was formerly known as Enerox.

CellCube systems have been deployed at over 140 sites worldwide.

Figure 50: CellCube projects

Source: CellCube

Bushveld noted, in its November 2022 update, that CellCube had deployed over 23MWh of capacity via 130 systems across 5 continents. Furthermore it had announced 5 new orders for 34MWh over the prior 12 months, including a 16MWh battery for an Australian renewable project developer – the largest order to date.

North American volumes account for ~16% of total energy capacity to date, a market in which CellCube intends to use locally processed vanadium. CellCube has signed a 5-year supply agreement with US Vanadium for up to 3 million litres/yr of vanadium electrolyte; an agreement which includes price caps, however, Bushveld notes the agreement is not exclusive and it retains a RoFR. CellCube's capacity in Africa and the Middle East accounts for around 7% of capacity.

Mini-grid project at Vametco

A mini-grid project, incorporating solar power generation plus storage, is being developed at Vametco as a funded IPP (independent power producer). The power generated and stored will be sold to Vametco and will reduce its reliance on the grid and will reduce CO_2 emissions.

The system incorporates 3.5MW of solar PV generation with a 1MW/4MWh VRFB, the largest permissible without a power generation licence under current regulations, to provide long-duration storage for the renewable power generated. The project is the first of its kind in South Africa, and one of the first on the African continent. It is intended to serve as a 'proof of concept' for further adoption of the technology across Bushveld Minerals' operations, and elsewhere.

Bushveld Energy has identified the potential for up to 120MW of solar PV generation and 180MWh of storage capacity across the Bushveld Minerals group.

In the context of the previously discussed load shedding challenges in South Africa, this combined renewable energy generation and long-duration storage solution could be applied at other mining and industrial sites to minimise the impact of load shedding upon industry. It could also contribute to the requirement to add clean generation capacity in South Africa to ensure power supplies as the ageing coal fleet is retired to meet COP26 commitments.

Although Bushveld's operations are connected to the power grid, mining activity globally is often undertaken in remote locations not connected to the grid. These operations are often fuelled using liquid petroleum products (eg diesel). The sharp increase in fuel prices following the invasion of Ukraine reduces the opportunity cost for miners of switching to renewable power generation with battery storage.

The Vametco mini-grid project is expected to supply just under 10% of Vametco's total power consumption at a given time. The project has secured financial close, with NESA Capital providing 60% of the equity and taking the majority of the project, with a ~US$4.1m loan provided by ABSA Bank. The project is expected to be complete in H1 2023 at a total cost of ~US$7.1m/ZAR113m (as of June 2022).

The mini-grid will reduce Vametco's CO_{2eq} emissions by >8,000 tonnes pa, or >200,000 tonnes over the 25 year period of the PPA.

Vametco has sold 26mt of vanadium for production of electrolyte for the VRFB, which is being converted into electrolyte overseas, since Bushveld Energy's electrolyte plant will not be operational until H1 2023.

Electrolyte plant (BELCO)

Bushveld and IDC committed to develop an electrolyte plant in early 2020, with Bushveld Energy holding a 55% interest and IDC 45%. The plant will be located on the south coast of South Africa, near East London.

The building which will house the plant was completed in April 2022, and the overall facility was ~80% complete as of September 2022. Cold commissioning was completed during 1Q 2023 and hot commissioning has started. Electrolyte production is expected to commence in H1 2023 with a potential capacity, post expansion, of 8 million litres pa/200MW which would make it one of the largest plants outside of China. The project has, however, run behind schedule, impacted by a longer than planned EIA process (incorporating potential future expansion phases) and COVID.

The facility is undergoing a qualification process for its electrolyte with VRFB companies and no sales contracts have yet been announced.

If Bushveld Energy is eventually carved out from the parent company as planned, it is intended that BELCO will remain with Bushveld.

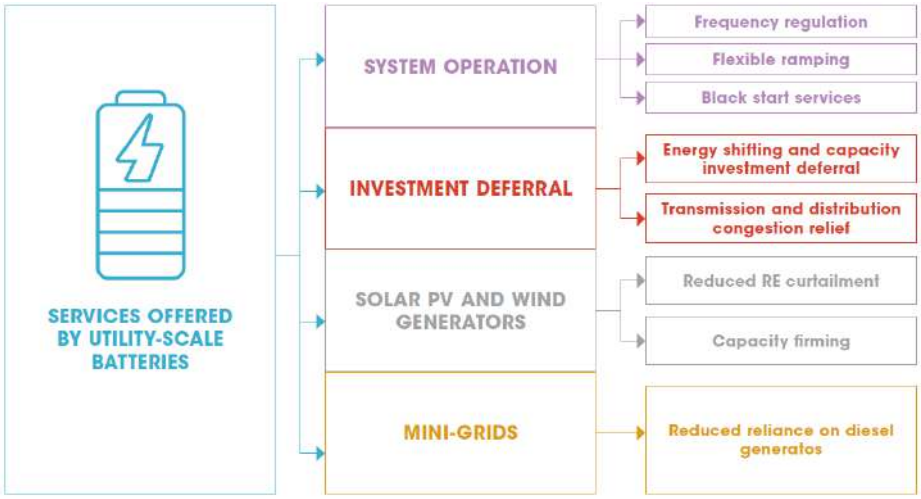
Energy storage – a growing market requiring a variety of services

We present an overview of grid-scale energy storage technologies and the growth drivers for this interesting sector of the energy market.

As the contribution on the grid from intermittent renewable generation sources increases, so does the value of long-duration energy storage (LDES). This technology can take advantage of periods of plentiful power supply, accompanied by low or negative power price, shifting this in time to periods of relatively tight supply-demand balance, which are accompanied by higher prices. This price arbitrage provides the economic 'reward' for construction and operation of storage.

In reality the benefits offered by energy storage systems are more varied and nuanced, including services related to the stable operation of the grid, deferral of T&D investments through better utilisation of existing capacity and managing bottlenecks, the development of mini-grids and integration with renewable energy producers.

Figure 51: A variety of services are offered by utility-scale battery storage systems



Source: IRENA

System operation services

Frequency regulation

– When imbalances between power supplied to, and demanded from, the grid arise there is a resulting change in frequency.

– Grid frequency must be maintained in close tolerances to ensure the proper functioning of electrical equipment.

– Rotating turbines typically used in 'traditional' power generation systems have a degree of resilience to frequency changes (system inertia), renewable generation technology does not.

– Fast acting storage, such as batteries, can be used to restore the frequency of operation to within tolerances.

– Slower acting storage is not particularly suitable for this purpose

Flexible ramping

– Wind and solar power generation are driven by meteorological conditions and the rotation of the planet. As a consequence power generation from these sources can ramp up/down in sync (for example solar power generation after sunrise).

– Increasing levels of renewable energy generation capacity on the grid amplify the impact, and the rest of the system must ramp up/down rapidly to compensate.

– Storage can smooth out the peak and trough imbalances in supply and demand, and reduce the steepness of the 'ramp' which must be supplied by the remainder of the grid.

Black start

– Restarting a national power grid following an outage is not trivial, involving a staged process in which generation units are restarted and synchronised sequentially.

– Diesel generators are typically employed to provide temporary power during the process to restore the grid to stable operations, however, large-scale grid storage systems can also perform this role.

– Such storage systems could also be employed to provide additional grid services when not being used for a 'black start'.

Investment deferral

Energy shifting/capacity investment deferral

– Storage systems can charge during periods of weak demand/low prices and discharge during periods of peak demand/high prices, thus deferring the requirement for investment in additional 'peaking' generation capacity.

T&D congestion relief

– Over time bottlenecks can emerge in the T&D network. If these bottlenecks occur for limited periods or only in specific situations it can be possible to use storage to alleviate the problem.

– This avoids the requirement to invest in substantial grid upgrades.

– Storage capacity can be installed downstream of the bottleneck. Power can be transmitted through the bottleneck during periods of lower demand and stored, to be subsequently released during periods of high demand.

Services for renewable energy generators

Reduced renewable energy curtailment

– Renewable energy generation fluctuates and may not match demand profiles.

– As the proportion of renewable generation capacity on the grid increases, so does the potential for peak generation to coincide with weak pricing (eg. during sunny/windy periods). In the extreme case generation can exceed demand, forcing curtailments.

– Storage can be used to maximise the price realised by renewable generation capacity, and in the extreme case can maximise the utilisation of low carbon, renewable energy generation capacity which would otherwise be wasted.

Capacity firming

– Renewable energy generation varies over shorter time periods driven by changes in cloud cover and varying wind speeds.

– Storage can be coupled to a renewable generation site to smooth these short terms fluctuations, delivering a smoother power profile which is easier to integrate into the grid.

Services for mini-grid systems

Reduced reliance on diesel generators

– Mini-grids supplying remote communities have typically relied upon diesel generators historically to ensure reliable supply, however, renewable generation costs have fallen significantly over recent years.

– Storage systems are required to ensure intermittent renewable generation can match demand needs in locations typically lacking in dispatchable generation capacity.

Different energy storage technologies have attributes which can make them better suited to particular applications.

Not all storage technologies are suited to all tasks; diversity of technologies will likely be required

A variety of different energy storage technologies have been developed, each with particular attributes making them better suited to different applications. The figure below presents a summary of the key types of grid-scale energy storage technology, and the discharge duration/power requirements for which they are particularly well-suited to deliver.

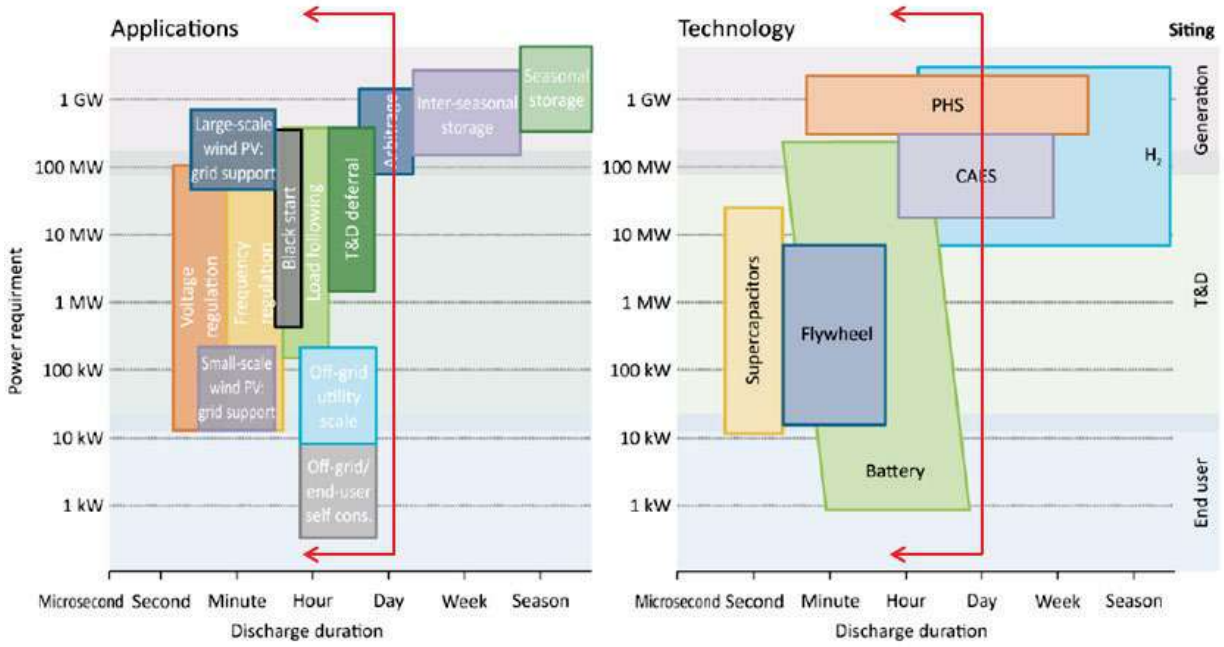
Energy storage systems are typically classified by their capacity – the amount of energy they are able to store, and power – the rate at which this energy can be delivered. A combination of capacity and power ratings will be required to balance the grid in a modern energy system, and as the penetration of renewables grows there will be increased requirements for larger-scale, longer-duration storage.

There is no universally accepted definition of storage durations, however, short duration is typically 0-4 hours, medium duration covers intra-day (4-12 hours) and inter-day (12-200 hours) with longer-duration applying to anything beyond that ranging from weeks to months, seasons and years.

Energy storage mechanisms can be electrical (eg supercapacitors, with extremely fast response times), mechanical (flywheels, compressed air and pumped hydro storage), and chemical (eg batteries, hydrogen). Technologies have also been developed to store thermal energy, which in some cases is delivered directly to reduce heating/cooling loads on the grid, and in some instances is used with a turbine to produce power.

The development and evolution of storage technologies will likely continue to push the boundaries beyond current use cases, with the chart below summarising the current position across a range of technologies.

Figure 52: Energy storage technologies and use cases compared to power requirement and discharge duration



Source: US Trade & Development Agency/Parsons – South Africa Energy Storage Technology and Market Assessment. PHS – Pumped Hydro Storage, CAES – Compressed Air Energy Storage. Note: Red line shows discharge duration applicable to the South Africa Energy Storage Technology/Mkt Assessment study

Policies needed to support deployment

The requirement for LDES, and increased storage capacity more generally, will grow significantly as power systems are decarbonised. Since there has been limited requirement to incentivise LDES deployment historically, policy development has not typically evolved to regulate and incentivise technology development and deployment. Pricing structures have not yet been developed for the numerous grid services offered by storage systems, to encourage deployment in conjunction with the build-out of renewable generation capacity. A challenge is that the there may be no, or limited, market requirement for some of these services today, but requirements are expected to grow rapidly in the not-too-distant future.

Policy support will need to adapt to the adoption, development and evolution of storage systems, from current projects which are typically relatively early stage (including proof of concept and demonstration systems) through to market maturity, which is unlikely before the next decade.

Investors in early-stage projects typically require a higher cost of capital to reflect the associated uncertainties. Early-stage projects would benefit from policies which provide revenue visibility and stability over the longer-term (20+ years). Funding grants to support projects could be used alongside targets for storage capacity additions.

As the market grows and matures and the technologies become more established costs of capital would likely fall as should unit capital costs with the expansion and development of manufacturing capacity along the supply chain. This would require an evolution in policy support mechanisms perhaps somewhat akin to those for the development of renewable energy projects. Eventually the aim would be for support mechanisms to be scaled back with market mechanisms able to efficiently price and incentivise the required storage services.

Summary of some key energy storage technologies in use and under development

In the below section we provide an overview of some of the key technologies and their attributes. Energy storage is a rapidly evolving area of research and development, both within industry and academia, and at this relatively early stage of development of the industry technologies will continue to evolve and develop.

It should be noted that for batteries the overall battery life and degradation profile of a given technology is often impacted by the use case and environmental conditions, which can have a significant impact upon lifecycle performance.

Battery costs, which in many cases have been reducing (per unit capacity) over recent years driven by technology improvements, are impacted by both raw material prices and broader supply chain issues. Inflationary trends combined with logistic/supply chain challenges have more than offset technology driven cost improvements.

There are also significant regional differences in battery costs, for example Li-ion battery costs were lowest in China in 2021, with prices in the US and Europe ~40% and 60% higher respectively.

Finally scale up of emerging technologies from lab scale to commercial scale can be accompanied by significant changes in performance characteristics, including reduced round trip efficiencies.

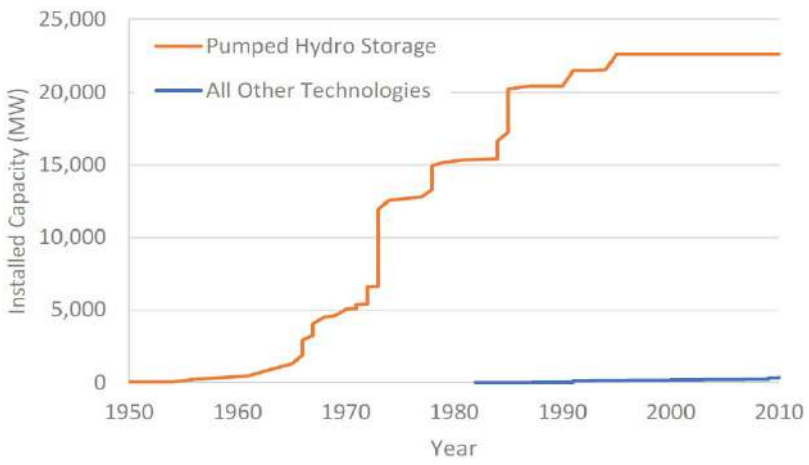
Pumped hydro – mechanical

Pumped hydro schemes can store enormous amounts of energy at relatively low operating cost once built. Pumped hydro schemes are not, however, individually scalable and can be challenging to develop given their specific geographic requirements (large bodies of water, separated vertically, potentially involving the construction of dams and associated flooding). They are large-scale engineering projects in their own right and are not typically well suited to co-location with renewable energy generation capacity in a distributed system.

Historic pumped storage developments account for the bulk (more than 90%) of existing high-capacity energy storage systems globally, with ~160GW installed capacity in 2021. The majority of plants in operation today are used to provide daily balancing, however, they can clearly store energy without degradation over longer time periods.

Figure 53: Pumped storage has dominated US energy storage capacity

Historical deployment of energy storage in the US



Source: NREL

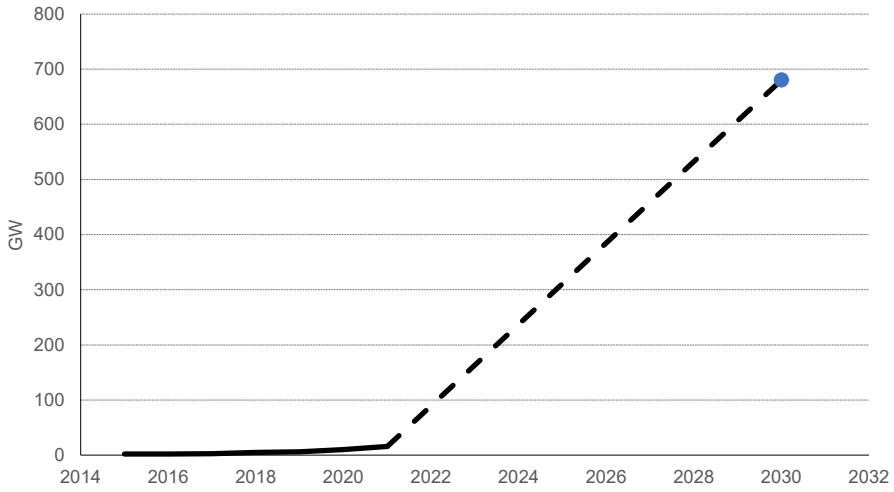
China is leading the way in pumped storage investment; 80% of all final investment decisions for new capacity since 2015 have been for Chinese projects, with close to 50GW of capacity under construction. In liberalised energy markets, permitting risks and a lack of visibility around the long-term revenue outlook have stalled new pumped hydro schemes.

A variation of the pumped storage approach is to use heavy weights which can be hoisted vertically during periods of plentiful power generation, and lowered to generate electricity during peak periods. Abandoned mine shafts could provide large vertical drops through which to operate such schemes. Such projects would be more modular and could be scalable.

Batteries – chemical

The IEA's Net Zero Scenario calls for a substantial increase in grid-scale battery storage, from ~16GW in 2021 to ~680GW by 2030. For context ~6GW of grid-scale battery storage capacity was added globally in 2021. Battery storage systems are projected to be the fastest growing source of power system flexibility in all of the IEAs outlook scenarios. There are of course a number of forecasts in the market, and although the growth rates may differ the broad consensus is for a multi-year increase in grid storage capacity.

Figure 54: Grid-scale battery storage capacity set to grow rapidly



Source: IEA, Net Zero Emissions scenario. Note the above chart shows grid-scale storage only estimated at ~10GW in 2020. The IEA WEO 2022 battery storage capacity figure of 18GW includes both grid scale (~59%) and behind the meter (~41%).

Grid storage batteries are a scalable technology, suitable for sub-hourly, hourly and daily balancing, and are expected to account for the majority of storage growth worldwide. Batteries typically have a short response time, enabling them to perform shorter term grid stabilisation and frequency regulation roles.

Investments in battery storage reached almost US$10bn in 2021 according to the IEA, and are estimated to increase towards US$20bn in 2022, based upon the existing pipeline and capacity targets set by governments. More than 70% of battery investments in 2021 were for grid-scale storage, and more than 90% of battery storage investments in 2020 and 2021 were for Li-ion batteries.

Battery R&D covers a wide range of technologies. Although Li-ion batteries have a dominant position in the marketplace today, driven by their application in consumer electronics and EVs, market shares are likely to continue to evolve. Research is ongoing both to improve Li-ion technology, and to further develop other battery technologies which are better suited to certain use settings.

Lithium-ion

To date lithium-ion has been the dominant battery technology, however, this technology looks predominantly suited to shorter duration storage. Technology improvements and dramatic cost reductions over the last decade have been driven by the rapid expansion of battery manufacturing capacity, predominantly driven by the growth of EVs. The EV battery market is roughly 10x that of grid-scale battery storage and a wide range of consumer electronics devices also utilise Li-ion batteries.

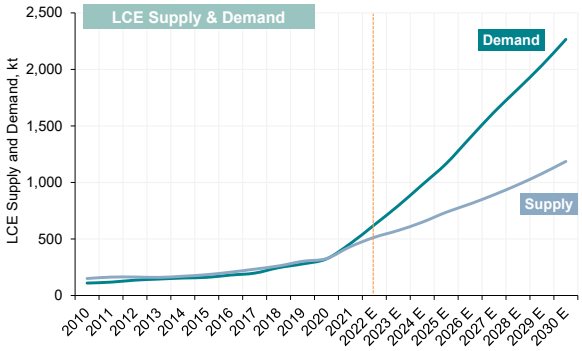
The technology's dominance in a rapidly growing marketplace does raise questions about the ability of the supply chain to keep up with demand growth. This could impact pricing and the pace and economics of future growth with the potential for Li-ion battery cost reduction trends to slow.

The IEA estimates demand for lithium for battery storage will increase over 20x by 2030, rising to almost 50x by 2050 in the net zero scenario. This is the sharpest demand growth forecast for all critical minerals in the energy transition, and compares to a tripling of demand for copper, silicon and rare earths in the net zero scenario by 2030.

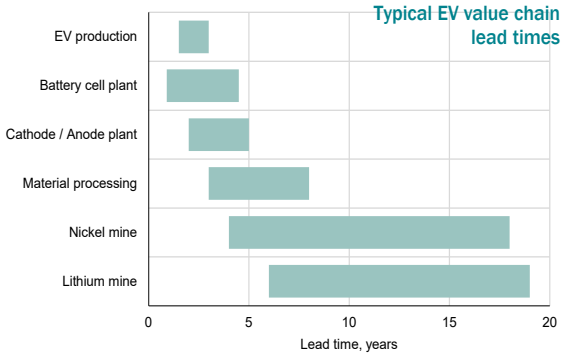
Lead times for construction of plant to supply batteries, anodes and cathodes are relatively short (~1-5 years) and in these areas the Li-ion battery supply chain looks on track to meet forecast demand growth. Problems in the supply chain are, however, located further upstream in the mining and refining of lithium, where lead times for new capacity additions typically amount to 5-15+ years.

Figure 55: Auto maker LCE demand expected to outstrip supply, with mining and refining a key constraint

Lithium remains the main supply constraint to BEV adoption rates (and profitability)



Step-up in lithium supply will take time to deliver

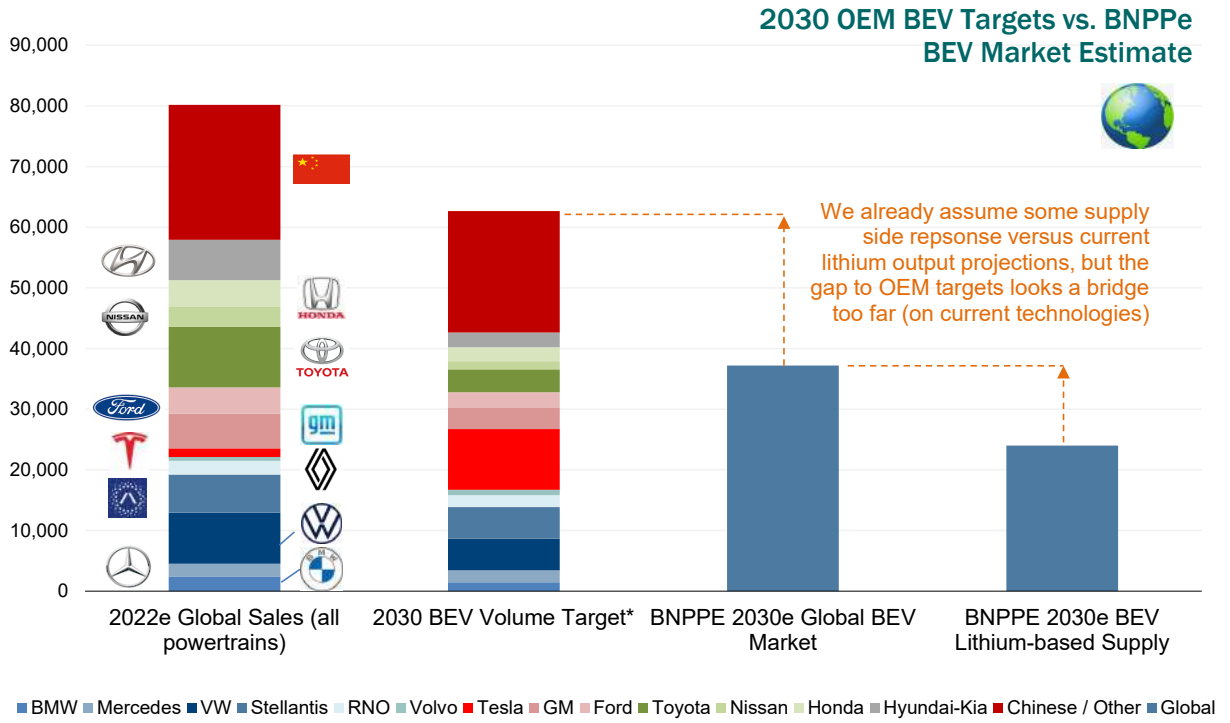


Source: USGS, BNP Paribas Exane estimates

The combination of these long lead times with the large capital investment programs required for new mines, the relatively rapid pivot by incumbent vehicle OEMs to electrification, and the macro uncertainty over recent years, has resulted in the upstream portion of the lithium supply chain being relatively slow to react to increased demand growth forecasts.

Our Autos and Mining teams estimate the aggregate Li-ion battery demand required to deliver upon automaker BEV ambitions, based upon today's known battery technology, equates to roughly double the forecasts for lithium production.

Figure 56: OEM 2030 BEV targets are >2x supply based on current lithium mining projections



Source: Company reports, BNP Paribas Exane estimates. Note: Tesla shown at 10m units rather than 20m ambition that Musk has touted (not an official hard target).

Faced with potential raw material shortages a number of car and battery manufacturers have indicated appetite to invest directly in lithium mining and/or refining directly. We expect considerable pressure on Li-ion supply chains from the forecast expansion of BEV manufacturing; further expansion of Li-ion battery deployment for grid level storage will only exacerbate these pressures.

Within the Li-ion battery family a number of cathode materials have been developed for different use cases. NMC technology is currently the most used, accounting for ~60% of Li grid storage applications and holding a dominant position in the EV market. A shift to higher nickel (NMC 811 etc) or cobalt-free (LFP) chemistries will continue to switch concerns around supply-chain bottlenecks away from cobalt and further towards lithium.

One consequence of the forecast growth in BEVs will be a substantial increase in the number of used EV batteries available for repurposing, once those BEVs come to the end of their lives. With up to 80% of usable capacity typically still available once the batteries no longer meet the standards for EV use, these batteries could potentially be re-used for grid-scale storage.

Substantial growth in used battery availability is, however, unlikely to materialise until into the next decade, and is therefore unlikely to alleviate near to medium-term pressures in the Li-ion supply chain. Used EV batteries must undergo refurbishment prior to re-use, the economic attractions of which will depend upon the evolution of new battery costs. Careful consideration will also need to be given to monitoring the health of used batteries, taking account of the lack of standardisation across the industry, with potential issues around certification and warranties/liabilities.

Li-ion batteries offer an attractive combination of energy density, efficiency, charge time, cycle life and cost. Whilst the organic electrolytes do present a potential fire risk, advanced control systems coupled with fire detection, cooling and suppression systems can largely address these concerns. These necessary systems do of course contribute

to a small reduction in overall system efficiency, and an increase in cost. Li-ion batteries are also somewhat challenging to recycle, which will need to be addressed to support continued growth of the technology.

Ongoing R&D to improve Li-ion battery performance, including solid-state
One area of focus is on the development of solid-state Li-ion batteries. Traditional Li-ion battery formulations incorporate a carbon anode, into which Li ions are transferred (intercalated) during the charging process. It has been known for ~50 years that higher battery capacities can be achieved using a solid Li anode, however, this formulation introduces other complexities in operation (namely the formation of needle-like Li dendrite particles during charging which can pierce the porous separator causing a short circuit and potentially a fire, and a rapid increase in impedance owing to an unwanted side reaction between the liquid electrolyte and solid Li).

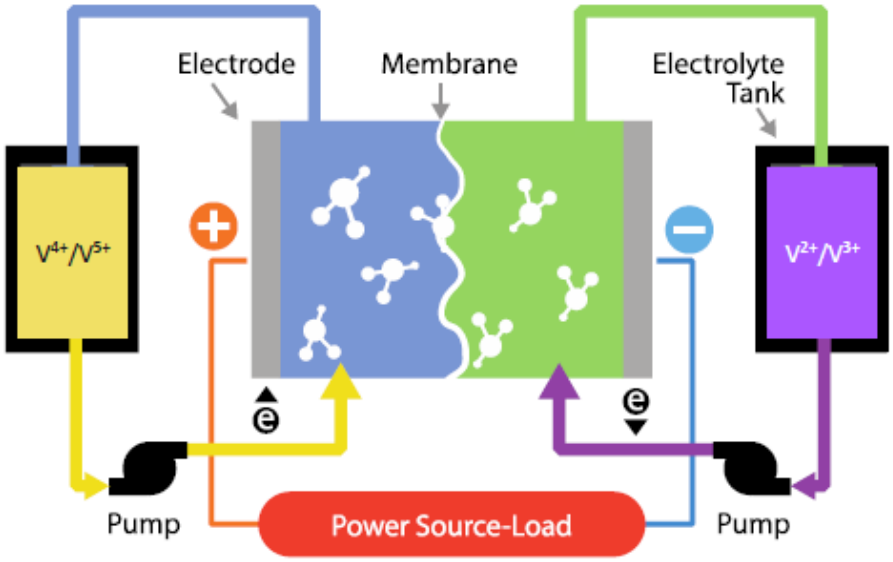
To solve these challenges research into a solid-state separator, which, alongside solid-state electrolytes would be impermeable to dendrites, has been ongoing for decades. Progress has been made, however, the 'holy grail' of a commercial solid-state Li-ion battery, enabling a solid Li anode, remains elusive.

If solid-state Li-ion batteries can be commercialised it could also offer additional improvements beyond just energy density, with potential reductions in the charging time and manufacturing cost, alongside increases in cycle life and improvements in safety (since the flammable hydrocarbon liquid electrolyte could also be eliminated).

The use of silicon as an anode would also substantially increase Li-ion battery capacity, however, silicon anodes swell by >300% during charging. This introduces other challenges, including capacity fade over time and shortened lives owing to damage caused by expansion/contraction of the anode.

Flow batteries
The flow battery was developed in the 1970s by NASA, and differs from a conventional battery since the liquid electrolytes are held in separate storage tanks, rather than in the power cell of the battery. The liquid electrolytes are pumped through a stack of power cells where the electrochemical reaction takes place; the system incorporates some moving parts (pumps and valves) in contrast to a conventional battery.

Figure 57: Schematic overview of VRFB



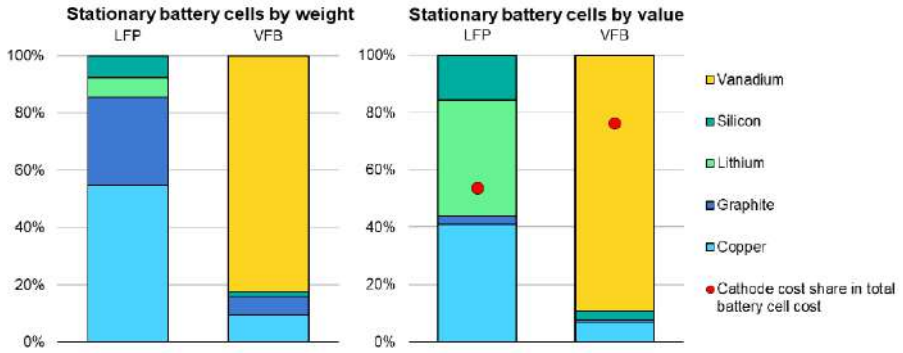
Source: Company, IEEE Spectrum October 2017

Different types of flow batteries incorporate different liquid electrolytes, with vanadium redox flow batteries taking advantage of the fact vanadium can exist in four different electrochemical states. This means a single element (vanadium) can be used in both parts of the battery (as catholyte and anolyte), avoiding the potential for cross contamination of the electrolyte. The electrolyte consists primarily of water, with additives such as sulfuric acid or hydrochloric acid. Vanadium has been used in flow batteries since the mid-1980s.

VRFBs have a few key differences to Li-ion batteries, they:

- Have very long lifespans, with the ability to charge/discharge 15-35,000+ times for over 20 years with minimal performance degradation. There can be no cross-contamination with the same metal in both electrolyte solutions.
- Are unaffected by almost complete discharge on each cycle.
- Cannot suffer from thermal runaway, and therefore are not a fire risk.
- Energy storage (electrolyte volume) and power generation (stack size) are decoupled, unique amongst batteries, permitting independent expansion of the storage capacity. This characteristic can be particularly beneficial in LDES applications.
- Are recyclable, with 100% of the vanadium content re-usable upon decommissioning.
- Have a lower energy density, i.e. for a given storage capacity the installation needs to be larger (size/weight), although this may not be a significant issue for static grid storage projects, for example storage facilities co-located with renewable energy projects.
- Have a long life with essentially no degradation of the electrolyte over time, although pumps and stack components (membranes and electrodes) will need replacement every 10-20yrs.
- Replace a reliance upon lithium with a reliance upon vanadium. Historically vanadium has accounted for a larger proportion of battery costs than lithium in li-ion batteries, as shown below. Clearly this can vary with market prices for the respective metals.

Figure 58: Vanadium accounts for a greater proportion of total costs for VRFBs
(2021 figs)



Source: IEA Energy Technology Perspectives 2023. LFP – lithium iron phosphate, VFB – vanadium flow battery

Since the vanadium is re-usable at the end of the battery life, and the electrolyte is stored in tanks separate from the stack, VRFBs are particularly well suited to rental models for the supply of vanadium.

The IEA notes “flow batteries could emerge as a breakthrough technology for stationary storage as they do not show performance degradation for 25-30 years and are capable of being sized according to energy storage needs with limited investment”. The technology is in the early stages of commercialisation, compared to Li-ion and lead-acid batteries, hence there is significant growth potential, within a growing broader energy storage market, over the coming years. China and Japan in particular have developed some large scale VRFB projects; last year a 100MW/400MWh VRFB was commissioned in Dailan, China in July 2022 with plans to double the capacity over time.

Other chemical formulations can be used with several zinc-based flow and hybrid batteries under development. In a hybrid redox flow battery at least one solid electroactive metal forms part of the electro-chemical reaction. Of these the zinc-bromine flow battery technology is the most mature, having been tested for use in EVs in the 1980s and 1990s, with grid level applications from the 2000s. The technology offers comparable performance characteristics to VRFBs, furthermore zinc and bromine are low-cost materials. The overall cost of a ZBFB is, however, increased owing to the requirement to sequester and recover toxic bromine vapour emissions, resulting in overall costs comparable to VRFBs.

Research and development activity is ongoing into a number of alternate flow battery chemistries, some of which incorporate vanadium, to try and improve performance and reduce costs with a particular focus on increasing energy density.

Lead acid
Lead acid batteries were invented in the 1850s and the technology is mature. The most common application today is in ICEs (Internal Combustion Engines), principally to drive the starter motor and store electrical energy for other electrical components. They are also still widely used in storage applications.

These batteries are relatively low cost (comparable with Li-ion prior to recent price increases), offer high efficiencies and can be recycled. Lead acid batteries do, however, come with some operational constraints. They are typically operated with a limited depth of discharge since their life is shortened if the state of charge falls below 20%. They also have a shorter life and lower round-trip efficiency than Li-ion. Around 50% of the energy capacity of a lead-acid battery is available over a one hour time period, and ~80% over 10 hours, with the stated capacity only deliverable over 50-100hrs. In storage applications lead-acid batteries are often cycled to 50%-80% DoD (Depth of Discharge). Liberation of hydrogen and oxygen gas during charging can be a safety concern.

Sodium-sulfur batteries
Sodium-sulfur batteries have been used for grid storage since the early 2000s and dominated grid storage deployments until around 2014, after which Li-ion technologies were favoured. They have a high energy density, high operating efficiency, a good lifetime and fast response times, however, they are high cost and sodium is highly flammable resulting in safety concerns.

Compressed air – mechanical
In this approach air is pumped into a large underground formation, building up pressure that can be released in the future to turn a turbine and generate electricity.

Compressed air systems have relatively low unit operating costs and reasonable cycle efficiencies but are only applicable in relatively large capacity installations. They are particularly well suited to areas where longer duration storage (12-24hrs) is required.

They require large, air-tight underground caverns (ideally pre-existing to reduce costs, often leached from underground salt formations) in which to store the compressed gas, which limits their global applicability. Compressed air projects are, therefore, not particularly well suited for co-location near renewable energy projects in a distributed system. To date this technology has seen relatively limited application.

Other compressed air solutions utilise abandoned mines, repurposing former mines as energy storage solutions in a net-zero carbon energy system.

Thermal storage – thermal

Thermal energy storage techniques are also being developed which can be particularly efficient where thermal energy is required for district heating systems, thus avoiding the requirement to convert thermal energy back into electrical energy, avoiding conversion losses.

If the amounts of thermal energy stored, and the operating temperatures, are sufficiently high the thermal energy can be converted back into electricity, although each conversion stage clearly introduces losses into the system.

Different materials are used for thermal storage, including molten salt, sand, concrete, rocks, metals or underground aquifers. Thermal storage can also involve cooling a material with energy released as the process is reversed.

A heat pump can be employed to transfer from a cold body to a hot body for storage, turning a generator when the system is operated in reverse.

Flywheels – mechanical

A spinning flywheel stores kinetic energy which can be released to turn a turbine to generate power. Inherent to the design of a flywheel is the inertia of the rotating mass, making it particularly suitable for short-term frequency regulation duties.

Flywheels can achieve high efficiencies, have long lifetimes and are unaffected by the depth of discharge, however, they are not well suited to longer-duration storage applications. Careful consideration must be given to the design of the rotor and bearings which need to operate consistently at high revolutions with significant mass, the product of which determines the capacity.

Hydrogen, ammonia, power to X – chemical

Electrical energy can be converted to hydrogen in an electrolyser. This hydrogen could potentially be stored in underground caverns and could bridge inter seasonal or inter year storage requirements in a similar way to natural gas storage today. This green hydrogen (if created using power from renewable sources) could be used to decarbonise sectors which are challenging to decarbonise through electrification; typically industrial processes requiring high temperatures. Alternatively green hydrogen could be converted into other green molecules (for example ammonia) for transport, storage, use in industrial processes or directly as a fuel (eg ammonia in shipping).

Each step in the conversion process, however, results in energy losses, reducing the overall efficiency. Although power prices may in future be significantly lower during periods of high renewable energy generation, intermittent operation of electrolysers during period of curtailment and lo (potentially negative) poer price is not anticipated to offer attractive economics overall.

Financial forecasts

Figure 59: Summary operating data

	Unit	2019	2020	2021	2022	2023E	2024E	2025E	2026E	2027E
Production (mtV)	**mtV**	**2,833.0**	**3,631.9**	**3,592.0**	**3,841.0**	**4,200.0**	**4,400.0**	**4,600.0**	**5,040.0**	**5,040.0**
Vametco @ 100% - fully consolidated	mtV	2,833.0	2,646.0	2,453.0	2,704.0	2,700.0	2,700.0	2,700.0	2,700.0	2,700.0
Vanchem	mtV	0.0	985.9	1,139.0	1,137.0	1,500.0	1,700.0	1,900.0	2,340.0	2,340.0
Sales (mtV)	**mtV**	**2,392.0**	**3,831.4**	**3,314.0**	**3,584.0**	**4,461.0**	**4,400.0**	**4,600.0**	**5,040.0**	**5,040.0**
Vametco @ 100% - fully consolidated	mtV	2,392.0	2,901.0	2,247.8	2,531.6	2,875.3	2,700.0	2,700.0	2,700.0	2,700.0
Vanchem	mtV	0.0	930.4	1,066.2	1,052.4	1,585.7	1,700.0	1,900.0	2,340.0	2,340.0
Sales as % of prod	%	84%	105%	92%	93%	106%	100%	100%	100%	100%
Realised price	US$/kg	48.7	23.5	32.2	42.5	37.9	40.8	42.4	42.6	43.7
LMB V price (US$/kgV)	US$/kg	42.3	25.0	34.5	39.2	35.0	38.5	40.7	41.8	42.8
Realised price as % of LMB (%)	%	115%	94%	93%	108%	108%	106%	104%	102%	102%

Source: Company, BNP Paribas Exane estimates

Figure 60: Income statement

	Unit	2019	2020	2021	2022	2023E	2024E	2025E	2026E	2027E
Revenue from contracts with customers	US$m	**116.5**	**90.0**	**106.9**	**152.2**	**168.9**	**179.5**	**194.9**	**214.7**	**220.1**
Sale of goods	US$m	116.4	89.9	106.9	152.2	168.9	179.5	194.9	214.7	220.1
Vametco (US$m)		117.2	66.6	73.0	108.0	109.1	110.2	114.4	115.0	117.9
Vanchem		0.0	23.3	33.9	44.2	59.8	69.4	80.5	99.7	102.2
Other revs (by deduction)		(0.8)	(0.1)	0.0						
Rendering of services										
Bushveld Energy	US$m	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Growth - period on period (%)	%	-39.3%	-22.8%	18.7%	42.4%	11.0%	6.3%	8.6%	10.1%	2.5%
Other income	US$m		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% of sales	%	*0%*	*0%*	*0%*	0%	0%	0%	0%	0%	0%
Gross Income	US$m	**116.5**	**90.0**	**106.9**	**152.2**	**168.9**	**179.5**	**194.9**	**214.7**	**220.1**
Growth - period on period	%	*-39.3%*	*-22.8%*	*18.7%*	42.4%	11.0%	6.3%	8.6%	10.1%	2.5%
COGS (incl depn)	**US$m**	**(56.2)**	**(91.3)**	**(102.8)**	**(116.3)**	**(133.0)**	**(130.7)**	**(137.0)**	**(148.2)**	**(150.7)**
% of sales	%	*-48.2%*	*-101.4%*	*-96.2%*	-76.4%	-78.8%	-72.8%	-70.3%	-69.0%	-68.5%
o/w depn		*-10.388*	*-17.866*	*-19.395*	-18.717	-18.600	-17.438	-16.283	-15.339	-14.608
COGS excl depn		*-45.811*	*-73.395*	*-83.388*	-97.592	-114.422	-113.245	-120.754	-132.898	-136.081
Gross profit	**US$m**	**60.3**	**(1.3)**	**4.1**	**35.9**	**35.9**	**48.9**	**57.9**	**66.5**	**69.4**
Gross profit margin (excl other income) on sale of goods	%	*51.8%*	*-1.4%*	*3.8%*	23.6%	21.2%	27.2%	29.7%	31.0%	31.5%
Other op income	US$m	0.9	2.3	2.6	2.6	2.6	2.6	2.6	2.6	2.6
Impairments	US$m	0.0	0.0	(2.4)	0.0	0.0	0.0	0.0	0.0	0.0
Selling & distr	US$m	(7.6)	(4.8)	(6.4)	(8.6)	(9.5)	(10.1)	(11.0)	(12.1)	(12.4)
Other mine opex	US$m	(3.9)	(4.7)	(3.2)	(2.6)	(2.6)	(2.6)	(2.6)	(2.6)	(2.6)
Idle plant costs	US$m	(2.9)	(4.2)	(3.4)	(5.2)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)
Sh based payments	US$m	0.0	(0.4)	0.4	0.0	0.0	0.0	0.0	0.0	0.0
Admin expenses	US$m	(24.7)	(19.8)	(20.9)	(19.7)	(18.8)	(19.3)	(19.9)	(20.5)	(21.1)
Other	US$m	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total other op/admin costs		(38.1)	(31.5)	(33.4)	(33.5)	(30.3)	(31.5)	(32.9)	(34.6)	(35.6)
EBIT	**US$m**	**22.3**	**(32.8)**	**(29.3)**	**2.4**	**5.6**	**17.4**	**25.0**	**31.9**	**33.8**
EBIT margin	%	*19.1%*	*-36.5%*	*-27.4%*	1.6%	3.3%	9.7%	12.8%	14.8%	15.4%
add back DD&A		10.4	17.9	21.8	18.7	18.6	17.4	16.3	15.3	14.6
EBITDA	**US$m**	**32.6**	**(14.9)**	**(7.4)**	**21.1**	**24.2**	**34.8**	**41.3**	**47.2**	**48.5**
EBITDA margin	%	*28.0%*	*-16.6%*	*-7.0%*	13.9%	14.3%	19.4%	21.2%	22.0%	22.0%
Net interest cost	US$m	1.9	(4.7)	(11.2)	(10.5)	(12.2)	(11.7)	(11.3)	(10.6)	(10.1)
Net other financial items	US$m	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Remeasurement of fin liabs		0.0	0.0	(1.9)	0.0	0.0	0.0	0.0	0.0	0.0
Losses from JV		0.0	0.0	(4.4)	(3.8)	0.0	0.0	0.0	0.0	0.0
Movement in earnout est		(1.5)	(0.2)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other		60.6	0.0	0.0	(0.1)	0.0	0.0	0.0	0.0	0.0
Income (loss) before tax	**US$m**	**83.3**	**(37.7)**	**(46.8)**	**(12.1)**	**(6.6)**	**5.7**	**13.7**	**21.3**	**23.7**
Income tax	US$m	(14.0)	6.6	4.7	(2.0)	1.9	(1.6)	(4.0)	(6.2)	(6.9)
Net income (loss) from continuing operations	**US$m**	**69.2**	**(31.1)**	**(42.1)**	**(14.1)**	**(4.7)**	**4.0**	**9.7**	**15.1**	**16.9**
Profit (loss) from discontinued operations	US$m	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Net income (loss) for the period	**US$m**	**69.2**	**(31.1)**	**(42.1)**	**(14.1)**	**(4.7)**	**4.0**	**9.7**	**15.1**	**16.9**
o/w: attributable to equity holders of the parent	US$m	62.0	(30.6)	(40.8)	(16.5)	(7.1)	1.6	7.3	12.7	14.5
o/w: attributable to non-controlling interests	US$m	7.3	(0.5)	(1.3)	2.4	2.4	2.4	2.4	2.4	2.4
Ave basic NOSH	m	1,125.6	1,164.7	1,201.7	1,267.3	1,303.0	1,348.6	1,348.6	1,348.6	1,348.6
Basic EPS	US$c/sh.	5.50	(2.60)	(3.38)	(1.30)	(0.54)	0.12	0.54	0.94	1.07
Dividend paid per share	US$/sh.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: Company, BNP Paribas Exane estimates

Figure 61: Cash flow statement

		2019	2020	2021	2022	2023E	2024E	2025E	2026E	2027E
Profit/(loss) before tax	US$m	83.3	(37.7)	(46.8)	(12.1)	(6.6)	5.7	13.7	21.3	23.7
DD&A (incl right of use assets)	US$m	10.4	17.9	19.4	18.7	18.6	17.4	16.3	15.3	14.6
Loss from JV	US$m	0.0	0.0	4.4	3.8	0.0	0.0	0.0	0.0	0.0
Movement in earnout est	US$m	1.5	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Remeasurement of fin liabs	US$m	0.0	0.0	1.9	0.0	0.0	0.0	0.0	0.0	0.0
Int income	US$m	(3.6)	(1.1)	(0.9)	(0.2)	(0.3)	(0.3)	(0.5)	(0.7)	(1.2)
Fin costs	US$m	1.7	5.7	12.2	10.8	12.5	12.0	11.8	11.3	11.3
Impairments	US$m	0.0	0.0	2.4	0.0	0.0	0.0	0.0	0.0	0.0
Non-cash items in op loss	US$m				0.0	0.0	0.0	0.0	0.0	0.0
Inc/(dec) provisions	US$m				0.0	0.0	0.0	0.0	0.0	0.0
Income tax (paid)/refunded	US$m	(8.8)	(3.5)	0.4	(0.7)	(8.3)	(1.2)	(3.9)	(6.2)	(7.0)
Sh based payments	US$m				0.0	0.0	0.0	0.0	0.0	0.0
Other	US$m	(60.6)	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Op CF (pre w/c)	**US$m**	**23.9**	**(18.4)**	**(7.1)**	**20.5**	**15.9**	**33.7**	**37.4**	**41.0**	**41.5**
Changes in working capital	US$m	4.6	1.3	(5.0)	4.1	(0.3)	(6.0)	(3.1)	(4.8)	(0.8)
Op CF (post w/c)	**US$m**	**28.5**	**(17.1)**	**(12.1)**	**24.6**	**15.7**	**27.7**	**34.2**	**36.2**	**40.7**
Fin income	US$m	3.6	1.0	0.9	0.2	0.3	0.3	0.5	0.7	1.2
Acqns	US$m	(30.7)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Proceeds from sale of PPE	US$m	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Purchase of PPE	US$m	(13.3)	(9.3)	(19.5)	(20.1)	(10.2)	(7.5)	(8.0)	(9.1)	(9.2)
Payment of deferred consideration	US$m	(3.6)	(1.7)	(3.9)	0.0	0.0	0.0	(1.7)	0.0	0.0
Purchase of investments	US$m	(4.4)	(1.9)	(10.0)	(1.2)	0.0	0.0	0.0	0.0	0.0
Purchase of expl assets	US$m	(1.3)	(1.5)	(0.9)	(0.5)	(0.5)	(0.5)	(0.5)	(0.5)	(0.5)
Disposal of fin assets held at FV	US$m	0.0	0.3	16.1	0.0	0.0	0.0	0.0	0.0	0.0
Sub-lease income received	US$m				0.0	0.0	0.0	0.0	0.0	0.0
Other	US$m				0.0	0.0	0.0	0.0	0.0	0.0
Net cash from investing activities	**US$m**	**(49.7)**	**(13.0)**	**(17.2)**	**(21.6)**	**(10.4)**	**(7.7)**	**(9.6)**	**(8.8)**	**(8.5)**
Change in external borrowings		**18.6**	**49.4**	**(4.7)**	**(0.6)**	**(4.1)**	**(7.8)**	**(9.1)**	**(13.2)**	**(1.0)**
Proceeds from loans		**0.0**	**1.6**	**1.3**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Finance costs	US$m	(0.1)	(3.1)	(2.9)	(3.1)	(4.9)	(6.8)	(6.3)	(5.7)	(5.3)
Acquisition of non-controlling interests	US$m				0.0	0.0	0.0	0.0	0.0	0.0
Transactions in own shares	US$m	0.0	0.0	0.0	0.0	4.5	0.0	0.0	0.0	0.0
Dividends paid to non-controlling interests	US$m				0.0	0.0	0.0	0.0	0.0	0.0
Dividends to shareholders	US$m	(4.5)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Leases paid	US$m	(0.7)	(0.8)	(0.7)	(0.5)	(0.5)	(0.5)	(0.5)	(0.5)	(0.5)
Other	US$m			0.0	0.0	0.0	0.0	0.0	0.0	0.0
Net cash from financing	**US$m**	**13.3**	**47.1**	**(7.0)**	**(4.2)**	**(4.9)**	**(15.0)**	**(15.9)**	**(19.3)**	**(6.8)**
Change in cash	**US$m**	**(8.0)**	**17.0**	**(36.3)**	**(1.2)**	**0.3**	**5.0**	**8.7**	**8.1**	**25.4**
Cash at the beginning of the period	US$m	42.0	34.0	50.5	15.4	11.7	12.0	17.1	25.8	33.8
FX impact	US$m	(0.0)	(0.4)	1.2	(2.5)	0.0	0.0	0.0	0.0	0.0
Cash at the end of the period	**US$m**	**34.0**	**50.5**	**15.4**	**11.8**	**12.0**	**17.1**	**25.8**	**33.8**	**59.3**

Source: Company, BNP Paribas Exane estimates

Figure 62: Balance sheet

		2019	2020	2021	2022	2023E	2024E	2025E	2026E	2027E
Assets										
Intangible assets	US$m	59.4	59.0	59.3	58.9	59.4	59.9	60.4	60.8	61.3
Property, plant and equipment	US$m	185.3	167.6	153.1	151.6	143.2	133.2	124.9	118.7	113.3
o/w Lease receivables	US$m	0.0	5.5	5.1	4.8	4.4	4.0	3.7	3.3	2.9
Investment property		2.9	2.8	2.6	2.5	2.5	2.5	2.5	2.5	2.5
Financial assets at fair value		4.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Right-of-use assets	US$m	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Deferred tax assets	US$m	0.0	0.0	0.0	0.0	7.2	6.7	6.6	6.6	6.7
Other investments / Inv. in associates & JVs	US$m	0.0	0.0	7.9	5.3	5.3	5.3	5.3	5.3	5.3
Other non-current assets	US$m	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Interest bearing receivables	US$m	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total non-current assets	**US$m**	**252.0**	**229.4**	**222.8**	**218.3**	**217.6**	**207.6**	**199.7**	**194.0**	**189.2**
Current tax assets	US$m	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Trade, inventories and other receivables	US$m	39.6	44.5	59.3	62.9	64.4	70.1	73.4	80.0	81.6
Restricted inv		6.6	3.1	2.9	2.8	2.8	2.8	2.8	2.8	2.8
Current tax rec		0.5	0.8	0.3	0.7	0.7	0.7	0.7	0.7	0.7
Fin assets @ fair value		2.0	22.5	0.0	1.5	1.5	1.5	1.5	1.5	1.5
Cash and cash equivalents	US$m	34.0	50.5	15.4	11.8	12.0	17.1	25.8	33.8	59.3
Total current assets	**US$m**	**82.7**	**121.4**	**77.9**	**79.6**	**81.4**	**92.2**	**104.1**	**118.8**	**145.9**
Total assets	**US$m**	**334.7**	**350.8**	**300.7**	**297.9**	**299.0**	**299.8**	**303.9**	**312.8**	**335.0**
Liabilities										
Retirement benefit obligation	US$m	2.3	2.1	1.9	1.9	1.9	1.9	1.9	1.9	1.9
Env rehab facility		17.8	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
Deferred consideration		7.1	1.8	1.7	0.8	0.8	0.8	0.0	0.0	0.0
Loans		0.0	1.6	3.3	0.0	0.0	0.0	0.0	0.0	0.0
Borrowings - non-current	US$m	41.8	70.9	67.4	35.1	82.7	82.7	78.6	70.6	75.2
Lease liabilities - non-current	US$m	4.7	4.4	3.9	3.7	3.7	3.7	3.7	3.7	3.7
Deferred tax liabilities - non-current	US$m	24.3	11.6	6.0	3.0	0.0	0.0	0.0	0.0	0.0
Other non-current liabililities	US$m	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total non-current liabilities	**US$m**	**98.0**	**110.3**	**102.3**	**62.6**	**107.2**	**107.2**	**102.3**	**94.3**	**98.9**
Current tax liabilities	US$m	0.0	0.0	0.0	4.5	4.5	4.5	4.5	4.5	4.5
Trade and other payables	US$m	15.8	22.1	33.1	42.6	43.8	43.1	43.1	44.7	45.4
Provisions	US$m	3.4	3.3	3.7	1.9	1.9	2.3	2.4	2.7	2.7
Current borrowings	US$m	0.0	13.3	10.2	47.6	3.0	0.0	0.0	0.0	0.0
Current lease liabilities	US$m	0.8	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Deferred consideration										
Other	US$m	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total current liabilities	**US$m**	**20.0**	**43.1**	**47.6**	**97.9**	**54.6**	**51.4**	**50.6**	**52.4**	**53.2**
Total liabilities	**US$m**	**118.0**	**153.5**	**149.9**	**160.5**	**161.8**	**158.6**	**152.9**	**146.7**	**152.1**
Equity										
Total equity attributable to the parent	US$m	183.1	165.2	118.3	102.4	99.8	101.4	108.8	121.5	135.9
Non-controlling interests	US$m	33.5	32.1	32.5	35.0	37.4	39.8	42.2	44.6	47.0
Total S/H equity	**US$m**	**216.6**	**197.4**	**150.8**	**137.4**	**137.2**	**141.2**	**151.0**	**166.1**	**182.9**
Total liabilities and equity	**US$m**	**334.7**	**350.8**	**300.7**	**297.9**	**299.0**	**299.8**	**303.9**	**312.8**	**335.0**
Net debt/(cash)	**71**	**7.7**	**33.7**	**62.2**	**70.9**	**73.7**	**65.6**	**52.8**	**36.8**	**15.9**

Source: Company, BNP Paribas Exane estimates

Management & board

CEO & co-founder: Fortune Mojapelo

Appointed to the board in 2012. Fortune has played leading roles in origination, establishment and project development of several junior mining companies in Africa and began his career at McKinsey as a strategy consultant

FD: Tanya Chikanza

Appointed to the board in 2019. Tanya has extensive experience managing publicly-listed company's relationships with financial markets and previously worked at Lonmin, Smith's Corp Advisory and JPM Cazenove. Tanya is a Qualified Chartered Accountant.

Non-exec Chairman: Ian Watson

Appointed to the board in 2012. Ian was a mining engineer with experience across the South African mining sector. He was previously MD of Northern Platinum, CEO of Platmin Ltd and International Ferro Minerals (SA).

Senior Independent NED: Michael Kirkwood

Appointed to the board in 2018. Michael worked at Citigroup for 31 years, chairs Ondra LLP and has held main board roles at a number of listed companies.

Independent NED: Jacqueline Musiitwa

Appointed to the board in 2022.Jacqueline is a qualified attorney and founder of Hoja Law Group.

Independent NED: Kevin Alcock

Appointed to the board in 2022. Kevin is a qualified chartered accountant, entrepreneur, business leader and advisor. He has managed a portfolio of clients and PE investments in the UK and Southern Africa including holding a number of NED roles.

Independent NED: Mirco Bardella

Appointed to the board in 2022. Mirco is a chartered accountant and former EY Assurance Partner.

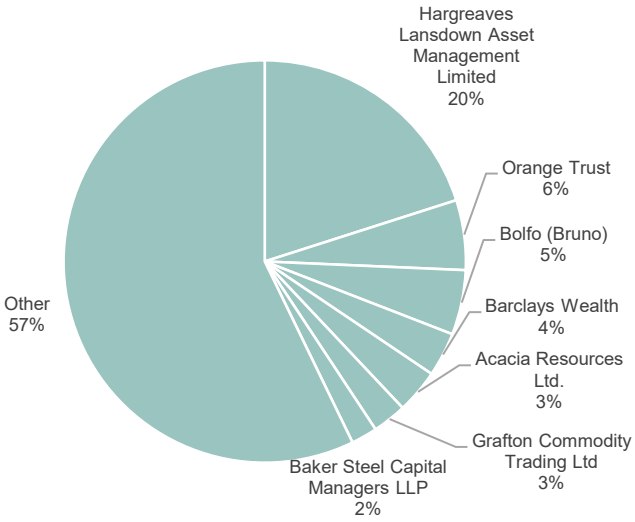
Independent NED: David Noko

Appointed to the board in 2022. David has held a number of senior roles at companies including GE, Pepsi, SA Breweries, De Beers and Anglo Gold Ashanti.

Major shareholders

The chart below shows the breakdown of major shareholders in Bushveld Minerals.

Figure 63: Shareholder register



Source: Reuters, BNP Paribas Exane estimates

Appendix

2020 Orion financing package - details

The Orion financing package comprised two tranches:

- US$35m convertible loan note (10% pa capitalised interest, 3yr tenor)
- US$30m Production Financing Agreement (PFA)

Initially the convertible debt was intended to fund a critical refurbishment program at Vanchem following its acquisition in 3Q 2019, and debt repayment, and the PFA was intended to fund expansion plans at Vametco and debt repayment. In August 2021 the terms of the PFA were amended so a portion of the proceeds could be used to fund the kiln 3 refurbishment at Vanchem.

Repayment of the PFA (interest and principal) is linked to production and sales; initially only for Vametco, but following the amendment it is also linked to production and sales from Vanchem.

Details of PFA repayment structure over life of project
The PFA repayment comprises a revenue-linked and a production-linked element over the life of the Vametco and Vanchem projects.

Revenue-linked payment:

- percentage of gross revenues
- 1.175% in 2020/21, 1.45% from 2022 onwards
- subject to an unspecified adjustment related to prevailing vanadium prices

Production-linked payment:

- Base unit rate of US$0.443/kg vanadium sold
- Paid on greater of annual sales, or 4,300mtV pa (from 2023); Bushveld targets sales >4,300mtV pa from 2023
- US CPI inflation applies to the base unit rate

Once cumulative production from Vametco and Vanchem reaches 132,020 mtV over the term of the facility, the revenue rate and unit rate will reduce to 25% of the applicable rate (at 5,000mtV pa this would take just over 26 years).

We calculate an effective interest rate of ~15.8% pa for the notional interest portion of the PFA over the life of the project.

2023 Orion convertible note refinancing - details

The proposed refinancing comprises the following instruments:

- A new US$27m 3-year term loan covering 60% of the existing convertible. Interest: 6.0% margin plus the greater of 3-month SOFR or 3% pa. 25% of the facility will be repaid in June 2024, 30% in June 2025 and 45% in June 2026.
- A new US$13.5m convertible loan covering 30% of the existing convertible. Interest 12%, exercise price 8p/sh, maturity 30 June 2028.
- Conversion of US$4.5m (10%) of the existing convertible loan notes into shares at 6p/sh

– A supplemental production financing agreement (PFA) comprising a 0.22% of gross revenues when vanadium prices are <US$47/kg and 0.18% >US$47/kg. In June 2027 the rate will reduce by 80% for the life of mine.

The refinancing transaction is conditional on several items, including due diligence, shareholder approval at a general meeting, definitive documentation, consent by the Financial Surveillance Dept of the South African Reserve Bank and any other amendments to the existing security structure with Nedbank as required.

The refinancing has been approved by Orion's investment committee, however, there are certain conditions precedent that need to be met, including completion of final legal documentation and final investment committee approval.

Investment case, valuation and risks

Bushveld

Investment case

Bushveld holds a significant position within the global primary vanadium production market, operating 2 of the 4 processing facilities and 1 of the 3 operating mines globally. We believe Bushveld has considerable asset value potential following recent investments, but successful implementation of the proposed convertible debt refinancing and continued production ramp-up is required to unlock this value.

Valuation methodology

We utilise a DCF based valuation when assessing Bushveld Minerals.

Risks

To the upside:
The production ramp-up, particularly at Vanchem, may proceed more rapidly than we have modelled.

Load shedding may have a less material impact on operations than modelled

Vanadium pricing may be higher than we have modelled; it hit >US$80/kg in 2018.

Unhedged FX exposure (principally ZAR/US$) may have a positive impact upon financial results.

It may be possible to contain operating costs below the levels we have modelled.

To the downside:
It may not be possible to complete the convertible refinancing on the agreed terms.

Production ramp-up may disappoint versus our forecasts, potentially driven by a greater than anticipated impact from load-shedding.

Vanadium pricing may be lower than we have modelled; it hit <US$25/kg in 2019.

Funding may not be available in the amounts/or the terms required.

Unhedged FX exposure (principally ZAR/US$) may adversely impact financial results.

Although agreements have been secured in the near-term, it may not be possible to secure sufficient volumes of third party ore for processing at Vanchem on the terms modelled.

Operating costs could move above the levels we have modelled.

DISCLOSURE APPENDIX

Analyst Certification

I, Thomas Martin, (authors of or contributors to the report) hereby certify that all of the views expressed in this report accurately reflect my personal view(s) about the company or companies and securities discussed in this report. No part of my compensation was, is, or will be, directly, or indirectly, related to the specific recommendations or views expressed in this research report.

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Thomas Martin	Exane SA London branch

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Bushveld	6; 12; 13

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13 – Sections of this report, with the research summary, target price and rating removed, have been presented to the subject company/ies prior to its distribution, for the sole purpose of verifying the accuracy of factual statements.
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Bushveld	4; 5

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Price and Ratings Chart

Bushveld

Not Available

The latest company-specific disclosures, valuation methodologies and investment case risks for all other companies covered by this document are available on http://cube.exane.com/compliance.

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BUSHVELD

Price at 25 May 23: 3.65p

Mining - United Kingdom

4.80p (+32%) | 6.80p (+86%)

Company description

Bushveld produces a range of vanadium products from its mining and processing operations in South Africa. It operates two of the world's four operational vanadium ore processing facilities (Vametco and Vanchem), and one of only three operating primary vanadium mines (the Vametco mine). Vanadium is a metal primarily used in steel production, which is increasingly being used globally in utility scale battery storage systems (Vanadium Redox Flow Batteries - VRFBs).

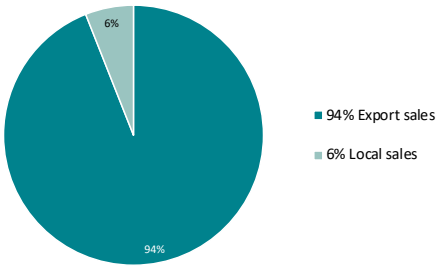
Management

Fortune Mojapelo, CEO
Tanya Chikanza, Financial Director

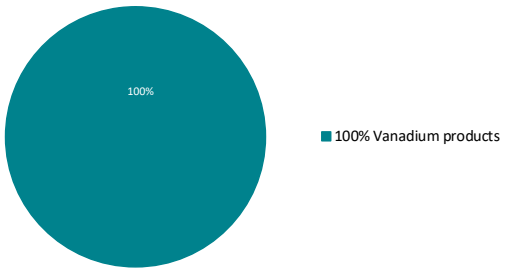
Ownership structure

Hargreaves Lansdowne	20.0%
Orange Trust	6.0%
Bruno Bolfo	5.0%
Barclays Wealth	4.0%
Grafton Commodity Trading	3.0%
Acacia Resources	3.0%
Baker Steel	2.0%
Other Shareholders	57.0%

Revenues



Revenues



Analyst

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Peer group YTD performance

Stock	Price (25 May 23)		YTD performance in EUR (%) Abs.	Rel. Sector
Eramet (=)	EUR	87.8	4.7	28
First Quantum M (=)	CAD	29.5	3.4	26
Imerys (+)	EUR	32.9	0.3	22
Barrick (=)	USD	17.1	(0.7)	21
Aurubis (=)	EUR	72.3	(4.0)	17
South32 (+)	p	206	(5.5)	15
BHP Group (-)	p	2,220	(8.0)	12
Antofagasta Plc (-)	p	1,350	(8.4)	12
Norsk Hydro (=)	NOK	68.3	(11.6)	8
Freeport (+)	USD	33.6	(11.6)	8
Boliden (-)	SEK	333.3	(12.8)	6
Rio Tinto (=)	p	4,758	(13.4)	6
Newmont (+)	USD	40.6	(13.9)	5
Glencore (+)	p	416	(19.9)	(2)
Vale (=)	USD	12.9	(23.0)	(6)
Bushveld (SR)	**p**	**3.65**	**(23.3)**	(6)
Anglo American (=)	p	2,267	(26.7)	(11)

Sector calendar

26 May 23	**Glencore**: AGM
06 Jun. 23	**Freeport**: AGM (19:00 CET)
13 Jun. 23	**Aurubis**: Capital Markets Day (09:00 CET)
18 Jul. 23	**Petra Diamonds**: Annual Trading Statement 2023 (08:00 CET)
	Rio Tinto: Q2 Operating Results 2023 (23:30 CET)
19 Jul. 23	**BHP Group**: Annual Operating Results 2022/23
	Antofagasta Plc: Q2 Production Report 2023 (08:00 CET)
20 Jul. 23	**Boliden**: Q2 Results 2023 (07:45 CET)
	Boliden: Q2 Results 2023 (07:45 CET)
	Anglo American: Q2 Production Report 2023 (08:00 CET)
21 Jul. 23	**Norsk Hydro**: H1 Results 2023 (07:00 CET)
	Glencore: GLEN LN - H1 Production Report 2023 (08:00 CET)
24 Jul. 23	**South32**: Q4 Operating Results 2022/23
26 Jul. 23	**Centamin Plc**: Q2 Results 2023 (08:00 CET)
	Rio Tinto: Interim Results 2023 (23:30 CET)
27 Jul. 23	**Anglo American**: Interim Results 2023 (08:00 CET)
	Imerys: H1 Results 2023 (17:45 CET)
07 Aug. 23	**Aurubis**: Q3 Results 2022/23 (07:00 CET)
08 Aug. 23	**Glencore**: Interim Results 2023 (08:00 CET)
10 Aug. 23	**Antofagasta Plc**: Interim Results 2023 (08:00 CET)
22 Aug. 23	**BHP Group**: Preliminary Results 2022/23
24 Aug. 23	**South32**: Annual Results 2022/23
12 Sep. 23	**Petra Diamonds**: Preliminary Results 2023 (08:00 CET)

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Price at 25 May 23: 3.65p

Valuation range (p): 4.80 (+32%) | 6.80 (+86%)

BUSHVELD

Refinitiv / Bloomberg: BMNB.L / BMN LN

Analyst: Thomas Martin (+44) 203 430 8435

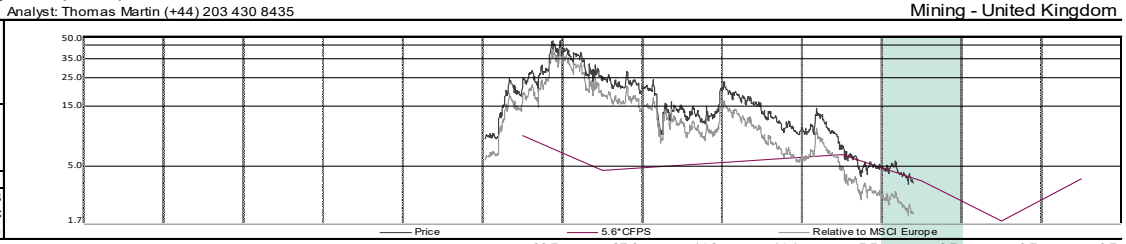
Mining - United Kingdom

Company Highlights	USDm / EURm
Enterprise value	177 / 165
Market capitalisation	61 / 57
Free float	49 / 45
3m average volume	0.3 / 0.2

Performance (*)	1m	3m	12m
Absolute	(10%)	(26%)	(59%)
Rel. Sector	(5%)	(11%)	(52%)
Rel. MSCI Europe	(7%)	(25%)	(63%)

12m Hi/Lo : 9.3p -61% / 3.60p +1%

CAGR	2019/2022	2022/2025
EPS restated	NC	NC
CFPS	10%	(14%)



Price (yearly avg from Dec. 18 to Dec. 22)	*22.7*	*27.6*	*14.3*	*14.1*	*7.7*	*3.7*	*3.7*	*3.7*
PER SHARE DATA (USD)	**Dec. 18**	**Dec. 19**	**Dec. 20**	**Dec. 21**	**Dec. 22e**	**Dec. 23e**	**Dec. 24e**	**Dec. 25e**
No of shares year end, basic, (m)	1 119.728	1 153.643	1 190.758	1 260.459	1 287.818	1 348.611	1 348.611	1 348.611
Avg no of shares, diluted, excl. treasury stocks (m)	2 163.636	2 279.205	1 164.710	1 201.683	1 267.299	1 303.016	2 697.222	2 697.222
EPS reported, Gaap								
EPS company definition								
EPS restated, fully diluted	0.01	0.03	(0.03)	(0.03)	(0.01)	(0.01)	0.00	0.00
% change	*NS*	*94.7%*	*NS*	*(29.2%)*	*61.6%*	*58.1%*	*NS*	*349.2%*
Book value (BVPS) (a)	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1
Net dividend								
STOCKMARKET RATIOS	**Dec. 18**	**Dec. 19**	**Dec. 20**	**Dec. 21**	**Dec. 22e**	**Dec. 23e**	**Dec. 24e**	**Dec. 25e**
P / E (P/ EPS restated)	21.6x	12.9x	NC	NC	NC	NC	74.5x	16.6x
P / E relative to MSCI Europe	143%	94%	NC	NC	NC	NC	626%	150%
P / CF	14.7x	33.7x	NC	NC	7.0x	5.4x	11.2x	5.2x
FCF yield	4.6%	(4.0%)	(12.4%)	(13.8%)	0.3%	(0.1%)	10.6%	14.3%
P / BVPS	2.61x	2.22x	1.32x	2.07x	1.20x	0.61x	0.60x	0.56x
Net yield								
Payout			NC	NC	NC	NC		
EV / Sales	1.67x	3.96x	3.37x	3.20x	1.56x	1.05x	0.93x	0.79x
EV / Restated EBITDA	3.2x	14.2x	NS	NS	11.2x	7.3x	4.8x	3.7x
EV / Restated EBITA	3.4x	20.8x	NS	NS	98.0x	31.8x	9.6x	6.1x
EV / NOPAT	4.7x	29.2x	NS	NS	NS	44.8x	13.6x	8.7x
EV / OpFCF	7.0x	NS	NS	NS	50.8x	13.4x	8.0x	5.5x
EV / Capital employed (incl. gross goodwill)	2.2x	1.7x	1.1x	1.4x	1.0x	0.8x	0.7x	0.7x
ENTERPRISE VALUE (USDm)	**321**	**462**	**304**	**342**	**237**	**177**	**168**	**154**
Market cap	316	396	213	233	120	61	61	61
+ Adjusted net debt	(42)	13	40	70	70	66	53	35
+ Other liabilities and commitments	2	2	2	2	2	2	2	2
+ Revalued minority interests	45	50	48	49	52	56	60	63
- Revalued investments	0	0	0	12	8	8	8	8
P & L HIGHLIGHTS (USDm)	**Dec. 18**	**Dec. 19**	**Dec. 20**	**Dec. 21**	**Dec. 22e**	**Dec. 23e**	**Dec. 24e**	**Dec. 25e**
Sales	**192**	**117**	**90**	**107**	**152**	**169**	**180**	**195**
Restated EBITDA (b)	**101**	**33**	**(15)**	**(10)**	**21**	**24**	**35**	**41**
Depreciation	(6)	(10)	(18)	(19)	(19)	(19)	(17)	(16)
Restated EBITA (b)	**95**	**22**	**(33)**	**(29)**	**2**	**6**	**17**	**25**
Reported operating profit (loss)	95	22	(33)	(29)	2	6	17	25
Net financial income (charges)	(9)	61	(5)	(13)	(11)	(12)	(12)	(11)
Affiliates	0	0	0	(4)	(4)	0	0	0
Other	0	0	0	0	0	0	0	0
Tax	(38)	(14)	7	5	(2)	2	(2)	(4)
Minorities	(19)	(7)	1	1	(2)	(2)	(2)	(2)
Net attributable profit reported	30	62	(31)	(41)	(17)	(7)	2	7
Net attributable profit restated (c)	**30**	**62**	**(31)**	**(41)**	**(17)**	**(7)**	**2**	**7**
CASH FLOW HIGHLIGHTS (USDm)	**Dec. 18**	**Dec. 19**	**Dec. 20**	**Dec. 21**	**Dec. 22e**	**Dec. 23e**	**Dec. 24e**	**Dec. 25e**
EBITDA (reported)	**101**	**33**	**(15)**	**(7)**	**21**	**24**	**35**	**41**
EBITDA adjustment (b)	**0**	**0**	**0**	**(2)**	**0**	**0**	**0**	**0**
Other items	0	(0)	(0)	2	0	0	0	0
Change in WCR	(25)	5	1	(5)	4	(0)	(6)	(3)
Operating cash flow	**76**	**37**	**(14)**	**(12)**	**25**	**24**	**29**	**38**
Capex	(30)	(49)	(12)	(24)	(21)	(11)	(8)	(10)
Operating free cash flow (OpFCF)	**46**	**(12)**	**(26)**	**(37)**	**5**	**13**	**21**	**28**
Net financial items + tax paid	(29)	(6)	(6)	(2)	(4)	(13)	(8)	(10)
Free cash flow	**17**	**(18)**	**(32)**	**(39)**	**1**	**(0)**	**13**	**18**
Net financial investments & acquisitions	0	(4)	(2)	6	(1)	0	0	0
Other	2	(23)	6	3	0	0	0	0
Capital increase (decrease)	23	0	0	0	0	5	0	0
Dividends paid	0	(4)	0	0	0	0	0	0
Increase (decrease) in net financial debt	**(42)**	**50**	**28**	**30**	**1**	**(4)**	**(13)**	**(18)**
Cash flow, group share	**45**	**24**	**(21)**	**(10)**	**17**	**11**	**11**	**23**
BALANCE SHEET HIGHLIGHTS (USDm)	**Dec. 18**	**Dec. 19**	**Dec. 20**	**Dec. 21**	**Dec. 22e**	**Dec. 23e**	**Dec. 24e**	**Dec. 25e**
Net operating assets	105	245	227	212	216	208	199	193
WCR	38	33	49	29	25	25	31	35
Restated capital employed, incl. gross goodwill	**143**	**278**	**275**	**242**	**241**	**234**	**231**	**228**
Shareholders' funds, group share	130	183	165	118	102	99	101	108
Minorities	30	34	32	32	35	37	40	42
Provisions/ Other liabilities	31	60	46	36	45	42	48	53
Net financial debt (cash)	(42)	8	35	65	66	62	49	31
FINANCIAL RATIOS (%)	**Dec. 18**	**Dec. 19**	**Dec. 20**	**Dec. 21**	**Dec. 22e**	**Dec. 23e**	**Dec. 24e**	**Dec. 25e**
Sales (% change)	NC	(39.3%)	(22.8%)	18.7%	42.4%	11.0%	6.3%	8.6%
Organic sales growth								
Restated EBITA (% change)	NC	(76.6%)	NC	10.7%	NC	130.2%	213.0%	43.7%
Restated attributable net profit (% change)	NC	105.1%	NC	(33.3%)	59.5%	57.0%	NC	349.2%
Personnel costs / Sales	3.7%	8.3%	9.1%	10.1%	5.3%	4.8%	4.9%	4.8%
Restated EBITDA margin	52.7%	28.0%	(16.6%)	(9.3%)	13.9%	14.3%	19.4%	21.2%
Restated EBITA margin	49.5%	19.1%	(36.5%)	(27.4%)	1.6%	3.3%	9.7%	12.8%
Tax rate	43.4%	16.8%	NC	NC	NC	NC	29.0%	29.0%
Net margin	25.5%	59.4%	(34.6%)	(39.4%)	(9.3%)	(2.8%)	2.2%	5.0%
Capex / Sales	15.8%	42.0%	13.8%	22.7%	13.5%	6.3%	4.4%	5.2%
OpFCF / Sales	23.7%	(10.0%)	(29.0%)	(34.4%)	3.1%	7.8%	11.6%	14.4%
WCR / Sales	19.5%	28.2%	54.3%	27.5%	16.6%	15.1%	17.5%	17.7%
Capital employed (excl. gdw./intangibles) / Sales	44.5%	187.2%	240.5%	170.8%	119.4%	103.3%	95.5%	86.6%
ROE	23.3%	33.8%	(18.5%)	(34.5%)	(16.2%)	(7.2%)	1.6%	6.8%
Gearing	(26%)	6%	20%	46%	52%	48%	38%	24%
EBITDA / Financial charges	NC	NC	NC	NC	2.0x	2.0x	3.0x	3.7x
Adjusted financial debt / EBITDA	NC	0.4x	NC	NC	3.3x	2.7x	1.5x	0.9x
ROCE, excl. gdw./intangibles	79.1%	7.2%	(10.8%)	(11.4%)	0.9%	2.3%	7.2%	10.5%
ROCE, incl. gross goodwill	47.4%	5.7%	(8.5%)	(8.6%)	0.7%	1.7%	5.4%	7.8%
WACC	15.7%				12.0%	11.3%	11.3%	11.3%

Latest Model update: 26 May. 23

(a) Intangibles: USD59.25m, or 0p per share. (b) adjusted for capital gains/losses, exceptional restructuring charges, capitalized R&D; EBITA also adjusted for impairments and am. of intangibles from M&A
(c) after EBITA adjustments and financial result/tax adjustments, (*) In listing currency, with div. reinvested