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NOVA – School of Business and Economics.

VALE, AN IRON GIANT WITH FEET OF CLAY? – IN
THE MIDST OF THE STEELMAKING TRANSITION
STRATEGY
PART 2

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Abstract

This report contains a detail of the cost assumptions for the Ferrous Minerals segment of Vale S.A., Then, it includes the Base Metals chapter, containing a deep dive into the nickel and copper markets, the future global scenarios the main revenue and costs assumptions for each metal. Finally, the report details the methodology and calculations performed in the Valuation chapter and, given the target share price for FY22 of \$14.06, the final recommendation of SELL is presented.

Keywords: Vale, iron ore, nickel, copper

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This report is part of the “*Vale, An Iron Giant With Feet of Clay? – In the Midst of the Steelmaking Transition Strategy*” report (annexed), developed by Pedro Ferreira and Rui Ramalhão and should be read as an integral part of it.

Table of Contents

▪ <i>CapEx</i>	2
BASE METALS	3
MARKET OVERVIEW	4
▪ <i>Long-Term Outlook</i>	4
▪ <i>Short-Term Outlook</i>	5
FORECASTS	5
▪ <i>Revenue Forecasts</i>	5
▪ <i>Operating Expenses</i>	10
▪ <i>CapEx</i>	10
COPPER OPERATIONS AND PRODUCT PORTFOLIO	10
MARKET OVERVIEW	10
▪ <i>Long-Term Outlook</i>	10
▪ <i>Short-Term Outlook</i>	11
FORECASTS	11
▪ <i>Revenue Forecasts</i>	11
▪ <i>Operating Expenses</i>	12
▪ <i>CapEx</i>	13
VALUATION	13
▪ <i>DCF Methodology</i>	13
▪ <i>Cash Flows</i>	13
▪ <i>Discount Rate</i>	13
▪ <i>Dividend Policy</i>	14
▪ <i>Sensitivity Analysis</i>	15
▪ <i>Final Recommendation</i>	15

Introduction

The joint report “*Vale, An Iron Giant With Feet of Clay? – In the Midst of the Steelmaking Transition Strategy*” has the purpose of performing a valuation of Vale S.A., one of the world’s leading mining companies, with operations spanning all continents.

The joint report includes a description of the company and its business segments, and the ownership structure. Then, the report is structured in three chapters, one for each segment of the company: Ferrous Minerals (mainly comprising the production of iron ore) and Base Metals (mainly comprising the production of nickel and copper). Each chapter describes the segment portfolio and operations and provides a detailed, in-depth analysis of the main markets in which the company operates, namely the iron ore, nickel, and copper markets. The market analysis include both short and long-term overviews, main trends and demand and price forecasts. Furthermore, an explanation of the two possible scenarios relatively to mineral and metal consumption in the context of the green transition going forward (the Stated Policies Scenario – STEPS – and the Sustainable Development Scenario – SDS) is also provided. Each chapter ends with the main revenue and cost forecasts for the corresponding segment. In the end of the joint report, the Valuation chapter explains the methodology, the discount rate calculation, the cash flow, EV, and Equity Values we arrived to, as well as an explanation of the dividend policy and a sensitivity analysis of our results. Finally, the report concludes with the target share price for FY23 of \$14.06, which translates into a SELL recommendation.

This individual report comprises roughly the second half of the joint report, specifically the final part of the chapter dedicated to the Ferrous Minerals segment, specifically the cost assumptions, the chapter dedicated to the Base Metals segment, with description of the segment portfolio and operations for nickel and copper, market overviews and revenue and cost assumptions. It also includes the Valuation chapter and the Final Recommendation.

Before this individual report, the other individual report should be read. It includes the description of the company and its business segments, and the ownership structure, and most of the chapter dedicated to the Ferrous Minerals segment, explaining the segment portfolio and operations, the market overview, and the revenue assumptions for the segment.

distinguishes between domestic sales, exports and internal mineral consumption, they are merged in a simplifying assumption, requiring the company to pay the current CFEM rate of 3.5% on a value equivalent to the prevailing iron ore price in international markets. The company also pays a tax on mineral production at the state level (TFRM)⁴⁸ in Minas Gerais (Southern and Southeastern Systems' location) and Pará (Northern System's location). In March 2021, a decree tripled the TFRM rate in Pará, with the company disputing its legality. In August 2022, the Supreme Court restated its legality. Thus, Vale will pay \$2.42/ton in Pará and \$0.37/ton in Minas Gerais for FY2022.⁴⁹ Since the implementation of the tax in Minas Gerais, and despite an increase at a CAGR of 7.43% in Brazilian Real terms, the decade-long currency depreciation has positively impacted royalties paid on a U.S. dollar basis. Based on a long-term R\$5 per U.S. dollar exchange rate, TFRM paid in Minas Gerais is forecasted to increase at the historical growth rate and in Pará is set at \$2.48/ton over the forecasting period.

Other Operating Expenses "SG&A & Other Operating Expenses", "R&D Expenses" and "Pre Operating and Operational Stoppage Expenses" have been relatively constant as a percentage of revenues. These are assumed to maintain the historical average percentage of revenues over the entire period.

▪ CapEx

Expansion CapEx There are two ongoing projects aimed at expanding the run rate capacity of iron ore mining operations: Serra Sul 120 and Capanema. Approved in August 2020, the Serra Sul 120 project consists of increasing the Serra Sul plant capacity by 20 mtpy, to a total of 120 mtpy at site.⁵⁰ The project comprises a total multiyear investment of \$1,548B, with \$553M already executed by the end of 2022. For valuation purposes, it is assumed that the remaining cash outflows mimic the physical progress of the project, with two additional investments of \$498M each in 2023 and 2024 until the expected start-up by H2 2024. The Capanema project, which includes investments in the Capanema mine (Mariana complex) to reopen the facilities and acquire new equipment, as well as to build a long-distance conveyor belt, is expected to total multiyear investments of \$495M. With \$248M expected to have already been committed by FY2022, an additional \$247M investment is expected until the start-up in H2 2023.

Sustaining CapEx Based on historical values, yearly sustaining CapEx is estimated to be \$6M/mmt of finished production for the entire period.

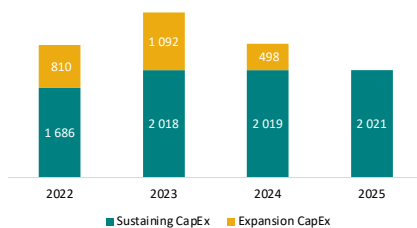


Figure 37 - CapEx breakdown (figures in \$USD million)

⁴⁸ Taxa de Fiscalização de Recursos Minerais

⁴⁹ Evaluated at the average Q1-Q3 2022 R\$/USD exchange rate

⁵⁰ The project is expected to result in an increase of the Northern System's mine-plant capacity to 260 Mtpy from the second half of 2024 onwards

Base Metals

Nickel Operations and Product Portfolio. Vale conducts its nickel mining and refining operations in three different geographies: North Atlantic, Asia-Pacific and South Atlantic. Under the subsidiary Vale Canada Limited, North Atlantic operations comprise three wholly-owned mines in Canada (Sudbury, Thompson and Voisey's Bay) and three refineries (Copper Cliff and Long Harbour in Canada, Clydach in Wales). Despite the mining leases in Canada having predetermined expiration dates,⁵¹ the right to future renewals assures that Vale will continue operating in all the aforementioned locations over the foreseeable future. Adding to nickel, the primary metal, copper is extracted as a co-product and cobalt, PGMs, gold and silver as by-products in the Canadian underground and open pit mining operations. In the Asia-Pacific, Vale operates in Indonesia under the subsidiary PT Vale Indonesia Tbk (PVTI), indirectly owning a 44.34% stake in three mining locations of the Sulawesi Province. Despite the corresponding mineral titles expiring in 2025, the company is entitled to two consecutive ten-year extensions beyond which is no longer expected to operate. PVTI produces nickel matte, which is shipped primarily to Vale's nickel refinery in Japan. Cobalt is also mined as a by-product in the open pit mining operations of Indonesia. Lastly, the company has also been mining and smelting high-quality ferronickel in Onça Puma, Brazil,⁵² since 2011.

Products and Pricing Mechanism. Primary nickel⁵³ can be categorized according to its purity level in Class I or Class II, depending on whether it is above or below the 99.8% purity standard, respectively. Class I finished products can be further classified as high-purity ones whenever they meet a 99.9% minimum nickel content and do not contain specific elemental impurities. High-purity Class I products include, but are not limited to, electrolytic cathodes, briquettes, powders and sulphates with extensive use in high-end applications, namely, the lithium-ion (Li-ion) batteries for electric mobility and other specialty industries like aircraft and spacecraft manufacturing. Low-purity Class I products, on their turn, suit more general nickel applications, such as foundry alloys. Class II products, with lower nickel content and higher impurity levels, are mostly used in stainless steel applications. Finally, ferronickel, which doesn't represent finished nickel production given its 15% to 40% nickel content, is mostly consumed by stainless steel and nickel alloy steel producers. Being an exchange-traded metal, nickel products are generally priced at a premium or discount relative to the London Metals Exchange (LME) reference price,

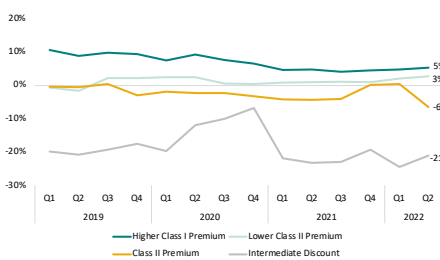


Figure 38 - Vale attained premium/discount by nickel product (% LME reference price)

⁵¹ For instance, the mineral lease contract covering Voisey's Bay operations expires in 2025

⁵² Sole nickel mining complex in the South Atlantic region

⁵³ Produced and used in the form of ferronickel, nickel oxides, other chemicals and as more or less pure nickel metal.

according to their content, purity, shape and size. Ferronickel, for instance, is recurrently sold at a deep discount given that it still needs to be processed before being sold to end consumers (Figure 38).

Market Overview

Long-Term Outlook

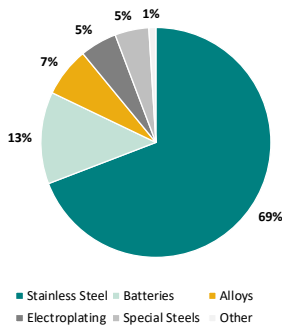


Figure 39 - Primary nickel consumption worldwide in 2021, by industry (figures in '000 metric tonnes)

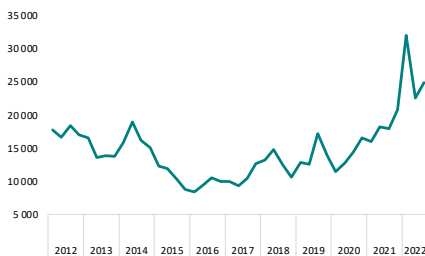


Figure 40 - LME Nickel Cash-Settlement (figures in USD/tonne)

Class I Nickel Shortage and Market Trifurcation Over the past two decades, the nickel market growth has been fueled by a rapid expansion in demand for stainless steel, mostly due to the booming construction in China. Following massive investment, nickel demand from stainless steel more than doubled to reach 1.97 mmt in 2021, accounting for 69% of worldwide primary nickel consumption (Figure 39). The growth dynamics were driven by Class II nickel products consumption, mainly nickel pig iron and ferronickel, with Class I nickel use growing at a comparatively smaller rate. As the dominant driver of nickel demand in the future is expected to change, so too is the product mix. The electrification of the transportation sector is set to prompt future developments under the form of Li-ion batteries. The growing importance of nickel in automotive energy storage systems comes from the fact that Li-ion batteries⁵⁴ show superior energy density and lower metal cost compared to higher cobalt containing technologies, fitting two important considerations for customers' plug-in electric vehicle (EV) adoption: driving range and cost. However, not all nickel is suitable for the sulphate used in cathode manufacturing. Although final Class I nickel products are not the only feedstock suitable for chemical conversion to nickel sulphate, their availability represents the key challenge for future nickel sulphate production. Firstly, because low nickel prices preceding 2021 (Figure 40) led to structural underinvestment in new Class I nickel supply capacity and secondly, due to the fact that current stainless steel production Class I load rates are incompatible with future high-end applications' requirements. In a scenario where Class I nickel usage in stainless steel remains at the current level, above a 10% load rate, no surplus units would be left available for processing into nickel sulphate by 2028.⁵⁵ As alternative feedstock sources, such as recycling and low-purity Class II nickel conversion, are unlikely to compensate entirely, the aforementioned Class I nickel scarcity is expected to push nickel price higher, thus pressuring stainless steel producers' margins and incentivizing to substitute more Class I with Class II nickel.⁵⁶ The market is then expected to gradually trifurcate between Class II nickel for stainless steel, Class I nickel sulphate for EV

⁵⁴ In particular, the nickel-manganese-cobalt (NMC) cathode chemistry

⁵⁵ Wood Mackenzie forecast (2021)

⁵⁶ *Study on future demand and supply scarcity of nickel for electric vehicle batteries (2021)*. Publications Office of the European Union. Luxembourg.

batteries and lower-purity Class I nickel for high-value applications (i.e., nickel alloy casting).

▪ Short-Term Outlook

Nickel’s Bull Market and Raw Material Competition Between the start of 2021 and May 2022, nickel prices almost doubled reaching levels not seen for almost a decade. The phenomenon wasn’t purely demand-driven, but rather the combination of surging battery demand, pressured supply chains and concerns regarding tightening supply, with the former motivated by the production challenges caused by the pandemic and uncertainty around Class I nickel supply from Russia.⁵⁷ High prices may be interpreted as beneficial for long-term nickel supply, stimulating investment and compensating for the underinvestment during the years of low prices. In the short-run though, rising prices incentivised battery chemistry substitutions, with many carmakers (i.e., Tesla) and Chinese suppliers switching to lower cost cathode chemistries with less commodity price exposure. Adding to improving energy density, there is a momentum behind lithium phosphate batteries (LFP), which can extend their market share and threaten the long-term prospects for nickel-rich chemistries. At the same time, given that cobalt is the most expensive component in batteries and its known ESG-related risks, gradual adoption of higher nickel chemistries (i.e., NMC811) may be favoured to offset some costs amongst high-density energy storage systems.

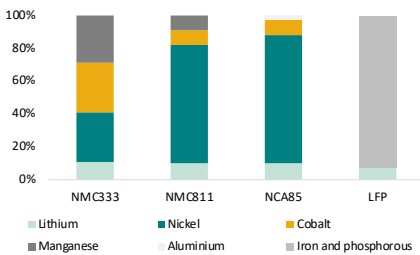


Figure 41 - High-nickel and LFP cathode battery chemistries

Forecasts

▪ Revenue Forecasts

Nickel’s Role in Clean Energy Transition and Stainless Steel Production Similarly to what has been discussed in the last section, the IEA provides the same benchmark scenarios, the STEPS and the SDS, concerning future nickel consumption in the context of the clean energy transition, breaking down demand in five different sources: low-carbon energy generation, electric mobility, battery storage, hydrogen-based technologies and stainless steel and other applications.⁵⁸ Under the STEPS, the former segment remains the main driver of worldwide nickel demand until 2040, growing at a CAGR of 1.3% and reaching 2.78 mmt by that time.⁵⁹ Despite low-carbon energy generation more than doubling its nickel requirements until 2040 (representing 285 kt of worldwide demand), the peak is expected by 2030 (404 kt), decreasing at a CAGR of - 4.6% over the following decade. This decline is explained by lower demand from

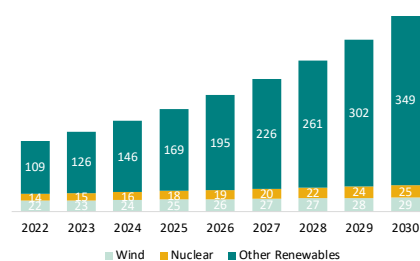


Figure 42 - Nickel demand (figures in kt) from low-carbon energy generation by source (STEPS)

⁵⁷ Russia is the world’s largest producer of battery-grade Class I nickel

⁵⁸ Nickel plating and nickel alloys, among others

⁵⁹ According to what has been discussed in the *Long-Range Outlook*, a 5% Class I nickel load rate has been considered in the stainless steel sector nickel demand projections. According to the Wood Mackenzie report, it is the loading rate ensuring no future Class I shortages affecting the EV market. The corresponding Class I nickel displacement is compensated by Class II nickel, which is built into this report’s forecasts as well.

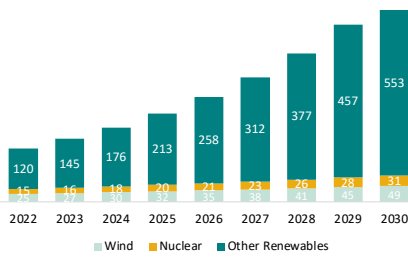


Figure 43 - Nickel demand (figures in kt) from low-carbon energy generation by source (SDS)

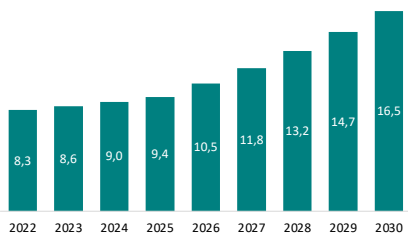


Figure 44 - Global EV sales in the STEPS (figures in millions)

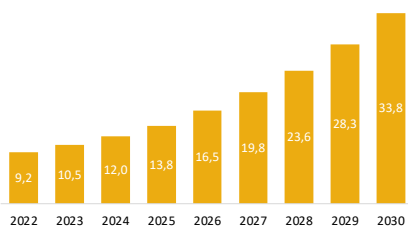


Figure 45 - Global EV sales in the SDS (figures in millions)

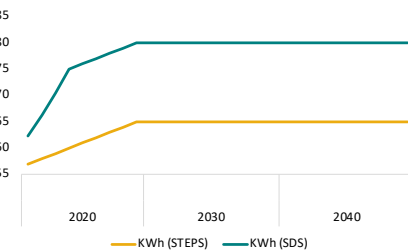


Figure 46 - Installed capacity per vehicle

geothermal electricity generation, which consumes significant volumes of nickel for cost-effective corrosion resistance and superior heat transfer conditions. In the SDS, stainless steel and other applications also account for a substantial share of worldwide nickel demand by 2040, reaching 2.45 mmt. Low-carbon energy generation consumption will increase fourfold by that time, translating into a 445 kt nickel demand. Battery storage and hydrogen-based technologies, which currently represent a small part of worldwide nickel demand and still account for a minor share in the future, will grow in absolute terms from a combined value of 0.4 kt in 2020 to 36.4 kt and 72.5 kt in the STEPS and the SDS, respectively.

Electric Mobility In 2022, Vale signed three multi-year low-carbon nickel supply agreements with Tesla⁶⁰, Northvolt AB⁶¹ and General Motors.⁶² Despite Vale believing it is well positioned to supply the North American EV market,⁶³ vertical integration of battery production is not the norm. Thus, it is prudent to model the battery-grade nickel sales only giving forecasted Tesla and GM's needs.

Multi-Year Contract with Tesla A top-down approach has been implemented to forecast Tesla's nickel demand under both the STEPS and the SDS. Firstly, it was necessary to determine Tesla's addressable market, obtaining global light-duty vehicle (LDV) stock over the years according to the following formula:

$$[\text{OECD Population}_t * \text{LDV Fleet}/'000 \text{ people}_t * (1\text{-Yearly Scrap Rate})] + [\text{Non-OECD Population}_t * \text{LDV Fleet}/'000 \text{ people}_t * (1\text{-Yearly Scrap Rate})]$$

A distinction between OECD and non-OECD countries has been made to capture the difference in travel demand per capita growth between the countries, which is tied to differences in annual average population growth and is three times faster in non-OECD countries than in OECD countries until 2050. Global LDV sales become the increase in LDV stock required to meet the demand, considering yearly scrappage rates. The STEPS and the SDS are taken as two benchmark scenarios for the evolution of EV sales share until 2050. Under the STEPS, electric mobility adoption increases at a CAGR of 4.6%, representing 37% of global LDV sales by 2050 (currently at 10%). In the SDS though, EV adoption becomes massive, reaching 86% of LDV sales by that time at a CAGR of 7.7%. To reach Tesla's global sales, the company's EV market share is forecasted to grow from 14% in 2021 to 18% in 2025,⁶⁴ declining thereafter to 10% by 2040.⁶⁵ A major determinant of Tesla's nickel demand is the average energy storage

⁶⁰ Source: <http://www.vale.com/canada/EN/aboutvale/news/Pages/vale-to-supply-northvolt-with-low-carbon-nickel-products-for-batteries.aspx>

⁶¹ Source: <http://www.vale.com/aboutvale/news/pages/vale-confirms-supply-deal-with-tesla-for-low-carbon-nickel.aspx>

⁶² Source: <https://www.vale.com/w/vale-and-gm-sign-long-term-nickel-supply-agreement-in-canada-critical-to-north-american-ev-supply-chain>

⁶³ Vale signed a non-binding memorandum of cooperation with Ford Motor Co to process nickel ore mined by PVTI

⁶⁴ *Electric Vehicles: What's Next VII: Confronting Greenflation*. Goldman Sachs Equity Research (March 2022)

⁶⁵ Piper Sandler equity research

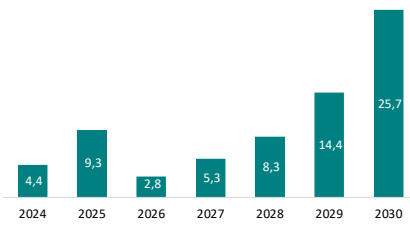


Figure 47 - Attainable nickel demand from Tesla in the STEPS (figures in kt)

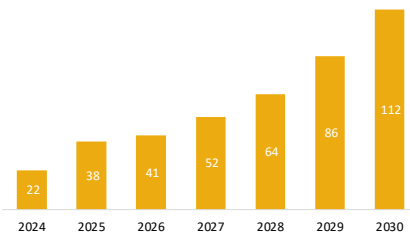


Figure 48 - Attainable nickel demand from Tesla in the SDS (figures in kt)



Figure 49 - Northvolt AB annual nickel procurement (figures in kt)

capacity installed in each vehicle. Without company-specific data, forecasts provided by the IEA in its benchmark scenarios were used instead (Figure 46). Another important driver concerns the chemistry used in Tesla's batteries. The company procures its nickel-rich 2170 battery cells (NCA85 cathode chemistry) from Panasonic, but has plans to ramp up the higher-density (and nickel content) 4680 cells' (NMC811 cathode chemistry) production before March 2024.⁶⁶ For forecast purposes, it is assumed that Tesla only procures nickel for its 4680 cells from 2024 onwards, either for those exclusively produced by Panasonic or in-house. After adjusting for the nickel content of NMC811 cathode batteries (0.69 Kg/KWh), Vale's attainable demand also considers other Tesla's disclosed agreements with BHP Nickel West (c. 18 kt/year), Talon Metals (12.5 kt/year from 2026 to 2031)⁶⁷ and Prony Resources (7 kt/year between 2024 and 2029, estimated according to similar contractual conditions disclosed by Talon Metals).⁶⁸ For valuation purposes, only BHP Nickel West is assumed to compete with Vale as a key supplier from 2031 onwards, given both operations' scale.

Multi-Year Contract with Northvolt AB is another source of revenue for Vale's Base Metals division. Like Tesla's, the Swedish Li-ion cell supplier's agreement remains undisclosed, but Vale remains its only known nickel supplier to date. Northvolt AB is currently ramping up its NMC chemistry cells' production, being expected to grow from the current 16GWh capacity to 60GWh by the end of the year. Northvolt AB has also announced in June 2021 that a second gigafactory developed through a joint venture with Volvo Cars is set to commence large scale production by 2026, having a 50GWh capacity. Most recently, another cell manufacturing plant in Germany has been announced, beginning its 60GWh annual production in late 2025. Cumulatively, the Swedish manufacturer will have a 170GWh annual production capacity by 2026, demanding approximately 117 kt of nickel per year. This figure cannot be straightforwardly inferred as an estimate of the contractual nickel amount to be supplied by Vale, once Northvolt AB is engaged in recycled raw materials for cell production, with a battery recycling plant handling 12 kt of battery packs per year since May 2022. Northvolt has also begun the construction of a giga-scale recycling plant in Q1 2022, enabling the recycling of additional 125 kt of batteries per year from 2023 onwards. After considering the recovered nickel amount, it is estimated that Northvolt's annual nickel procurement will reach 90 kt/year after 2026 (Figure 49).⁶⁹

⁶⁶ Source: <https://www.reuters.com/business/autos-transportation/panasonic-planning-massive-battery-plant-us-supply-tesla-nhk-2022-03-03/>

⁶⁷ Source: <https://talonmetals.com/tesla-and-talon-metals-enter-into-supply-agreement-for-nickel/>

⁶⁸ Source: <https://www.nasdaq.com/articles/prony-resources-says-tesla-has-agreed-to-a-multi-year-nickel-purchasing-deal-2021-10-13>

⁶⁹ Assuming that most available end-of-life batteries are those used in consumer electronics (NMC333 chemistry) and an average nickel recovery of 60%, in line with official IEA data

Multi-Year Contract with GM The most recent long-term contract with GM sets that Vale will supply 25 ktpy of battery-grade (Class I) nickel starting in H2 2026.

Mineral Assets As of the FY2021, the company reported nickel 2P reserves amounting to 241.5 mmt and averaging 1.59% Ni content, of which 113.5 mmt were proven reserves and 128.2 mmt were probable reserves. Since Vale runs its nickel operations in Brazil and Canada, it has also been required to report and make a clear distinction between measured (55.1 mmt), indicated (191.0 mmt) and inferred (72.6 mmt) resources. Given measured resources' prospects of being economically extracted in the future, for valuation purposes, the average recovery rate per mine was applied to the corresponding 2P reserves (Figure 50) and measured resources (Figure 51), reaching a total marketable nickel tonnage of 3.7 mmt. It is assumed that each mine's measured resources are extracted in their entirety until the corresponding exhaustion date at a fixed yearly rate. Sudbury and Voisey's Bay are the only mining operations classifying for Class I nickel projects, providing the company with 1.09 mmt of marketable nickel for EV battery and high-value segments' demand. Thompson, Onça Puma and PTVI's corresponding Class II marketable nickel figures make the remaining 2.6 mmt, mainly for stainless steel applications.

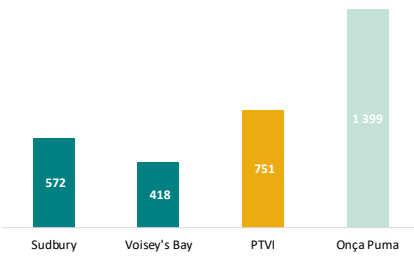


Figure 50 - Marketable nickel reserves by mining complex (figures in kt)

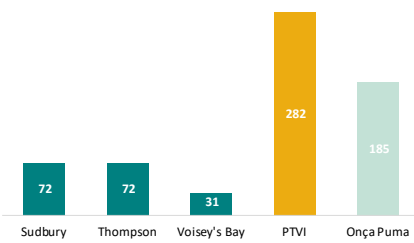


Figure 51 - Marketable (measured) nickel resources by mining complex (figures in kt)

Production Capacity Sudbury has integrated mining, smelting and refining operations to process ore into finished nickel with a nominal capacity of 66 ktpy. Under the current Voisey's Bay mine expansion project, which is expected to extend the mine life and increase production to an estimated 45 kt annual output, on average, Vale's annual Class I nickel production capacity will be 111 ktpy until Voisey's Bay exhaustion in 2035. Thompson and Onça Puma's output levels have been determined based on each mine's expected expiration date, with Thompson representing a 6.1 kt output until 2032 and Onça Puma contributing with 30.3 ktpy through the entire project duration. In Q2 2022 Earnings Call, Vale pointed out that current PTVI capacity is between 76 ktpy and 78 ktpy after the completion of Furnace 4, adding that an additional 73 ktpy capacity is expected to be online by 2025, with PTVI controlling 49% of the joint venture. Thus, adjusting for Vale's 44.34% position in PTVI, the company's attributable Class II production capacity will be 49.6 ktpy from 2025 onwards. This brings Class II total production capacity to 86.7 ktpy until Thompson's exhaustion in 2031.

Product Mix In 2019, predicting the potential trifurcation in nickel markets, Vale set a commercial strategy for nickel that includes preserving its market share in high-value segments, reducing the exposure to intermediate products and maintaining its product portfolio optionality for a potential surge in EV battery demand. Nevertheless, it hasn't been able to sustain its global market share in both the high-value segments (Figure 52) and stainless steel applications (Figure

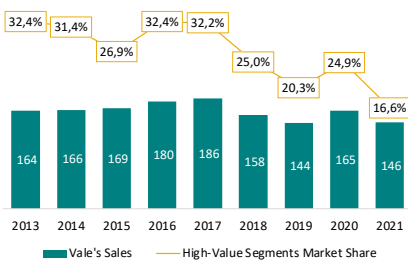


Figure 52 - Vale's sales (figures in kt) and market share in high-value segments

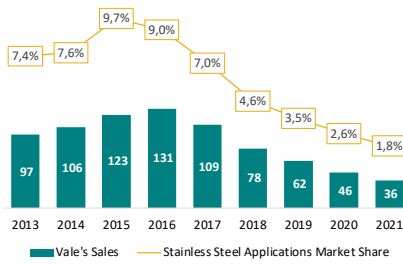


Figure 53 - Vale's sales (figures in kt) and market share in stainless steel applications

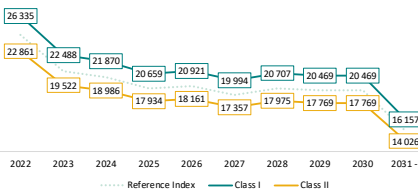


Figure 54 - Nickel price relative to the benchmark index (\$USD per tonne)

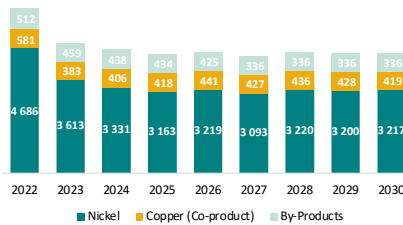


Figure 55 - Nickel operations' sales in the STEPS (figures in \$USD million)

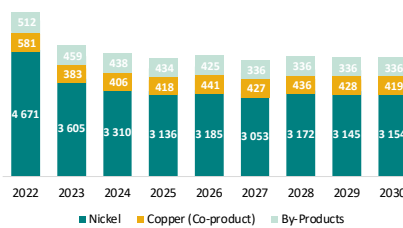


Figure 56 - Nickel operations' sales in the SDS (figures in \$USD million)

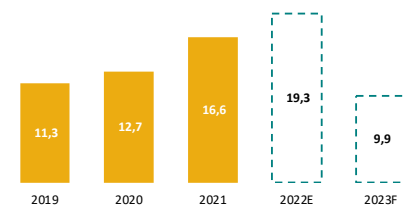


Figure 57 - Nickel operations' COGS/ton (figures in \$USD thousand)

53) since the outbreak of the pandemic. In line with its strategic positioning, it is forecasted that Vale will attempt to recover its pre-pandemic market share in stainless steel applications and gradually replace sales for high-value segments with surging EV battery-grade nickel sales arising from the long-term contracts signed in 2022, bringing more volume stability to its nickel revenues.

Prices On average, Vale has been able to realize 103.3% of the reference LME Nickel Official Cash Price, capturing a premium by focusing on higher-value segments' sales. For instance, in 2021, 80% of the company's refined nickel sales were made into non-stainless steel applications, compared to the industry average of nickel producers of 31%. Once nickel sales' forecasts are split into EV battery-grade procurement, high-value segments and stainless steel applications, the corresponding products' prices are set according to historical Class I and Class II price realization relative to the index mentioned above (Figure 54).⁷⁰

Revenues In FY2022, nickel operations' revenues should increase by 7.5%, from approximately \$5.4B in FY2021 to \$5.8B, \$4.7B being the contribution of nickel sales and the remaining portion arising from co-product (i.e., copper) and by-product (i.e., gold, palladium, platinum, cobalt) sales. Nickel sales volume in FY2022 will be in line with FY2021 (185 kt *vis-à-vis* 182 kt in the previous year), with a positive price effect justifying the higher revenue figures. Vale's nickel sales are forecasted to be relatively flat over the decade in either scenario (Figures 55 and 56), in line with Vale's goal of targeting between 20% to 30% of its sales towards battery-grade nickel and achieve higher volume stability. Nevertheless, against the company's view of being in a privileged position to fuel the electric mobility revolution, Vale's low carbon nickel assets and production capacity are not enough to cope with announced long-term supply deals, ensuring the contracts performance only up to 2031 (in both scenarios) and exhausting Sudbury project more than 10 years earlier than predicted. However, Vale is forecasted to continuously grow its nickel sales to stainless steel applications, benefitting from its vast Class II nickel endowment.

▪ **Operating Expenses**

COGS Without a detailed cost breakdown available, the best approach to forecast nickel cost of goods sold (excluding by-product credits)⁷¹ are normalized pre-pandemic figures, reaching \$9,932/ton (Figure 57).

Other Operating Expenses "SG&A & Other Operating Expenses", "R&D Expenses" and "Pre Operating and Operational Stoppage Expenses" have been

⁷⁰ Sources: S&P Capital IQ, Goldman Sachs

⁷¹ Includes both direct cash costs (i.e., mining, processing,...) and indirect cash costs (i.e., royalties/production taxes)

relatively constant as a percentage of revenues. These are assumed to maintain the historical average percentage of revenues over the entire period.

- **CapEx**

Expansion CapEx Voisey's Bay underground mine expansion (VBME) project, to extend the mine life and annual production, will end by H2 2022. A final \$565M cash outflow will occur in 2023 to meet the planned \$2.69B investment.

Maintenance CapEx Based on historical values, yearly sustaining CapEx is estimated to be \$1,7 million/kt of finished production for the entire period.

Copper Operations and Product Portfolio

Copper Mining Operations and Products Vale conducts its copper operations primarily at the parent company level and through its wholly owned subsidiary Salobo Metais S.A. in Brazil, and through its subsidiary Vale Canada. In Brazil, the company produces copper concentrates in the open-pit mining operations of Sossego and Salobo, with no expiration date. It produces copper concentrates, anodes and cathodes in conjunction with its Canadian nickel mining operations of Sudbury and Voisey's Bay. It is conducting technical studies for two additional mining sites, the Alemão Project (Brazil) and the Hu'u Project (Indonesia).

Pricing Mechanism Copper is an exchange-traded metal, being priced in terminal markets like the LME, the SHFE and the COMEX. In the case of intermediate goods, such as the copper concentrates and copper anodes making up most of the company's sales, treatment and refining charges above the prevailing copper market price are negotiated with each customer.

Market Overview

- **Long-Term Outlook**

Copper-Intensive Clean Energy Transition Similarly to other minerals, copper demand during the coming decades will be driven by the massive deployment of clean energy technologies. Copper will be the cornerstone of the energy transition, given its cost-effective electrical and thermal conducting properties. Ripple effects into non-green energy sources mean the 2020s will witness the strongest phase of volume growth in global copper demand in history, surpassing the incremental Chinese-generated demand during the 2000s. However, a decade of poor returns and ESG concerns, coupled with the uncertainty generated by the COVID-19 pandemic, have frozen companies' greenfield investment projects. The compounding of growing demand and sticky supply reinforce the prediction of large deficits from 2025 onwards. Having a strong

portfolio of copper assets and multi-year copper expansion plans in Salobo, Sossego ⁷² and Alemão, Vale is well positioned to capture value as copper prices are expected to trend above \$9,000/ton by the mid-decade.

▪ Short-Term Outlook

Challenging Times Ahead Copper’s short-term outlook is deeply influenced by the recessionary prospects that affect the metal demand in various economic activities, from construction to the automotive industry. Surging energy prices in Europe and ongoing inflation hurt copper demand, but in China pandemic stimulus have supported a resurgence in demand amid stagnant supply.

Forecasts

▪ Revenue Forecasts

Copper Demand in the Context of the Clean Energy Transition Resorting to the same benchmark scenarios provided by the IEA, the STEPS and the SDS, future copper consumption is also forecasted according to five different sources of demand: low-carbon energy generation, EV and battery storage, electricity networks, hydrogen-based technologies and other sectors.⁷³ Under the STEPS, global copper consumption is set to increase at a CAGR of 1.4% between 2021 and 2040, from 24.4 Mt to 31.7 Mt. Demand is set to increase at a CAGR of 1.7% over the same period under the SDS, peaking at 33.5 Mt by 2040. Although copper usage in construction, infrastructure and equipment manufacturing is still predicted to account for most global consumption,⁷⁴ the increase is mainly driven by electricity network developments, with a CAGR of 2.1% and 3.5% in the STEPS and the SDS, respectively.

Market Share It is expected that Vale will be able to sustain its pre-pandemic 2% share of the global copper concentrate market in the short-run.

Mineral Assets As of FY2021, the company reported copper 2P reserves amounting to 1,299.4 mmt and averaging 0.66% Cu content, of which 262.9 mmt were proven reserves and 1,036.5 mmt were probable reserves. As the company runs its copper operations in Brazil and Canada, it is required to report and make a clear distinction between measured (265.2 mmt), indicated (1,548.9 mmt) and inferred (1,098.9 mmt) resources. Given measured resources’ prospects of being economically extracted in the future, for valuation purposes, the average recovery rate per mine was applied to the corresponding 2P reserves (Figure 60) and measured resources (Figure 61), reaching a total marketable nickel tonnage

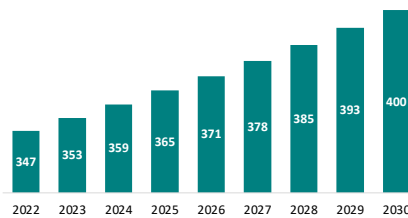


Figure 58 - Attainable copper demand in the STEPS (figures in kt)

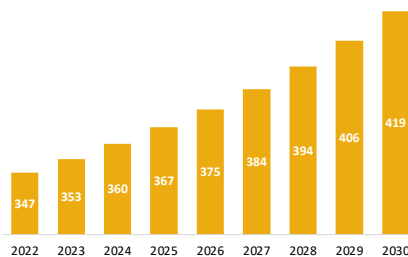


Figure 59 - Attainable copper demand in the SDS (figures in kt)

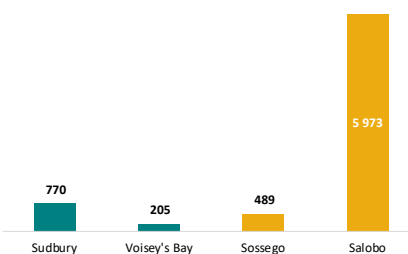


Figure 60 - Marketable copper reserves by mining complex (figures in kt)

⁷² Cristalino deposit

⁷³ Construction, infrastructure and equipment accounted for 76% of global copper consumption in 2021

⁷⁴ Approximately 68.5% and 54.8%, in the STEPS and the SDS, respectively

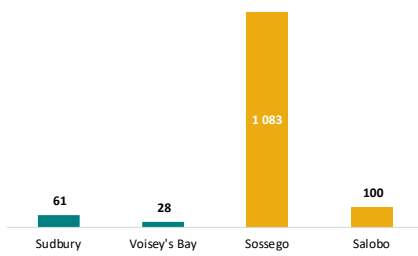


Figure 61 - Marketable (measured) resources by mining complex (figures in kt)

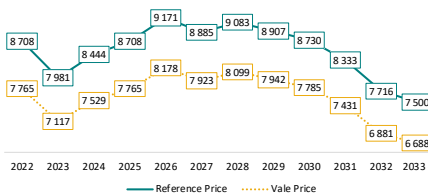


Figure 62 - Copper price relative to the benchmark index (\$USD per tonne)

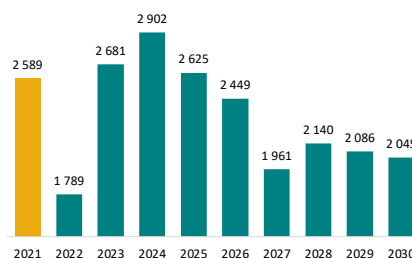


Figure 63 - Copper operations' revenues in the STEPS (figures in \$USD million)

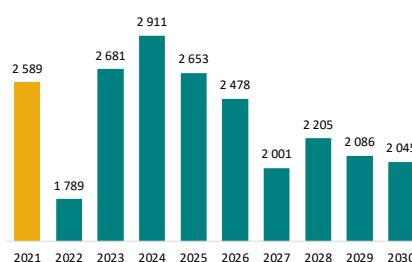


Figure 64 - Copper operations' revenues in the SDS (figures in \$USD million)

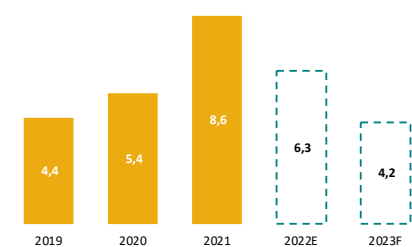


Figure 65 - Copper operations' COGS/ton (figures in \$USD thousand)

of 8.7 mmt. It is assumed that each mine's measured resources are extracted in their entirety until the corresponding exhaustion date at a fixed yearly rate.

Production capacity Current capacity stands at 344 ktpy. After the completion of the Salobo III project, aimed at expanding Salobo operations' output, the run rate capacity will be c.410ktpy until the exhaustion of Sossego in 2028.

Prices Copper price forecasts are set according to historical price realization against the reference LME Copper Official Cash Price, with the company's products being sold, on average, at a 10.8% discount (Figure 62).

Revenues Copper operation's revenues are expected to plummet 30.9% yoy in FY2022, from approximately \$2.6B in FY2021 to \$1.8B, recovering thereafter in FY2023 to \$2.7B. Adding to a negative volume effect decurrent from the recessionary dynamics, decreasing from 216 kt to 168 kt (22.2% decrease yoy), copper prices are also expected to drop 16.6% yoy by the end of FY2022. Over the long-run, revenues are expected to increase at a CAGR₂₂₋₂₈ of 3.0% and 3.5% in the STEPS and SDS, respectively, until mineral assets in Sossego are exhausted (Figures 63 and 64). Past 2028, it is expected that Vale will be unable to benefit from increasing copper demand driven by the energy transition losing its ability to sustain the 2% share of the global copper concentrate market.

- Operating Expenses

COGS Without a detailed cost breakdown available, the best approach to forecast copper cost of goods sold (excluding by-product credits)⁷⁵ are normalized pre-pandemic figures, reaching \$4,361/ton from 2023 onwards (Figure 65).

Other Operating Expenses "SG&A & Other Operating Expenses", "R&D Expenses" and "Pre Operating and Operational Stoppage Expenses" have been relatively constant as a percentage of revenues. These are assumed to maintain the historical average percentage of revenues over the entire period.

- CapEx

Expansion CapEx Despite Salobo III project ramp-up in H2 2022, a final \$48M cash outflow is forecasted for 2023 to meet the planned \$1.056B investment.

Maintenance CapEx Based on historical values, yearly sustaining CapEx is estimated to be \$1,7 million/kt of finished production for the entire period.

⁷⁵ Includes both direct cash costs (i.e., mining, processing,...) and indirect cash costs (i.e., royalties/production taxes)

Valuation

DCF Methodology

Valuing a mining company, first and foremost, is valuing its current mineral assets. Since we deal with finite reserves, the DCF methodology is the best approach to capture the value generated in each year until the exhaustion of the last mining project, with an explicit forecasting period of 67 years being used for the effect. Unlike most valuation exercises, resorting to the Gordon Growth Model at a certain stage of the forecast is a misleading approach in the context of the mining industry, since it assumes that a company will be able to replenish its mineral assets in perpetuity, which is physically impossible.

Cash Flows

Iron Ore Cash Flows In the STEPS, forecasted operating cash flows for FY2023 stand at \$10.005B, only 0.80% below the estimate for FY2022. Operating cash flows are projected to decrease at a CAGR₂₂₋₃₈ of -4.1% until the exhaustion of the Serra Norte project, averaging a 55.7% EBITDA conversion rate (Figure 66). In the SDS, FY2023 operating cash flows are forecasted to be down -1.31% yoy, plummeting at a CAGR₂₂₋₃₈ of -4.8% thereafter (Figure 67).

Base Metals Cash Flows In FY2023, \$1.813B operating cash flows have been forecasted under the STEPS, up 14.2% yoy (Figure X). Operating cash flows are also projected to decrease at a CAGR₂₂₋₃₁ of -3.8% until the exhaustion of the low-carbon nickel project of Sudbury, averaging a 55.3% EBITDA conversion rate (Figure 68). In the SDS, FY2023 operating cash flows are forecasted to be up 15.0% yoy, plummeting at a CAGR₂₂₋₃₈ of -3.8% thereafter as well (Figure 69).

Discount Rate

Capital Structure To calculate the WACC, no changes to Vale's capital structure are forecasted, given its maturity and no further publicly available information.

Cost of Debt To compute Vale's cost of debt, the longest publicly traded bond issued by the company, a 30-year bond maturing in 2034 with a corresponding YTM of 6.05%, has been considered. Moreover, based on S&P BBB- and Moody's Baa3 credit rating assessments, a corresponding 10-year average cumulative probability of default of 2.94%⁷⁶ and a senior unsecured bonds' recovery rate of 51%⁷⁷ were used, leading to a cost of debt of 4.61%.

Cost of Equity was estimated using the CAPM model. Despite being incorporated in Brazil and operating across the globe, as cash flows are

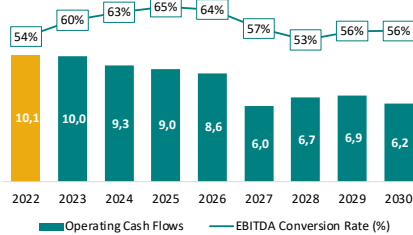


Figure 66 - Iron ore operating cash flows in the STEPS (figures in \$USD billion)

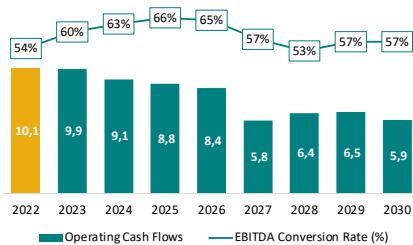


Figure 67 - Iron ore operating cash flows in the SDS (figures in \$USD billion)

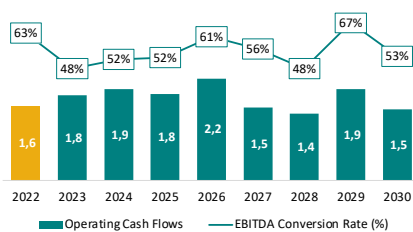


Figure 68 - Base metals operating cash flows in the STEPS (figures in \$USD billion)

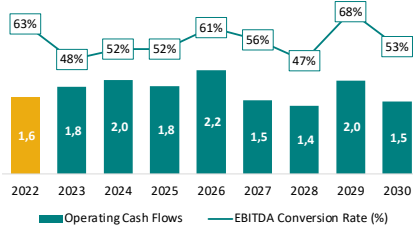


Figure 69 - Base metals operating cash flows in the SDS (figures in \$USD billion)

⁷⁶ Source: S&P 2021 Annual Global Corporate Default and Rating Transition Study (default rate for emerging and frontier markets)

⁷⁷ Source: Moody's Annual Default Study 2021

estimated in US dollars, the risk-free rate used for valuation purposes, 3.56%, is the 90-day average yield on a 10-year US Treasury Bond. Similarly, as the price recommendation concerns the American Depositary Shares traded in the NYSE, the S&P500 is the marginal investor's diversified portfolio alternative, using the index's equity risk premium, 6.01%, as the MRP. The levered beta of the company was calculated by regressing Vale's monthly stock returns against the S&P 500's, from November 2017 until the present, using 60 data points as it is common in the industry. This approach resulted in a levered beta coefficient of 0.89, with a confidence interval of [0.86, 0.91]. The narrow confidence interval allows to use the regressed coefficient without further analysis. To exclude the effect of the capital structure, the regressed beta was unlevered using the average D/E ratio from the last fiscal years, resulting in an unlevered beta of 0.79. The CAPM output is an estimated 8.29% cost of equity.

WACC With the Brazilian corporate tax rate of 34% and a constant target capital structure (D/E) of 0.04, the WACC is estimated to be 7.42%.

Equity Value The scenarios outlined in this report's forecasting analysis, the Stated Policies Scenario (STEPS) and the Sustainable Development Scenario (SDS), are two benchmark development scenarios that translate the uncertainty regarding the accomplishment of the climate action targets set forth by the international treaties. Decurrent of this doubtful framework, for valuation purposes, both scenarios are forecasted to be equally likely to occur. A \$65.732B Equity Value is then obtained by averaging the Enterprise Value in the STEPS (\$75.551B) and in the SDS (\$72.812B), as well as adjusting for Net Debt of \$6.980B and Noncontrolling Interests of \$1.470B.

- **Dividend Policy**

In March 2018, the board of directors approved a new dividend policy under which the company would distribute 30% of its adjusted EBITDA less sustaining CapEx in dividends from the six-month results, to be paid in two semiannual installments. Forecasting a \$20.285B adjusted EBITDA and sustaining CapEx around \$2.683B, the expected dividend payment for FY2023 stands at \$0.73/share, corresponding to a 5.2% dividend yield.

- **Sensitivity Analysis**

Despite the company's strategy of aiming to be more than an iron ore mining company, leveraging the development of its Base Metals division on the energy transition dynamics, its core business is mature and lacking growth opportunities, as already outlined in this report. Then, Vale's operating performance must be mainly affected by movements in iron ore prices, which has been identified as the

most significant input risk built into this report's valuation. Additionally, it has been assessed how sensitive the share price is to changes in the discount rate.

		WACC				
		6,48%	7,29%	8,10%	8,91%	9,72%
Iron ore price	70,20	14,61	13,41	12,36	11,43	10,60
	74,10	15,75	14,40	13,21	12,17	11,25
	78,00	16,89	15,38	14,06	12,91	11,90
	81,90	18,03	16,36	14,91	13,65	12,55
	85,80	19,17	17,34	15,76	14,40	13,20

Figure 70 - Share price sensitivity analysis (figures in USD)

From the sensitivity analysis, it can be concluded that the share price is both exceptionally sensitive to changes in the long-term iron ore price input as to changes in the discount rate, strengthening the thesis that Vale's iron ore business maturity is a risk under volatile market conditions. Second, under the 8.10% discount rate used for valuation purposes, not even a 10% higher long-term iron ore price forecast would change the recommendation set in this report. It is then believed that the aforementioned fact reinforces the recommendation set forth in this report.

Final Recommendation

Pursuant the DCF valuation performed, Vale's American Depositary Shares should be traded at \$14.06 as of December 14th, 2021. No other valuation method has been used in the issuance of the recommendation below. Given the lack of public comparable companies with such a diversified product portfolio and geographical reach, the value-added of performing a multiples analysis was questionable. The price recommendation translates two main concerns on Vale's current business model. First, the iron ore business's maturity that may be challenged in the context of the steelmaking transformation strategy. Second, the questionable value captured by having a base metals segment within a company whose performance swings with marginal changes in iron ore prices, a point that is reinforced by the company's intention of spinning off the division. The company is considering the creation of a new entity comprising the nickel and copper assets, in which Vale would hold a 90% stake and the remaining be sold to a strategic partner during 2023.

Given the concerns on the company's true ability to seize the opportunities heading the global energy transition and the carbon neutrality pathway, the issued recommendation is SELL, with the 14.3% capital loss and 5.2% dividend yield culminating in a -9.1% total shareholder return.

VALE S.A.

MINING

PEDRO FERREIRA | RUI RAMALHÃO

COMPANY REPORT

16 DECEMBER 2022

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An Iron Giant With Feet of Clay?

In the Midst of the Steelmaking Transition Strategy

- Based on the FY2023 target share price of \$14.06 and the corresponding -9.1% total shareholder return, a SELL recommendation is issued, already accounting for a \$0.73/share dividend in the coming fiscal year.
- The company's true ability to seize the opportunities heading the global energy transition and the carbon neutrality pathway is questionable, leading to the issued recommendation.
- Vale's mature iron ore business may be challenged in the context of the steelmaking transformation strategy that has already commenced in China, with operating cash flows decreasing at a CAGR₂₂₋₂₈ of -4.1% in the best case scenario.
- Despite the long-term nickel supply agreements with EV automakers and battery producers, Vale's existing reserves are far from being enough to guarantee the performance of the contracts entering the next decade.
- The price recommendation is not highly reliant on the long-term iron ore price consensus. Prolonged and weaker than expected future market conditions may further hinder the prospects of the company.

Company description

Vale S.A. is one the largest mining and metals companies in the world, being the top iron ore producer. It also produces nickel, copper concentrates, platinum group metals (PGM), gold, silver and cobalt.

Recommendation: **SELL**

Total Shareholder Return -9.1%

Price Target FY22: **14.06 \$**

Dividend Yield 5.2%

Price (as of 14-Dec-22) **16.41 \$**

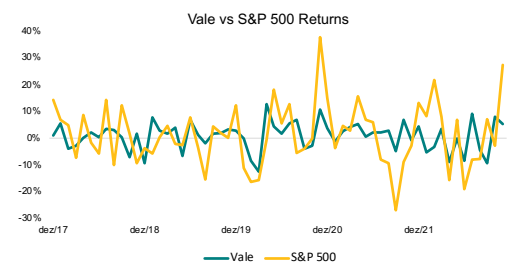
Reuters: VALE.N, Bloomberg: VALE:US

52-week range (\$) 11.72-21.29

Market Cap (\$m) 77,636

Outstanding Shares (m) 4,674

Source: Reuters



Source: Reuters

(Values in \$ millions)	2021	2022E	2023F
Revenues	54,502	40,155	36,830
EBITDA	31,154	23,093	20,380
Operating Cash Flow	22,844	12,731	11,974
Net Profit	24,736	12,103	12,578
EPS	4.47	2.59	2.69
P/E	2.91	6.10	5.87

Source: Analysts' estimates

THIS REPORT WAS PREPARED EXCLUSIVELY FOR ACADEMIC PURPOSES BY PEDRO FERREIRA AND RUI RAMALHÃO, MASTER IN FINANCE STUDENTS OF THE NOVA SCHOOL OF BUSINESS AND ECONOMICS. THE REPORT WAS SUPERVISED BY A NOVA SBE FACULTY MEMBER, ACTING IN A MERE ACADEMIC CAPACITY, WHO REVIEWED THE VALUATION METHODOLOGY AND THE FINANCIAL MODEL. (PLEASE REFER TO THE DISCLOSURES AND DISCLAIMERS AT END OF THE DOCUMENT)

Table of Contents

COMPANY OVERVIEW	3
FERROUS MINERALS	4
MARKET OVERVIEW	6
▪ <i>Long-Term Outlook</i>	<i>6</i>
▪ <i>Short-Term Outlook.....</i>	<i>9</i>
FORECASTS	11
▪ <i>Revenue Forecasts</i>	<i>11</i>
▪ <i>Operating Expenses.....</i>	<i>16</i>
▪ <i>CapEx.....</i>	<i>18</i>
BASE METALS	19
MARKET OVERVIEW	20
▪ <i>Long-Term Outlook</i>	<i>20</i>
▪ <i>Short-Term Outlook.....</i>	<i>21</i>
FORECASTS	21
▪ <i>Revenue Forecasts</i>	<i>21</i>
▪ <i>Operating Expenses.....</i>	<i>25</i>
▪ <i>CapEx.....</i>	<i>26</i>
COPPER OPERATIONS AND PRODUCT PORTFOLIO	26
MARKET OVERVIEW	26
▪ <i>Long-Term Outlook</i>	<i>26</i>
▪ <i>Short-Term Outlook.....</i>	<i>27</i>
FORECASTS	27
▪ <i>Revenue Forecasts</i>	<i>27</i>
▪ <i>Operating Expenses.....</i>	<i>28</i>
▪ <i>CapEx.....</i>	<i>28</i>
VALUATION	29
▪ <i>DCF Methodology.....</i>	<i>29</i>
▪ <i>Cash Flows</i>	<i>29</i>
▪ <i>Discount Rate.....</i>	<i>29</i>
▪ <i>Dividend Policy.....</i>	<i>30</i>
▪ <i>Sensitivity Analysis.....</i>	<i>30</i>
▪ <i>Final Recommendation.....</i>	<i>31</i>
APPENDIX.....	32
DISCLOSURES AND DISCLAIMERS.....	34

Company Overview

Vale S.A. was founded in 1942, as “Companhia Vale do Rio Doce”, by the Brazilian government. It is currently the fifth largest mining and metals company in the world, based on market capitalization, as well as one of the world’s largest producers of iron ore and nickel. It also produces iron ore pellets, copper, platinum group metals (PGMs), gold, silver and cobalt. Its greenfield mineral explorations are present in all five continents. Besides mining, it operates several logistics complexes. As stated in the annual reports, Vale operates in three different business segments: Ferrous Minerals, Base Metals and Others.

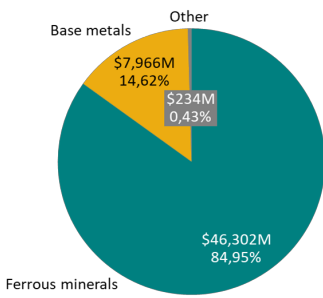


Figure 1 - Revenue per segment (FY21)

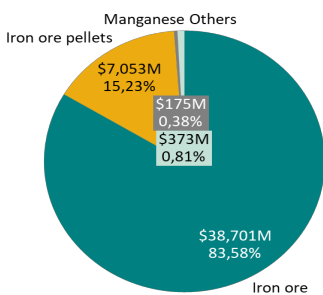


Figure 3 - Ferrous Minerals revenue per product (FY21)

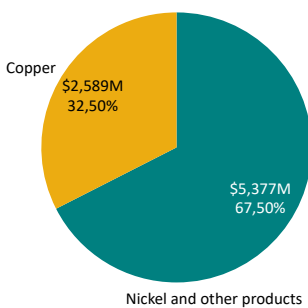


Figure 2 - Base Metals revenue per product (FY21)

Ferrous Minerals The segment comprises the production of iron ore fines and pellets, as well as the sale of ore prior to processing (ROM). Vale is the world’s largest supplier of iron ore, operating nine mines and nine pellet plants in Brazil. The company also conducts pelletizing operations in Oman, having two pellet plants integrated in its distribution centre. Ferrous Minerals is the most significant segment of the company, corresponding to 85% of total company revenues (\$46,302m) and \$31,589m of Adjusted EBITDA in FY2021. Most total Ferrous Minerals’ revenues come from the sale of iron ore fines (84%), with pellets (15%) and other products (i.e., ROM and manganese) being less significant.

Base Metals The segment involves mining and refining operations related with the sale of nickel, copper, PGMs, gold, silver and cobalt. The company mines nickel in Canada, Indonesia and Brazil, having refining facilities in the United Kingdom, Canada and Japan. Vale is then the second largest producer of nickel on a volume basis, only being surpassed by the Russian company MMC Norilsk Nickel. Vale’s copper operations are located in Brazil and Canada, where it is also mined as a co-product of nickel mining activities. Furthermore, PGMs, gold, silver and cobalt are obtained as by-products from nickel and copper mining operations. Base Metals represent the second largest segment, corresponding to 15% of total revenues (\$7,966m) and \$3,193m of Adjusted EBITDA in 2021.

Others This segment is intended to the allocation of revenues and costs of other products, services, research and development, investments in joint ventures and associates of other business and unallocated corporate expenses.

Discontinued Operations Vale has been pursuing a portfolio consolidation strategy, focusing on its core mining operations. US-based Mosaic Company US bought Vale’s fertilizers business for \$1.4B in 2016, except for the Cubatão assets, which were bought for \$255M by the Norwegian Yara International ASA in 2017. The company divested its coal operations in 2021, selling its Mozambique coal assets to Vulcan Resources for \$270M plus a 10-year royalty

agreement subject to the evolution of mine production and coal prices. Vale divested its manganese mining operations at Morro da Mina (sold to VDL Group in 2022) and its ferroalloys operations in Barbacena and Ouro Preto. Until April 2022, Vale also conducted mining operations in the Midwestern System through the subsidiary Mineração Corumbaense Reunida S.A., entering into an agreement with J&F Mineração Ltda. for the sale of all iron ore, manganese ore and logistics assets in the Midwestern System, which was concluded in July 2022. Other less significant transactions were conducted over the last years.

Ownership Structure Vale S.A., despite being headquartered in Rio de Janeiro, Brazil, is traded in the B3 (Vale3), the New York Stock Exchange (VALE) and the Bolsa de Madrid (XVALO). The company's outstanding share capital is represented by 4.6B common shares. There are also 12 golden shares belonging to the Brazilian government, providing limited veto power over changes to the name of the firm, the location of headquarters and the corporate purpose. Currently, there are six shareholders owning more than 5% of total stock (totaling 40.2% of outstanding share capital). In 2021, a share repurchase program was completed, with 270M shares (5.3% of the outstanding common shares) being bought at an average price of \$19.95. As of FY2021, roughly 21.85M common shares were bought (0.4% of the outstanding common shares) at an average price of \$12.47 (\$0.3B investment) under the program announced in October 2021. In April 2022, a new share repurchase program was announced, under which 500M common shares (10% of the outstanding common shares) would be bought over the next 18 months.

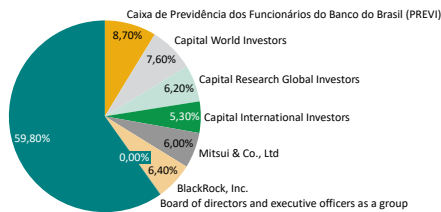


Figure 4 - Main shareholders
(as reported in the 2021 Annual Report)

Ferrous Minerals

Operations and Product Portfolio Vale conducts its iron ore business in Brazil primarily at the parent-company level, running its mining and beneficiation operations in three main systems: Northern, Southern and Southeastern. The Northern System comprises three mining complexes. Serra Norte (three mining areas and three beneficiation plants), Serra Sul (one main mining area and one beneficiation plant) and Serra Leste (one mining area and one beneficiation plant) are open pit mining operations with high-grade hematite ore type (iron ore grade around 65%). There is also a minor amount of itabirite material (iron grade of 35-60%). Most mining concessions have no expiration date. Brazilian operations are subject to extensive environmental regulation, requiring Vale to modify mining plans or to incur additional costs that may limit production volumes, costs or mineral reserves. Two mining complexes, Vargem Grande (five mines and five major beneficiation plants) and Paraopeba (five mines and three major beneficiation plants) incorporate the Southern System, open pit mining

operations with high ratios of itabirite ore relative to hematite ore type (lower average iron ore grade, 35-60%). Part of the ore is concentrated to achieve shipping grade (higher than 60%) and part is shipped and blended in Asia with the high-grade ore from the Northern System. The Midwestern System operates three mining complexes (Itabira, Minas Centrais and Mariana) with the same mine type and mineralization style.

Vale produces iron ore pellets in Brazil and Oman, directly (Fábrica, Vargem Grande and São Luís are fully owned by the company, as well as a 70% stake in Vale Oman Pelletizing Company LLC and majority stakes in Tubarão pelletizing plants) and through joint ventures (Vale holds a 50% stake in Samarco Mineração S.A., the remaining being held by BHP Billiton). Although the company reports a combined pelletizing capacity of 59.3 mtpy (excluding Samarco joint venture), operations in Fábrica (4.5 mtpy pelletizing capacity) have been suspended since February 2019 following new regulations concerning the use of the dams. Operations in the JV of Samarco are resuming with approximately 26% of the productive capacity (7-8 mtpy) after having been halted since the 2015 dam rupture. The current run rate capacity should be revised to fall within the 61.8 - 62.8 mtpy range.

Products and Pricing Mechanism Pursuant the company's portfolio consolidation strategy, the sale of its ferroalloys and manganese mining operations has scaled down the ferrous minerals segment to three sources of revenue, reliant on the steel industry performance: iron ore fines, iron ore pellets and run-of-mine (ROM). Products in the form of fines, pellet and lump are sold both under long-term contracts with customers and on a spot basis through tenders and trading platforms, generally priced based on an impurity discount or premium to the Platts IODEX 62% Fe CFR China index base specification.¹ In August 2018, Fastmarkets MB launched the 62% Fe low-alumina index, which is based on the Brazilian blend fines product (BRBF) launched by Vale in 2015. BRBF is a product with silica content limited to 5% and lower alumina (1.5%) that is produced by blending fines from Carajás ores (Northern System) with Southern and Southeastern ores. In 2019, Vale also launched the GF88 product (obtained by grinding Carajás fines in Chinese ports) with the intention of supplying the growing market of pellet production in China. At the same time, to avoid an oversupply of 65% Fe content fines in the seaborne market, the company introduced the use of Carajás fines as a pellet feed, being able to sustain a premium product sales share above 80%. Therefore, to align the chemistry of the pellet products with that of the feed used by the company, Vale's quarterly-

¹ Iron ore fines with 62% iron, 2.25% alumina, 4% silica and 0.09% phosphorus

negotiated pellet premium has been quoted as a dollar figure above the Fastmarkets MB 65% Fe Fines Index.

Market Overview

▪ Long-Term Outlook

Chinese Demand Amid Environmental Regulations China has been the main driver of global demand for metal commodities over the last decades and accounted for 74% of demand for iron ore and 64% of Vale's iron ore fines and pellets shipments in 2021. Economic growth in the 2000s² has consolidated China as the leading steel producer³ and exporter,⁴ responsible for 52.97% of global output (1032.8 million metric tonnes) and 14.44% of total export volume in 2021 (66.9 million metric tonnes).

As the Chinese economy leaves a rapid growth stage (heavily dependent on investment) towards an innovation-led high-quality development era (driven by consumption), the steel industry is also being reformed, transitioning from the "quantity-phase" to the "quality-phase" of lower output and growing environmental concerns (the sector is responsible for about 8% of global final energy consumption and 7% of energy sector CO₂ emissions). China introduced in 2015 a capacity swap program incentivizing steelmakers to replace old facilities with more efficient ones, attempting to curb steelmaking capacity in environmentally sensitive regions. Nonetheless, given the decentralized structure of the industry (Figure 5), some steel mills were able to expand production capacity under the framework of the capacity swap scheme. This event led the Chinese government to release a new draft version of a capacity swap program in December 2020, demanding the capacity swap ratio for environmentally sensitive regions to be raised from 1.25:1 to 1.5:1 whenever the renewed capacity is based on the blast furnace - basic oxygen furnace (BF-BOF) route.⁵ Steel mills operating in environmentally sensitive regions and planning to replace existing capacity with electric arc furnaces (EAFs) or hydrogen-based facilities will maintain their current capacity.

While the Chinese steelmaking industry evolves towards environmentally friendly production processes, the characteristics of the required metallic inputs will also reshape the seaborne market dynamics. The BF-BOF route typically requires unprocessed iron ore in a blend of fines and lumps, being the highly concentrated

China Baowu Group	119,95
Ansteel Group	55,65
Shagang Group	44,23
HBIS Group	41,64
Jianlong Group	36,71
Shougang Group	35,43
Delong Steel Group	28,82
Shandong Steel Group	28,25
Valin Group	26,21
Fangda Steel	19,98
Top 10 Output	436,87
Total Crude Steel Output	1032,8
Top 10 Output (% Total)	42,30%

Figure 5 - Chinese steel industry concentration

² GDP per capita CAGR of 8.07% from 2000 to 2021 (constant LCU)

³ Chinese crude steel production increased from 127.2 to 1032.8 million metric tonnes from 2000 to 2021 (CAGR = 10.49%)

⁴ Peaked at 112.4 million metric tonnes in 2015, approximately 26.32% of total export volume

⁵ As of 2021, 89.4% of Chinese crude steel output was produced in BF-BOF (above the 71.1% global average)

forms of the latter ⁶ directly used without further processing in steelmaking (typically commanding a premium over fines). Iron ore fines, on their turn, need to be agglomerated, either by producing sinter or pellets. As these processes consume great quantities of coal, coke and natural gas, Chinese governmental authorities have already put sintering operations on halt in the past. Development guidelines for the local steel industry urge producers to meet high-level environmental protection standards while sustaining historical annual crude steel output figures. For reducing particulate and carbon emissions from BOFs while keeping productivity, high-grade products' (65% Fe fines and pellets) lower level of impurities may be favoured to improve sinter quality, thus reducing BOFs' slag volumes and metallurgical coal usage. Accordingly, Vale's Carajás high-grade iron ore fines enjoy a strong long-term demand profile, with Chinese BF-BOF producers avoiding pollution penalties and forced shutdowns potentially widening the spread over lower-grade iron ore fines and pellets' prices.

Secondary Steel Production on the Rise Simultaneously, the goal of Chinese carbon neutrality by 2060 relies on domestic steel industry consolidation. Mergers between steelmakers to form large-scale companies ⁷ will allow to cut steel production, cap seaborne iron ore prices and further reduce carbon emissions by implementing scrap-based EAFs, which are 1/8 as energy intensive as production from iron ore (using electricity as the main energy input). Scrap can contribute to future crude steel production, negatively impacting demand for iron ore. However, persistent growth in steel demand and the lifetime lag between products coming into use and becoming obsolete (end-of-life scrap) will not allow scrap inputs to fully meet the higher demand requirements of the next decades.

The Emergent Steelmaking Hubs Southeast Asian steel demand growth has been attracting foreign investment projects, mainly supported by Chinese companies. Although additional production has been absorbed by domestic demand (Figure 6), major BF-BOF capacity developments in the Philippines, Malaysia and Myanmar have risen concerns of significant overcapacity in the region. The Southeast Asia Iron and Steel Demand Institute estimates that steelmaking capacity in the ASEAN region could increase to about 151 million metric tonnes (mmt), raising total excess capacity to more than 60 mmt by 2026 with demand taking c.20 years to catch up with this capacity level. With profitability under pressure, local steel manufactures have urged governments to take protectionist measures and curb finished steel imports (which stand at 60% of consumption). Vietnam has levied duties of up to 25% on cold-rolled sheets and coil from China and Indonesia has also imposed duties on several flat

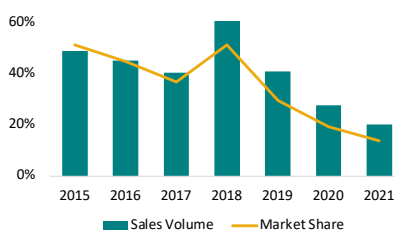


Figure 6 - Southeast Asian steel production and net export position (figures in mmt)

⁶ High-grade lumps are typically supplied from Australian mining operations owned by BHP and Rio Tinto

⁷ China wants its top five steelmakers to account for 40% of the country's total steel output by 2025

product imports from China, Russia and India. This path towards self-reliance coupling with rising steel demand from infrastructure, automotive and industrial investments is set to expand regional demand for iron ore. Vale's blending operations in the Malaysian Teluk Rubiah Maritime Terminal, one of the 18 Asian ports in which the BRBF premium product is produced, allows the company to pursue an ambitious strategy of supplying the growing regional steelmakers.⁸

Steelmaking capacity is also increasing in the Middle East due to expansions in Iran. Conditional on all projects currently underway being concluded as scheduled, Iran's crude steelmaking capacity can reach 68.7 mmt by 2023 and become the seventh largest in the world. An idiosyncrasy of the industry in the Middle East is that, given the abundance of natural gas, around 80% of the nominal steel production comes from the gas-based direct reduced iron-electric arc furnace route (DRI-EAF). Unlike other production processes, DRI-EAF has less flexibility to use iron ore with more impurities, typically using high-quality direct reduced iron ore pellets. Vale's Oman pelletizing operations allowed the company to supply the largest DRI-EAF steelmakers in the Middle East, being able to capture higher premiums due to the scarcity of such high-grade DRI pellet products.⁹ However, since 2018, Iran's largest steel producer, Mobarakeh Steel Co, and other state-owned companies have expanded pellet production capacity, halting most of their imports. Adding to the US-imposed sanctions that weakened the local currency and made imports more expensive, Vale's regional market share has suffered a major setback (Figure 7) without apparent signs of significant recovery. Only marginal DRI-EAF capacity developments from other Middle Eastern countries can sustain the current market share.

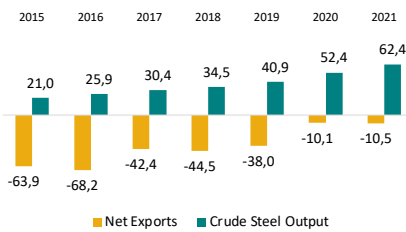


Figure 7 - Vale's sales volume (figures in mmt) and market share in the Middle East

An Ever-growing Giant Called India Despite being the second largest steel-producing country in the world (118.2 mmt output in 2021), further growth is expected in the long-term¹⁰ to meet the demand from infrastructure development, construction, and automotive industry. Given the extensive use of DRI-EAF and scrap-based EAF in the country, India has become world's largest producer of direct reduced iron while maintaining a modest iron ore net export position. India's minimal iron ore imports (Figure 8), which are set to remain at low levels given recent developments, mostly comprise high-grade fines and lumps to offset the inconsistent quality of domestic products. Last May, the Indian Ministry of Mines imposed a 45% export tax on all grades of iron ore to increase the availability of low-grade ores (58% Fe content and below), mandating as well that 80% of total iron ore produced by a mining leaseholder that is below 58% Fe

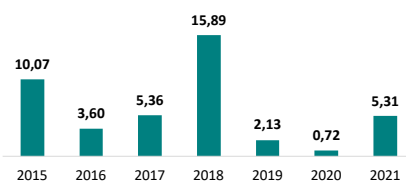


Figure 8 - India's iron ore import volume (figures in mmt)

⁸ In 2021, the terminal unloaded 20.4 million metric tonnes of iron ore and loaded 20.1 million metric tonnes of iron ore

⁹ The Oman plant is supplied by iron ore from the Southeastern System and by high-grade iron ore from Carajás (65% Fe content)

¹⁰ The National Steel Policy of 2017 set a target to more than double capacity by 2030

content shall be beneficiated to 62% Fe content and above. These policies will be implemented for an initial period of five years and seek to guarantee there is no shortage of iron ore to meet present domestic demand and the National Steel Policy target of 300 mmt steelmaking capacity by 2030. Despite the promising steelmaking industry prospects, Vale's market development opportunities in the subcontinent are limited amid the expected high-grade domestic feed availability.

▪ Short-Term Outlook

Global Landscape As higher interest rates in response to inflation raise the chance of recession in some countries, global steel demand is set to increase a modest 0.4% by the end of 2022 up to 1,840.2 mmt.¹¹ Russia's invasion of Ukraine, notwithstanding the impact on energy prices that drove inflation up, may account for a 13.9 mmt decrease in steel demand that offsets other expected regional developments. Chinese demand is set to stagnate by the end of 2022 at 972 mmt, with the country's debt-strapped real estate sector dip in H1 2022 (down 4.2% *vis-à-vis* H1 2021) unlikely to be reverted until 2023. Furthermore, China's zero-COVID policy has also impacted the recovery of domestic consumption and manufacturing logistics, a key driver of steel demand. Historically, government subsidies and other forms of state intervention have created market distortions, the most impactful being a persistent oversupply of steel that worsened in 2021, amid the substantially lower demand caused by the delta variant resurgence-related economic crisis.¹² The substantial inventory build-up coupled with weak consumer and manufacturer confidence have cut global steel production by 5.5% in H1 2022 *vis-à-vis* H1 2021. Only India challenges the trend with an 8.8% increase *vis-à-vis* H1 2021.

Chinese Response Amid Stimuli Package Though being the second highest percentual decline among the top ten steel producing economies,¹³ Chinese steel mills had production cuts circa 37 mmt in the first half of 2022. Declining reinforced steel bar (Rebar) and hot rolled coil (HCR) steel prices (Figure 9 and Figure 10, respectively) have been pressuring steelmakers, who decided to idle capacity in May as weak rebar margins progressed towards negative territory in mid-June (hitting negative \$40.57/mmt in the beginning of July).¹⁴ European sanctions on Russian coal, however, may marginally improve Chinese BOFs' margins entering 2023. As Russia becomes increasingly dependent on exports of coking and thermal coal to China, a paramount strategic partner, local buyers have become able to import cargoes at a deep discount, with an all-time high

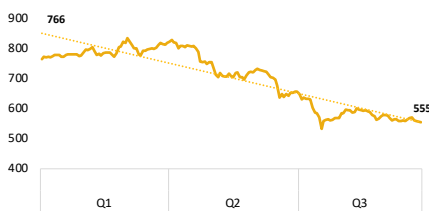


Figure 9 - China Rebar 16-25 mm HBR400 Shanghai market price Q1-Q3 2022 (figures in \$USD/tonne)

¹¹ World Steel Association Short Range Outlook, April 2022

¹² 116.2 mmt gap, the highest since 2015

¹³ Iran's crude steel production declined by 10.8% in H1 2022 when comparing with H1 2021

¹⁴ Source: S&P Global Analysis



Figure 10 - China Hot Rolled Coil 5.5 mm Steel SS400 Shanghai market price Q1-Q3 2022 (figures in \$USD/tonne)

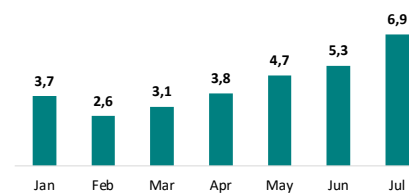


Figure 11 - China's thermal and coking coal imports from Russia Jan-Jul 2022 (figures in mmt)

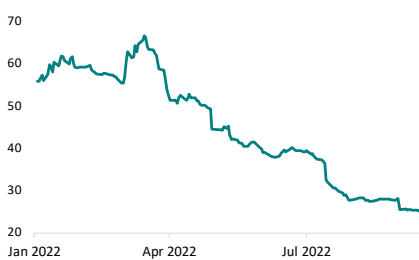


Figure 12 - Seaborne 65% pellet premium Qingdao index (figures in \$USD/tonne)

import in July (Figure 11) at \$144/ton on a free on board (FOB) basis ¹⁵ (roughly 20.79% below the H1 2022 average market price).¹⁶ Coupling with the unofficial import ban on Australian thermal and coking coal, the share of imports from Russia has increased since the conflict started and is expected to continue in Q1 2023. At the same time, Chinese authorities announced stimuli to boost the country's infrastructure construction and manufacturing, offsetting headwinds to steel demand from the property sector. Most of the fiscal support is expected to be employed in less steel-intensive projects, such as power generation, water conservation and tech-related infrastructure. Steel intensive sectors receive less focus, with investments in highways and railways down by 0.2% and 4.4% on the year.¹⁷ These measures seem to be aimed at preventing further downturn rather than propelling economic growth heading in 2023.

The Russian-Ukrainian Conflict is shaping the European market. Following the EU-imposed restrictions on iron and steel-related imports from Russia, Ukraine became the largest supplier of iron ore concentrates and pellets to the EU in March, accounting for 30% of European needs. Metinvest ¹⁸ announced that it would stop operating several mining and processing centers due to the supply chain disruptions caused by the war, with exports from Ukraine falling by 23% in June. Rising iron ore prices and steelmakers' margins pressured by the high energy prices and poor downstream steel demand led some European steel mills to start talks with Vale to accommodate the supply shortage from Eastern Europe. Two-month voyage times from Brazil to Europe, instead of the typical 8 to 14 days from Ukraine though may hinder that possibility.

Other Regional Developments DRI pellets demand from plants located in oil and gas exporting regions, such as the Middle East and North Africa, should be strong in the short-run, as steel production is bounded to regional markets sustained by the escalating oil and gas prices. Solid sales figures in Southeast Asia have also been referred by the company in the Q2 2022 Earnings Call.

Premium Dynamics Despite more favorable steel demand prospects for 2023, with the World Steel Association forecasting a 2.2% global increase in steel demand (reaching 1,881.4 mmt), the short-lived Chinese fiscal stimuli will shape the seaborne iron ore market going from Q4 2022 to Q1 2023. After a 70.82% dip in July, 75% Tangshan BOFs' capacity utilization in September prompts steel production amid possible sintering restrictions throughout the winter months. Carbon emission targets and depressed steelmaking margins will favor direct-charge solutions in Q1 2023 (i.e., lumps and blast-furnace grade pellets).

¹⁵ Source: Bloomberg

¹⁶ Average FOB prices of Newcastle (Australia) and Qinhuangdao (China) thermal coal with 5,500 kcal/kg and 6,000 kcal/kg net calorific value

¹⁷ Source: S&P Global Analysis

¹⁸ International steel and mining group holding most of Ukrainian iron ore reserves

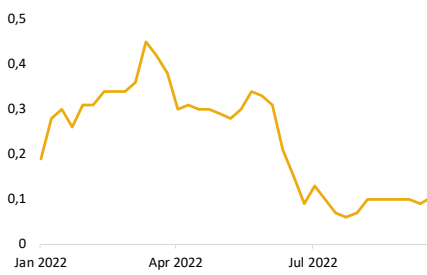


Figure 13 - Seaborne 62.5% lump premium Qingdao index (figures in \$USD/tonne)

Nevertheless, suppressed high-grade pellets and lumps' premiums during H1 2022 (Figure 12 and Figure 13, respectively) should persist. Steelmakers must prioritize cost-effective alternatives, seeking products with more impurities (i.e., higher silica and alumina contents) and lower grades while attempting to recover margins. Consequently, Vale's spot sales of medium-to-high silica fines from the Southeastern and Southern Systems have a strong profile over the short-run in detriment of the low-impurity BRBF and high-grade IOCJ products, whose supply has already been limited by the H1 2022 constraints in the Northern System. The company should then privilege its current *value over volume* strategy and place mainstream products at fixed prices with their preferred customers, being able to negotiate at higher premiums than those offered in the seaborne market.¹⁹

Forecasts

Revenue Forecasts

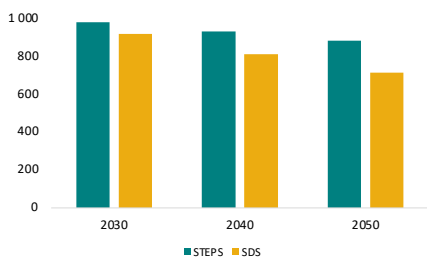


Figure 14 - China nominal crude steel output by scenario (figures in mmt)

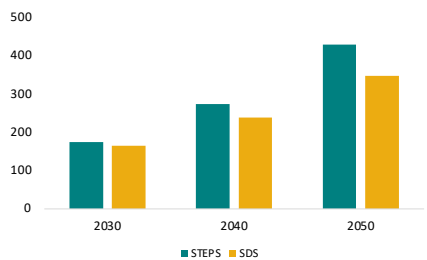


Figure 15 - India nominal crude steel output by scenario (figures in mmt)

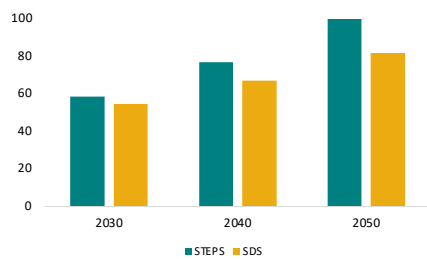


Figure 16 - Middle East nominal crude steel output by scenario (figures in mmt)

Steel Production Scenarios To model global iron ore demand, two pathways for the steel industry, provided by the International Energy Agency (IEA),²⁰ have been used: the Stated Policies Scenario (STEPS) and the Sustainable Development Scenario (SDS). The STEPS outlines a conservative benchmark for the future, in which governments may not reach all decarbonization and energy-related goals expected to impact the global steel industry. It considers Nationally Determined Contributions under the Paris Agreement and the "Fit for 55" package of measures announced by the European Commission in July 2021.²¹ The SDS is based on a surge in clean energy policies and investment that lead to all current net zero pledges being fully achieved.²²

Under the STEPS, and assuming that global consumption equals production over the long-term, steel production grows from 1,950 mmt in 2021 to 2,535 mmt in 2050 at a CAGR of approximately 1.1%. In the SDS, material efficiency policies ensure that global production equals 2,053 mmt by 2050 (19% reduction *vis-à-vis* the STEPS, increasing at a CAGR of 0.4%). Following the structural changes in the Chinese economy currently being implemented, in both scenarios China's steel production is set to fall (at a CAGR of -1.66% and -1.79%, respectively) and account for 35% of global production by 2050 (nominal crude steel output of 887 mmt and 719 mmt, respectively). India's output will ramp up and compensate the Chinese decline, representing 17% of global crude steel output by 2050 in both scenarios (nominal output of 431 mmt and 349 mmt in the STEPS and the SDS, respectively). Other economies in which production changes may be less

¹⁹ \$30/ton higher pellet premiums were negotiated in Q3

²⁰ *Iron and Steel Technology Roadmap. Towards more sustainable steelmaking (2020)*. International Energy Agency. Paris, France

²¹ Provides the foundations for the EU to reach a 55% reduction in emissions by 2030 compared with 1990 levels

²² Advanced economies reach net zero emissions by 2050, China in 2060 and all other countries by 2070 at least

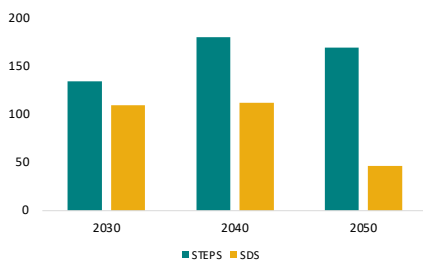


Figure 17 - Southeast Asia nominal crude steel output by scenario (figures in mmt)

influential in terms of global output will still be regionally significant. The Middle East is expected to account for 4% of global steel production by 2050 in both scenarios, more than doubling its current output in the STEPS (101 mmt). Emerging economies in Latin America, Africa and Southeast Asia, which accounted for 6.6% of global steel production in 2021, will represent a small percentage of global production by 2050 but output will increase between 2 and 4 times in the STEPS. Advanced economies are not expected to make large additions of steelmaking capacity, with Japan, South Korea and the USA maintaining a relatively constant steel output in both scenarios. Europe’s output, however, increases up to 266 mmt in the STEPS and 216 mmt in the SDS.

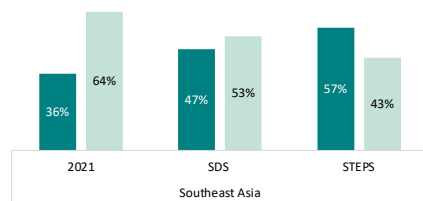


Figure 18 - China BOF and EAF penetration rates in 2050 by scenario

Changing Production Routes Scrap-based EAF and DRI-EAF steel production will dominate by 2050 in the SDS, accounting for 53% of nominal crude steel output. In the STEPS, the increase in production levels relative to steel scrap availability allows BF-BOF to dominate, accounting for 57% of global steel output. Besides scrap inputs, age and size of existing steel mills, local regulatory agendas and energy resources will influence the adoption of the scrap-based EAF route across the world. China, with just a 10.6% share of secondary steel production in 2021, is set to progress to 45% in the STEPS and 47% in the SDS. The transition will be enabled by a large amount of end-of-use steel scrap becoming available very quickly, given the substantial build-up of in-use steel stocks during China’s boom period. Given that recent regulation favors the adoption of EAFs to replace older BOFs, a large share of the Chinese installed capacity is in the middle of the typical 25-year investment cycle, meaning the country will be able to experience the rapid transition to secondary steelmaking as the natural phase-out of existing primary production facilities is aligned with increasing scrap availability. India, contrarily to China, is expected to have a strong output growth trajectory in any scenario. Limited availability of scrap inputs relative to overall production levels will coincide with primary steelmaking capacity additions, resulting in lower-than-current shares of secondary steel production by 2050 (45% in the STEPS and 52% in the SDS). The growing hubs of the Middle East, Latin America, Africa, and Southeast Asia will also add substantial amounts of primary steelmaking capacity until 2050. Regions with access to low-cost renewable electricity, such as Africa, will tend to favor the hydrogen-based DRI-EAF route over the long-run, whereas the Middle East and Latin America, regions with low-cost natural gas, will invest in the gas-based DRI-EAF route. In Europe, the predicted constant scrap availability throughout this horizon will limit the replacement of older blast furnaces with scrap-based EAFs.

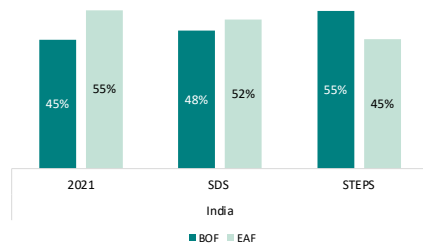


Figure 19 - India BOF and EAF penetration rates in 2050 by scenario



Figure 20 - Middle East BOF and EAF penetration rates in 2050 by scenario

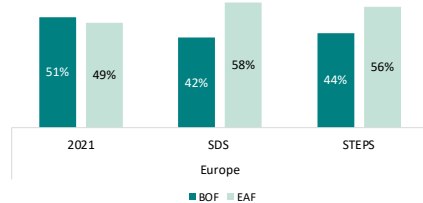


Figure 21 - Southeast Asia BOF and EAF penetration rates in 2050 by scenario

Metallic Inputs Steelmaking has two main metallic inputs: iron ore and recycled steel scrap. These are consumed in different proportions given the chosen

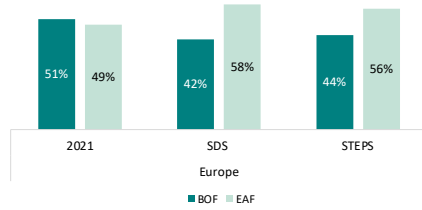


Figure 22 - Europe BOF and EAF penetration rates in 2050 by scenario

production technology. On average, the EAF route uses 710 kg of recycled steel and 586 kg of iron ore to produce 1,000 kg of crude steel. To obtain the same quantity, the BF-BOF route requires 1,370 kg of iron ore.²³ The increasing adoption of the EAF route implies that iron ore will account for a lower share of metallic inputs' consumption in both scenarios -70.5% in the STEPS and 67.5% in the SDS by 2050.²⁴ Following the BF-BOF capacity additions discussed, the total amount of iron ore inputs is projected to increase at a CAGR of 0.39% in the STEPS, from an estimated 2,230 mmt iron ore consumption in 2021 to 2,496 mmt by 2050. In the SDS material efficiency and amplified secondary steelmaking implementation ensure that total iron ore inputs consumed decrease at a CAGR of -0.52%, to 1,919 mmt in 2050. The results were obtained assuming that scrap-based EAF adoption is capped by an annual 1,400 mmt and 1,160 mmt steel scrap inventory in the STEPS and SDS, respectively. In neither scenario the pace of secondary steelmaking implementation is affected by this restriction, as annual steel scrap consumption tops at 1,045 mmt and 923 mmt, respectively.

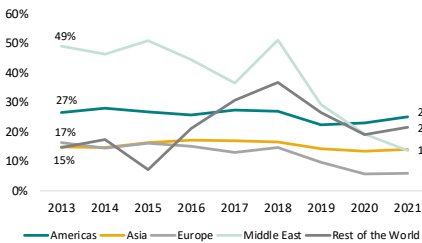


Figure 23 - Vale's market share evolution by region

Market Share To complete the top-down approach to the attainable demand in each region, Vale's historical sales and regional iron ore consumption estimates were used to compute the company's market share by region from 2013 to 2021 (Figure 23). The company sustained its market share in the Asian market (averaging 15.5%) and this is expected to continue. Despite higher freight costs compared to Australian producers, Vale secured valuable sales relationships based on a consistent supply of a specific mix of iron ore and pellets at competitive prices, supported by the distribution centres in Malaysia and Oman, and long-term agreements with 19 ports in China that serve as distribution centres. Historical market positioning in the Americas (average market share of 25.9%) is also sustainable. Given the competitive nature of the Brazilian iron ore market,²⁵ with many small producers and vertically integrated steelmaking companies conducting iron ore mining operations,²⁶ Vale is likely to have achieved its maximum attainable market share in the region. North America's high adoption of secondary steelmaking (c.69% of total crude steel production in 2021) also hinders growth opportunities. In Europe the market share has been declining since 2018, stabilizing at 6% with the outbreak of the COVID-19 pandemic. The 5.1% sales decline in H1 2022 compared to the homologous period is in line with the 6.2% decrease in crude steel production, suggesting that Vale's market share may bottom at 6% in the next years. In Middle East the most

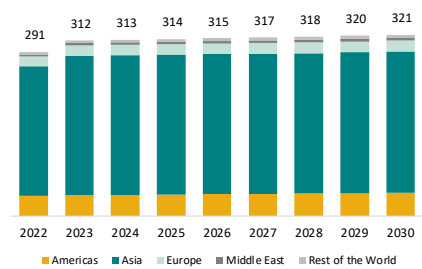


Figure 24 - Attainable demand under the STEPS (figures in mmt)

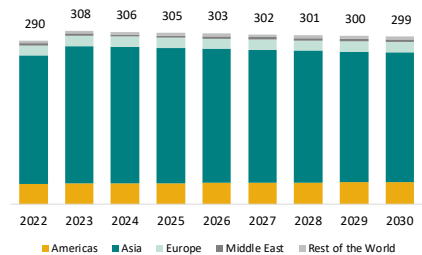


Figure 25 - Attainable demand under the SDS (figures in mmt)

²³ World Steel Association calculation (2018)

²⁴ Down from 79.5% as of 2021

²⁵ By far the most relevant iron ore producer in Latin America: 28.47 mmt of primary iron ore production, followed by Mexico with 8.41 mmt

²⁶ Arcelor-Mittal and Gerdau S.A., for instance, run both steelmaking and iron ore mining operations in Brazil

recent market share (14%) is the best guidance amid increasing domestic DRI pellet supply.

Mineral Assets The top-down approach described above, together with the rationale explained in the *Market Overview*, portrait two prospective iron ore demand scenarios for the company (Figure 24 and Figure 25). Existing mineral assets' management under these possible paths, however, is the determinant driving sales volume and the segment's valuation. As of the FY2021, Vale reported ²⁷ iron ore mineral reserves amounting to 12,495.4 mmt,²⁸ averaging 56.6% Fe content, of which 3,858.9 mmt were proven reserves and 8,636.5 were probable reserves. Although the mining industry only reports 2P reserves (proven and probable) according to SEC guidelines, this may be conservative for valuation purposes. Therefore, 3P reserves (proven, probable and possible) should be used. Despite not reporting possible reserves, Vale conducts mining operations under Brazilian and Canadian jurisdictions, where it is mandatory to report and make a clear distinction between measured (6,871.6 mmt), indicated (7,574.6 mmt) and inferred (8,243.3 mmt) mineral resources. As measured resources have reasonable prospects of eventual economic extraction, they may become a reserve at a future date whenever economic constraints may be fulfilled.²⁹ For valuation purposes, the average recovery rate per mine ³⁰ was applied to the corresponding 2P reserves and measured resources, reaching a total marketable iron ore tonnage of 15,532.1 mmt. It is then assumed that each mine's measured resources are extracted in their entirety until the corresponding exhaustion date at a fixed yearly rate. From 2020 to 2021, reported mineral reserves decreased by 1,948.8 mmt, though only 459 mmt are justified by the incorporation of new geological information and depletion. The remaining reduction concerns the Mariana complex, where technical and strategic revision of a long-term project to process low grade ores led the company to reclassify a large portion of its mineral reserves as measured mineral resources (Figure 27). Nonetheless, the referred amount is incorporated in the segment's valuation.

Production Capacity Each mine's production capacity was determined based on expected exhaustion dates and expansion projects currently underway. The Capanema Project (Mariana mining complex), with the start-up expected for H2 2023, will bring a net capacity addition of 14 mtpy, ramping total figures up to

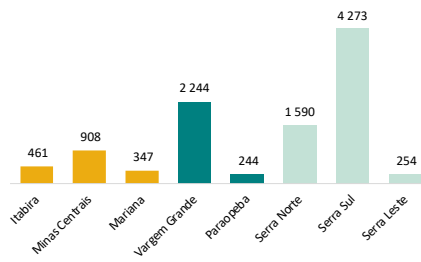


Figure 26 – Marketable iron ore reserves by mining complex (figures in mmt)

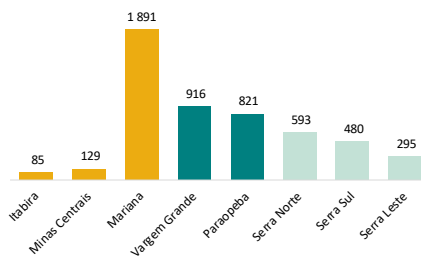


Figure 27 - Marketable (measured) iron ore resources by mining complex (figures in mmt)

²⁷ For the first time in accordance with the SEC-implemented S-K 1300 regulation

²⁸ Including moisture and dry iron content

²⁹ The extraction of mineral resources occurs over a longer period of time compared to the extraction of reserves, and, therefore, conditions allowing the economic extraction of mineral resources may only apply in the future.

³⁰ According to the company, the reported recovery rates correspond to the overall metal recovered to point of first material sale. It is then assumed that beneficiation yields are already taken into account (i.e., high-grade iron ore mines from the Northern System have a 100% average recovery rate given that no beneficiation process is required)

c.394 mtpy in 2024.³¹ Upon completion of Serra Sul 120 project (Northern System) Vale will surpass the 400 mtpy run-rate capacity goal over the medium term. This consists of increasing the S11D mine capacity by 20 mtpy to a total 120 mtpy. Thus, expected production capacity by 2025 is 414 mtpy.

Sales volume and size of inventory tend to move in opposite directions during times of growth and recession. However, mining companies are unable to navigate the business cycle, failing to adjust production volume in response to changes in demand. Lower capacity utilization during downturns exposes the company to operating inefficiencies, such as higher unit production costs, since a large portion of its cost structure is fixed in the short-term due to the capital intensity of mining operations. Consequently, increasing capacity in Serra Sul is modelled as a buffer, producing to meet sales volume requirements and to build-up inventories according to a long-term averaging holding period trend.³² Operating efficiency is then ensured for different iron ore demand scenarios.

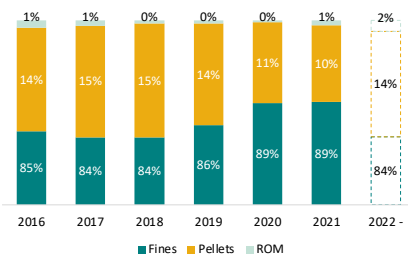


Figure 28 - Historical and forecasted product mix

Product Mix Iron ore revenues are forecasted for 3 different sources: fines, pellets and ROM. The product mix is obtained using historical averages: 84%, 14% and 2%, respectively (Figure 28).³³ Without knowledge of possible changes in steel producers' preferences, the historical average sales mix is the best approach as it accounts for the cyclical marginal changes in the demand for direct feed charges over the business cycle.³⁴

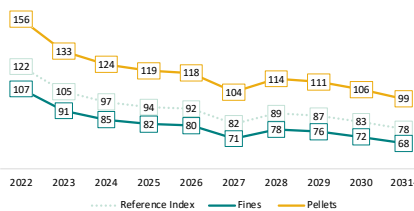


Figure 29 - Fines and pellets' pricing relative to the benchmark index (figures in \$USD/ton)

Prices Iron ore fines and pellets' prices are estimated according to historical price realization relative to the 62% Fe CFR China Index forecasts. On average, Vale attained 87.1% of the reference price in its fines sales. As pellets allow steel producers to bypass the sintering stage, those are sold at a premium relative to the same reference index, having averaged a 40.4% premium.³⁵ Using historical averages is the best approach to estimate each product's discount/premium, as it accounts for the cyclical preference for direct feed inputs over fines and *vice-versa*. The 62% Fe CFR China benchmark forecasts used for valuation purposes (Figure 29) reflect the market consensus that prices should consistently trend downwards, in line with the growing replacement of Chinese BF-BOF capacity and higher iron ore output. Growth is expected to average 2.8% between 2022 and 2026, raising annual production by 367 mmt in 2026, representing more than India, Russia and South Africa's combined output in 2022.³⁶ Long-term forecast for the 62% Fe CFR China Index is \$78/ton, with Vale pricing iron ore fines and pellets at c.\$68/ton and c.\$99/ton, respectively.

³¹ Already accounting for possible delays and the initial production ramp-up
³² Average holding period of 50 days (days of COGS)
³³ Historical average concerns the period between 2013 and 2019
³⁴ As already discussed in the *Short-Term Outlook*
³⁵ Historical averages concern the period between 2013 and 2019
³⁶ Source: Fitch Solutions

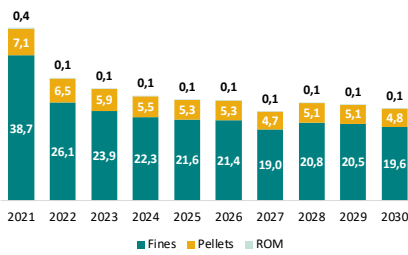


Figure 30 - Ferrous minerals revenues by product in the STEPS (figures in \$USD billion)

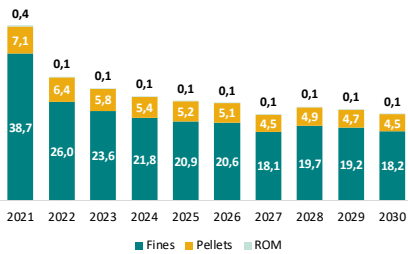


Figure 31 - Ferrous minerals revenues by product in the SDS (figures in \$USD billion)

Revenues Revenue forecasts strictly concern the company’s sales of its own mineral assets, excluding sales of iron ore fines and pellets obtained from third-party purchases. In the STEPS, revenues are expected to plummet 29.5% yoy,³⁷ from \$46.3B in FY2021 to \$32.6B in FY2022, with the negative trend still impacting FY2023 sales figures that are forecasted at \$29.9B (Figure 30). Both lower realized prices and a negative volume effect driven by lower Chinese steel production justify the results, with fines’ sales volume decreasing 12.0% yoy, from 276 mmt in FY2021 to 245 mmt in FY2022. Pellets’ sales volume is expected to increase by 28.1%, from 32 mmt in FY2021 to 41 mmt in FY2022. Vale’s marketable mineral assets will only allow the company to sustain its regional market shares until 2040 in the STEPS and 2042 in the SDS. By then, Vale will have exhausted mineral reserves in the mining complex of Serra Norte under the STEPS,³⁸ and the mineral reserves of Serra Norte, Itabira and Paraopeba under the SDS.³⁹ Between FY2022 and FY2027, the segment’s revenues are set to decline at a CAGR₂₂₋₂₇ of -6.2% in the STEPS and at a CAGR₂₂₋₂₇ of -7.0% in the SDS. Under the STEPS, the expected 0.8% annual sales volume growth will not offset the yoy realized price decrease. From 2027 until 2040, under the STEPS, the company won’t benefit from marginal sales volume increase, with revenues decreasing at the CAGR₂₇₋₄₀ of -1.3%. Under the SDS as well, revenues decrease at a CAGR₂₇₋₄₂ of -0.6% until 2042. From 2040 and 2042 onwards, under the STEPS and the SDS, respectively, successive mining projects’ exhaustions will translate into revenue decreases. Marketable mineral assets by 2089 ⁴⁰ only ensure \$3.340B revenues, decreasing at a CAGR₄₀₋₈₉ of -3.9% and a CAGR₄₂₋₈₉ of -4.0% in the STEPS and the SDS, respectively.

▪ Operating Expenses

Iron Ore Fines C1 Cash Costs are the standard metric used in mining to represent the unitary cash cost of extracting and processing a company’s metal product until it may be delivered to customers.⁴¹ Among the cost drivers, the average ore grade is the most impactful over the long-run. Wet processing is generally used to beneficiate low-grade ores, using water in various stages to remove impurities. Being reliant on dam raisings and a more capital-intensive process by the use of filtration systems to remove ultrathin ore waste mixed in water, dry processing is more cost-effective and a competitive advantage for companies in regions where iron content is high. The blending strategy behind

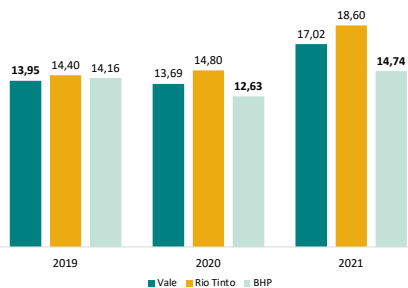


Figure 32 - C1 cash costs among competitors (figures in \$USD)

³⁷ Year-over-year

³⁸ 130.5 mtpy output loss

³⁹ Cumulative 183.5 mtpy output loss

⁴⁰ Latest exhaustion date

⁴¹ Net of by-product revenues, as defined by the World Gold Council



Figure 33 - BRL/USD exchange rate (Q1-Q3 2022)

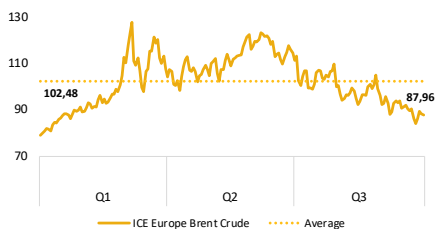


Figure 34 - ICE Europe Brent Crude Energy Future price history (Q1-Q3 2022, figures in USD)

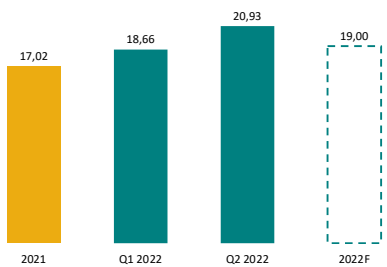


Figure 35 - C1 cash costs forecast for 2022 (figures in \$USD)

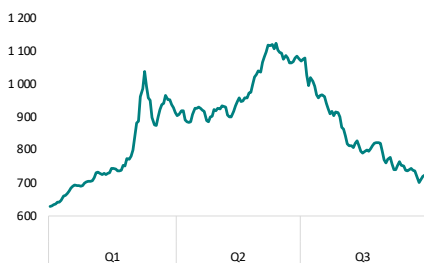


Figure 36 - Price of very low sulfur fuel oil (VLSFO) worldwide in 2022 (figures in \$USD)

the BRBF product, mixing low-grade ores from the Southern and Southeastern system with higher-grade ores from the Northern System, allows greater use of dry processing. The continuous promotion of the product allowed the company to reach a 70% share of dry processing production in 2021 compared to 40% in 2014. This will increase to 85% with the completion of capacity increase in Serra Sul and the Capanema project start-up. By adopting more efficient beneficiation methods, Vale’s goal of delivering \$14 to \$15/ton C1 cash costs is attainable over the medium to long-term. However, for conservative reasons, we incorporate C1 cash costs falling in the higher-end of that range from 2023 onwards.⁴²

In the short-run, rising fuel prices⁴³ and appreciation of the Brazilian real⁴⁴ were responsible for the immediate \$2.2/ton C1 cash cost increase in Q1 2022, that persisted in Q2 2022 given the carryover effect of selling inventories produced at higher costs in the first quarter. Lower production in Q1 2022 (4.1 mmt lower than in Q1 2021) due to halts caused by heavy rains increased pressures. Vale hasn’t revised its end-of-year C1 cash cost guidance (\$18.5 to \$19/ton), based on an exchange rate of R\$5/USD (Figure 33) and an average \$100/barrel Brent price (Figure 34). Recession fears and expected U.S. Dollar appreciation after interest rate hikes may curb crude oil prices in the last quarter, but markets’ focus shifting from recession concerns to tightening oil supply may end up with C1 cash costs falling in the higher-end of the predicted range at \$19/ton (Figure 35).

Freight Costs are a key component of total cost, affecting the competitiveness relatively to players more conveniently located.⁴⁵ Increases in bunker oil prices during H1 2022 (Figure 36) justified the inflationary pressure on unitary freight costs, which topped at \$21.3/ton in Q2 2022. The impact was softened by 70% to 80% of the company’s vessel needs being tied to long-term agreements. Given the cyclical nature of the costs, the figure used for valuation purposes is a normalization of pre-pandemic unitary freight costs, averaging \$17.9/ton. Following the pandemic, the failures and delays in supply chain led some clients to pass the risk in physical performance of sales contracts to sellers, resulting in an increase in the proportion of sales conducted on a cost and freight (CFR) basis.⁴⁶ The pre-pandemic mix of CFR/FOB sales should thus be considered over the forecasting period (76.5% of sales on a CFR basis).

Royalties Vale is required to pay a royalty known as CFEM⁴⁷ on revenues from the sale of extracted iron ore. Although the Brazilian National Mining Agency

⁴² \$15/ton over the entire forecast period

⁴³ As most of the company costs are denominated in Brazilian reais

⁴⁴ Costs of fuel oil, gas and electricity represented 7.6% of total cost of goods sold in 2021

⁴⁵ Australian operations conducted by Rio Tinto and BHP

⁴⁶ As opposed to those conducted on a FOB basis, in which the buyer has the responsibility to procure the right vessel at the right time, it is the seller that must place the goods on board the vessel

⁴⁷ *Compensação Financeira pela Exploração de Recursos Minerais*

distinguishes between domestic sales, exports and internal mineral consumption, they are merged in a simplifying assumption, requiring the company to pay the current CFEM rate of 3.5% on a value equivalent to the prevailing iron ore price in international markets. The company also pays a tax on mineral production at the state level (TFRM)⁴⁸ in Minas Gerais (Southern and Southeastern Systems' location) and Pará (Northern System's location). In March 2021, a decree tripled the TFRM rate in Pará, with the company disputing its legality. In August 2022, the Supreme Court restated its legality. Thus, Vale will pay \$2.42/ton in Pará and \$0.37/ton in Minas Gerais for FY2022.⁴⁹ Since the implementation of the tax in Minas Gerais, and despite an increase at a CAGR of 7.43% in Brazilian Real terms, the decade-long currency depreciation has positively impacted royalties paid on a U.S. dollar basis. Based on a long-term R\$5 per U.S. dollar exchange rate, TFRM paid in Minas Gerais is forecasted to increase at the historical growth rate and in Pará is set at \$2.48/ton over the forecasting period.

Other Operating Expenses "SG&A & Other Operating Expenses", "R&D Expenses" and "Pre Operating and Operational Stoppage Expenses" have been relatively constant as a percentage of revenues. These are assumed to maintain the historical average percentage of revenues over the entire period.

▪ CapEx

Expansion CapEx There are two ongoing projects aimed at expanding the run rate capacity of iron ore mining operations: Serra Sul 120 and Capanema. Approved in August 2020, the Serra Sul 120 project consists of increasing the Serra Sul plant capacity by 20 mtpy, to a total of 120 mtpy at site.⁵⁰ The project comprises a total multiyear investment of \$1,548B, with \$553M already executed by the end of 2022. For valuation purposes, it is assumed that the remaining cash outflows mimic the physical progress of the project, with two additional investments of \$498M each in 2023 and 2024 until the expected start-up by H2 2024. The Capanema project, which includes investments in the Capanema mine (Mariana complex) to reopen the facilities and acquire new equipment, as well as to build a long-distance conveyor belt, is expected to total multiyear investments of \$495M. With \$248M expected to have already been committed by FY2022, an additional \$247M investment is expected until the start-up in H2 2023.

Sustaining CapEx Based on historical values, yearly sustaining CapEx is estimated to be \$6M/mmt of finished production for the entire period.

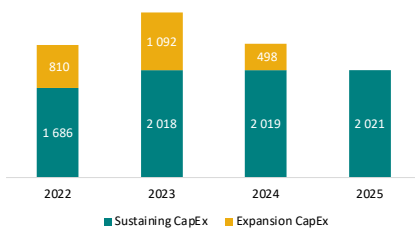


Figure 37 - CapEx breakdown (figures in \$USD million)

⁴⁸ Taxa de Fiscalização de Recursos Minerais

⁴⁹ Evaluated at the average Q1-Q3 2022 R\$/USD exchange rate

⁵⁰ The project is expected to result in an increase of the Northern System's mine-plant capacity to 260 Mtpy from the second half of 2024 onwards

Base Metals

Nickel Operations and Product Portfolio. Vale conducts its nickel mining and refining operations in three different geographies: North Atlantic, Asia-Pacific and South Atlantic. Under the subsidiary Vale Canada Limited, North Atlantic operations comprise three wholly-owned mines in Canada (Sudbury, Thompson and Voisey's Bay) and three refineries (Copper Cliff and Long Harbour in Canada, Clydach in Wales). Despite the mining leases in Canada having predetermined expiration dates,⁵¹ the right to future renewals assures that Vale will continue operating in all the aforementioned locations over the foreseeable future. Adding to nickel, the primary metal, copper is extracted as a co-product and cobalt, PGMs, gold and silver as by-products in the Canadian underground and open pit mining operations. In the Asia-Pacific, Vale operates in Indonesia under the subsidiary PT Vale Indonesia Tbk (PVTI), indirectly owning a 44.34% stake in three mining locations of the Sulawesi Province. Despite the corresponding mineral titles expiring in 2025, the company is entitled to two consecutive ten-year extensions beyond which is no longer expected to operate. PVTI produces nickel matte, which is shipped primarily to Vale's nickel refinery in Japan. Cobalt is also mined as a by-product in the open pit mining operations of Indonesia. Lastly, the company has also been mining and smelting high-quality ferronickel in Onça Puma, Brazil,⁵² since 2011.

Products and Pricing Mechanism. Primary nickel⁵³ can be categorized according to its purity level in Class I or Class II, depending on whether it is above or below the 99.8% purity standard, respectively. Class I finished products can be further classified as high-purity ones whenever they meet a 99.9% minimum nickel content and do not contain specific elemental impurities. High-purity Class I products include, but are not limited to, electrolytic cathodes, briquettes, powders and sulphates with extensive use in high-end applications, namely, the lithium-ion (Li-ion) batteries for electric mobility and other specialty industries like aircraft and spacecraft manufacturing. Low-purity Class I products, on their turn, suit more general nickel applications, such as foundry alloys. Class II products, with lower nickel content and higher impurity levels, are mostly used in stainless steel applications. Finally, ferronickel, which doesn't represent finished nickel production given its 15% to 40% nickel content, is mostly consumed by stainless steel and nickel alloy steel producers. Being an exchange-traded metal, nickel products are generally priced at a premium or discount relative to the London Metals Exchange (LME) reference price,

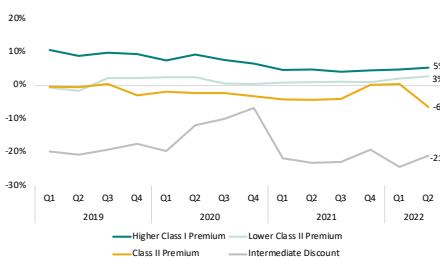


Figure 38 - Vale attained premium/discount by nickel product (% LME reference price)

⁵¹ For instance, the mineral lease contract covering Voisey's Bay operations expires in 2025

⁵² Sole nickel mining complex in the South Atlantic region

⁵³ Produced and used in the form of ferronickel, nickel oxides, other chemicals and as more or less pure nickel metal.

according to their content, purity, shape and size. Ferronickel, for instance, is recurrently sold at a deep discount given that it still needs to be processed before being sold to end consumers (Figure 38).

Market Overview

▪ Long-Term Outlook

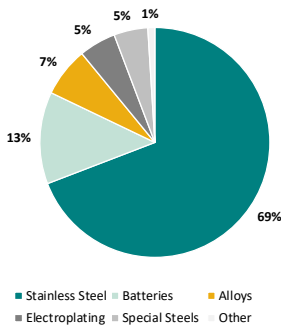


Figure 39 - Primary nickel consumption worldwide in 2021, by industry (figures in '000 metric tonnes)

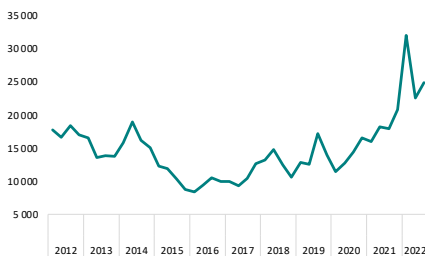


Figure 40 - LME Nickel Cash-Settlement (figures in USD/tonne)

Class I Nickel Shortage and Market Trifurcation Over the past two decades, the nickel market growth has been fueled by a rapid expansion in demand for stainless steel, mostly due to the booming construction in China. Following massive investment, nickel demand from stainless steel more than doubled to reach 1.97 mmt in 2021, accounting for 69% of worldwide primary nickel consumption (Figure 39). The growth dynamics were driven by Class II nickel products consumption, mainly nickel pig iron and ferronickel, with Class I nickel use growing at a comparatively smaller rate. As the dominant driver of nickel demand in the future is expected to change, so too is the product mix. The electrification of the transportation sector is set to prompt future developments under the form of Li-ion batteries. The growing importance of nickel in automotive energy storage systems comes from the fact that Li-ion batteries⁵⁴ show superior energy density and lower metal cost compared to higher cobalt containing technologies, fitting two important considerations for customers' plug-in electric vehicle (EV) adoption: driving range and cost. However, not all nickel is suitable for the sulphate used in cathode manufacturing. Although final Class I nickel products are not the only feedstock suitable for chemical conversion to nickel sulphate, their availability represents the key challenge for future nickel sulphate production. Firstly, because low nickel prices preceding 2021 (Figure 40) led to structural underinvestment in new Class I nickel supply capacity and secondly, due to the fact that current stainless steel production Class I load rates are incompatible with future high-end applications' requirements. In a scenario where Class I nickel usage in stainless steel remains at the current level, above a 10% load rate, no surplus units would be left available for processing into nickel sulphate by 2028.⁵⁵ As alternative feedstock sources, such as recycling and low-purity Class II nickel conversion, are unlikely to compensate entirely, the aforementioned Class I nickel scarcity is expected to push nickel price higher, thus pressuring stainless steel producers' margins and incentivizing to substitute more Class I with Class II nickel.⁵⁶ The market is then expected to gradually trifurcate between Class II nickel for stainless steel, Class I nickel sulphate for EV

⁵⁴ In particular, the nickel-manganese-cobalt (NMC) cathode chemistry

⁵⁵ Wood Mackenzie forecast (2021)

⁵⁶ *Study on future demand and supply scarcity of nickel for electric vehicle batteries (2021)*. Publications Office of the European Union. Luxembourg.

batteries and lower-purity Class I nickel for high-value applications (i.e., nickel alloy casting).

▪ Short-Term Outlook

Nickel’s Bull Market and Raw Material Competition Between the start of 2021 and May 2022, nickel prices almost doubled reaching levels not seen for almost a decade. The phenomenon wasn’t purely demand-driven, but rather the combination of surging battery demand, pressured supply chains and concerns regarding tightening supply, with the former motivated by the production challenges caused by the pandemic and uncertainty around Class I nickel supply from Russia.⁵⁷ High prices may be interpreted as beneficial for long-term nickel supply, stimulating investment and compensating for the underinvestment during the years of low prices. In the short-run though, rising prices incentivised battery chemistry substitutions, with many carmakers (i.e., Tesla) and Chinese suppliers switching to lower cost cathode chemistries with less commodity price exposure. Adding to improving energy density, there is a momentum behind lithium phosphate batteries (LFP), which can extend their market share and threaten the long-term prospects for nickel-rich chemistries. At the same time, given that cobalt is the most expensive component in batteries and its known ESG-related risks, gradual adoption of higher nickel chemistries (i.e., NMC811) may be favoured to offset some costs amongst high-density energy storage systems.

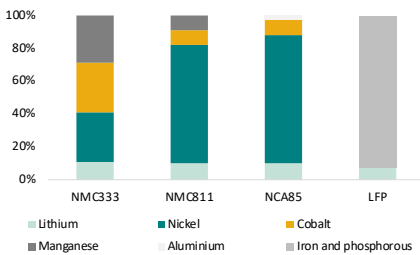


Figure 41 - High-nickel and LFP cathode battery chemistries

Forecasts

▪ Revenue Forecasts

Nickel’s Role in Clean Energy Transition and Stainless Steel Production Similarly to what has been discussed in the last section, the IEA provides the same benchmark scenarios, the STEPS and the SDS, concerning future nickel consumption in the context of the clean energy transition, breaking down demand in five different sources: low-carbon energy generation, electric mobility, battery storage, hydrogen-based technologies and stainless steel and other applications.⁵⁸ Under the STEPS, the former segment remains the main driver of worldwide nickel demand until 2040, growing at a CAGR of 1.3% and reaching 2.78 mmt by that time.⁵⁹ Despite low-carbon energy generation more than doubling its nickel requirements until 2040 (representing 285 kt of worldwide demand), the peak is expected by 2030 (404 kt), decreasing at a CAGR of - 4.6% over the following decade. This decline is explained by lower demand from

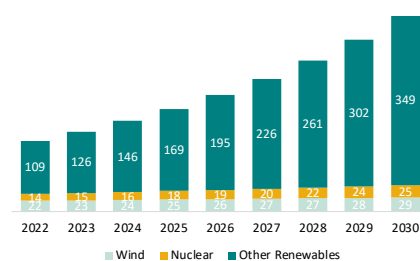


Figure 42 - Nickel demand (figures in kt) from low-carbon energy generation by source (STEPS)

⁵⁷ Russia is the world’s largest producer of battery-grade Class I nickel

⁵⁸ Nickel plating and nickel alloys, among others

⁵⁹ According to what has been discussed in the *Long-Range Outlook*, a 5% Class I nickel load rate has been considered in the stainless steel sector nickel demand projections. According to the Wood Mackenzie report, it is the loading rate ensuring no future Class I shortages affecting the EV market. The corresponding Class I nickel displacement is compensated by Class II nickel, which is built into this report’s forecasts as well.

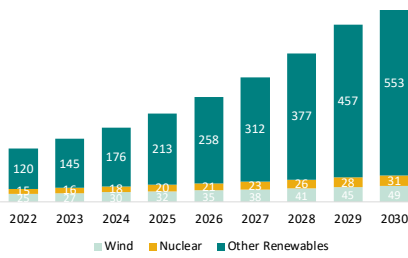


Figure 43 - Nickel demand (figures in kt) from low-carbon energy generation by source (SDS)

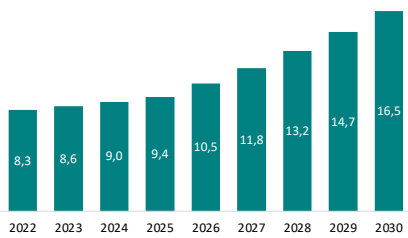


Figure 44 - Global EV sales in the STEPS (figures in millions)

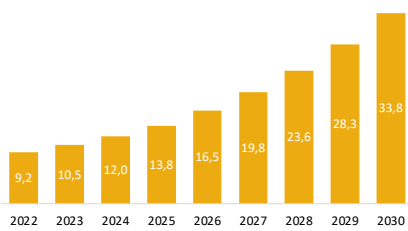


Figure 45 - Global EV sales in the SDS (figures in millions)

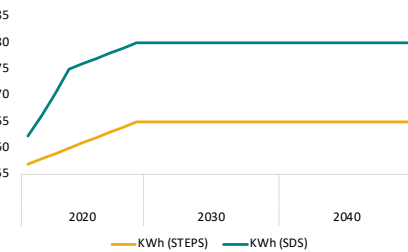


Figure 46 - Installed capacity per vehicle

geothermal electricity generation, which consumes significant volumes of nickel for cost-effective corrosion resistance and superior heat transfer conditions. In the SDS, stainless steel and other applications also account for a substantial share of worldwide nickel demand by 2040, reaching 2.45 mmt. Low-carbon energy generation consumption will increase fourfold by that time, translating into a 445 kt nickel demand. Battery storage and hydrogen-based technologies, which currently represent a small part of worldwide nickel demand and still account for a minor share in the future, will grow in absolute terms from a combined value of 0.4 kt in 2020 to 36.4 kt and 72.5 kt in the STEPS and the SDS, respectively.

Electric Mobility In 2022, Vale signed three multi-year low-carbon nickel supply agreements with Tesla ⁶⁰, Northvolt AB ⁶¹ and General Motors.⁶² Despite Vale believing it is well positioned to supply the North American EV market,⁶³ vertical integration of battery production is not the norm. Thus, it is prudent to model the battery-grade nickel sales only giving forecasted Tesla and GM's needs.

Multi-Year Contract with Tesla A top-down approach has been implemented to forecast Tesla's nickel demand under both the STEPS and the SDS. Firstly, it was necessary to determine Tesla's addressable market, obtaining global light-duty vehicle (LDV) stock over the years according to the following formula:

$$[\text{OECD Population}_t * \text{LDV Fleet}/'000 \text{ people}_t * (1\text{-Yearly Scrap Rate})] + [\text{Non-OECD Population}_t * \text{LDV Fleet}/'000 \text{ people}_t * (1\text{-Yearly Scrap Rate})]$$

A distinction between OECD and non-OECD countries has been made to capture the difference in travel demand per capita growth between the countries, which is tied to differences in annual average population growth and is three times faster in non-OECD countries than in OECD countries until 2050. Global LDV sales become the increase in LDV stock required to meet the demand, considering yearly scrappage rates. The STEPS and the SDS are taken as two benchmark scenarios for the evolution of EV sales share until 2050. Under the STEPS, electric mobility adoption increases at a CAGR of 4.6%, representing 37% of global LDV sales by 2050 (currently at 10%). In the SDS though, EV adoption becomes massive, reaching 86% of LDV sales by that time at a CAGR of 7.7%. To reach Tesla's global sales, the company's EV market share is forecasted to grow from 14% in 2021 to 18% in 2025,⁶⁴ declining thereafter to 10% by 2040.⁶⁵ A major determinant of Tesla's nickel demand is the average energy storage

⁶⁰ Source: <http://www.vale.com/canada/EN/aboutvale/news/Pages/vale-to-supply-northvolt-with-low-carbon-nickel-products-for-batteries.aspx>

⁶¹ Source: <http://www.vale.com/aboutvale/news/pages/vale-confirms-supply-deal-with-tesla-for-low-carbon-nickel.aspx>

⁶² Source: <https://www.vale.com/w/vale-and-gm-sign-long-term-nickel-supply-agreement-in-canada-critical-to-north-american-ev-supply-chain>

⁶³ Vale signed a non-binding memorandum of cooperation with Ford Motor Co to process nickel ore mined by PVTI

⁶⁴ *Electric Vehicles: What's Next VII: Confronting Greenflation*. Goldman Sachs Equity Research (March 2022)

⁶⁵ Piper Sandler equity research

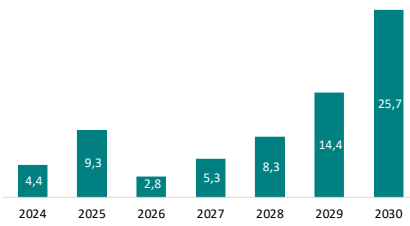


Figure 47 - Attainable nickel demand from Tesla in the STEPS (figures in kt)

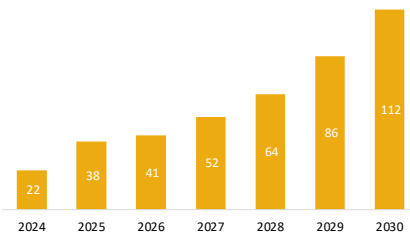


Figure 48 - Attainable nickel demand from Tesla in the SDS (figures in kt)



Figure 49 - Northvolt AB annual nickel procurement (figures in kt)

capacity installed in each vehicle. Without company-specific data, forecasts provided by the IEA in its benchmark scenarios were used instead (Figure 46). Another important driver concerns the chemistry used in Tesla's batteries. The company procures its nickel-rich 2170 battery cells (NCA85 cathode chemistry) from Panasonic, but has plans to ramp up the higher-density (and nickel content) 4680 cells' (NMC811 cathode chemistry) production before March 2024.⁶⁶ For forecast purposes, it is assumed that Tesla only procures nickel for its 4680 cells from 2024 onwards, either for those exclusively produced by Panasonic or in-house. After adjusting for the nickel content of NMC811 cathode batteries (0.69 Kg/KWh), Vale's attainable demand also considers other Tesla's disclosed agreements with BHP Nickel West (c. 18 kt/year), Talon Metals (12.5 kt/year from 2026 to 2031)⁶⁷ and Prony Resources (7 kt/year between 2024 and 2029, estimated according to similar contractual conditions disclosed by Talon Metals).⁶⁸ For valuation purposes, only BHP Nickel West is assumed to compete with Vale as a key supplier from 2031 onwards, given both operations' scale.

Multi-Year Contract with Northvolt AB is another source of revenue for Vale's Base Metals division. Like Tesla's, the Swedish Li-ion cell supplier's agreement remains undisclosed, but Vale remains its only known nickel supplier to date. Northvolt AB is currently ramping up its NMC chemistry cells' production, being expected to grow from the current 16GWh capacity to 60GWh by the end of the year. Northvolt AB has also announced in June 2021 that a second gigafactory developed through a joint venture with Volvo Cars is set to commence large scale production by 2026, having a 50GWh capacity. Most recently, another cell manufacturing plant in Germany has been announced, beginning its 60GWh annual production in late 2025. Cumulatively, the Swedish manufacturer will have a 170GWh annual production capacity by 2026, demanding approximately 117 kt of nickel per year. This figure cannot be straightforwardly inferred as an estimate of the contractual nickel amount to be supplied by Vale, once Northvolt AB is engaged in recycled raw materials for cell production, with a battery recycling plant handling 12 kt of battery packs per year since May 2022. Northvolt has also begun the construction of a giga-scale recycling plant in Q1 2022, enabling the recycling of additional 125 kt of batteries per year from 2023 onwards. After considering the recovered nickel amount, it is estimated that Northvolt's annual nickel procurement will reach 90 kt/year after 2026 (Figure 49).⁶⁹

⁶⁶ Source: <https://www.reuters.com/business/autos-transportation/panasonic-planning-massive-battery-plant-us-supply-tesla-nhk-2022-03-03/>

⁶⁷ Source: <https://talonmetals.com/tesla-and-talon-metals-enter-into-supply-agreement-for-nickel/>

⁶⁸ Source: <https://www.nasdaq.com/articles/prony-resources-says-tesla-has-agreed-to-a-multi-year-nickel-purchasing-deal-2021-10-13>

⁶⁹ Assuming that most available end-of-life batteries are those used in consumer electronics (NMC333 chemistry) and an average nickel recovery of 60%, in line with official IEA data

Multi-Year Contract with GM The most recent long-term contract with GM sets that Vale will supply 25 ktpy of battery-grade (Class I) nickel starting in H2 2026.

Mineral Assets As of the FY2021, the company reported nickel 2P reserves amounting to 241.5 mmt and averaging 1.59% Ni content, of which 113.5 mmt were proven reserves and 128.2 mmt were probable reserves. Since Vale runs its nickel operations in Brazil and Canada, it has also been required to report and make a clear distinction between measured (55.1 mmt), indicated (191.0 mmt) and inferred (72.6 mmt) resources. Given measured resources' prospects of being economically extracted in the future, for valuation purposes, the average recovery rate per mine was applied to the corresponding 2P reserves (Figure 50) and measured resources (Figure 51), reaching a total marketable nickel tonnage of 3.7 mmt. It is assumed that each mine's measured resources are extracted in their entirety until the corresponding exhaustion date at a fixed yearly rate. Sudbury and Voisey's Bay are the only mining operations classifying for Class I nickel projects, providing the company with 1.09 mmt of marketable nickel for EV battery and high-value segments' demand. Thompson, Onça Puma and PTVI's corresponding Class II marketable nickel figures make the remaining 2.6 mmt, mainly for stainless steel applications.

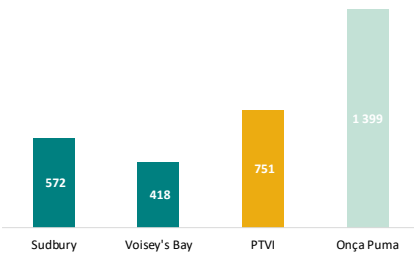


Figure 50 - Marketable nickel reserves by mining complex (figures in kt)

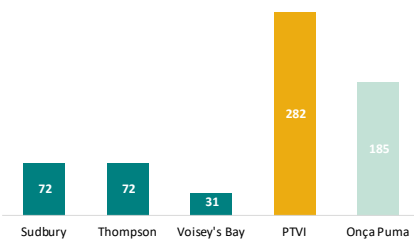


Figure 51 - Marketable (measured) nickel resources by mining complex (figures in kt)

Production Capacity Sudbury has integrated mining, smelting and refining operations to process ore into finished nickel with a nominal capacity of 66 ktpy. Under the current Voisey's Bay mine expansion project, which is expected to extend the mine life and increase production to an estimated 45 kt annual output, on average, Vale's annual Class I nickel production capacity will be 111 ktpy until Voisey's Bay exhaustion in 2035. Thompson and Onça Puma's output levels have been determined based on each mine's expected expiration date, with Thompson representing a 6.1 kt output until 2032 and Onça Puma contributing with 30.3 ktpy through the entire project duration. In Q2 2022 Earnings Call, Vale pointed out that current PTVI capacity is between 76 ktpy and 78 ktpy after the completion of Furnace 4, adding that an additional 73 ktpy capacity is expected to be online by 2025, with PTVI controlling 49% of the joint venture. Thus, adjusting for Vale's 44.34% position in PTVI, the company's attributable Class II production capacity will be 49.6 ktpy from 2025 onwards. This brings Class II total production capacity to 86.7 ktpy until Thompson's exhaustion in 2031.

Product Mix In 2019, predicting the potential trifurcation in nickel markets, Vale set a commercial strategy for nickel that includes preserving its market share in high-value segments, reducing the exposure to intermediate products and maintaining its product portfolio optionality for a potential surge in EV battery demand. Nevertheless, it hasn't been able to sustain its global market share in both the high-value segments (Figure 52) and stainless steel applications (Figure

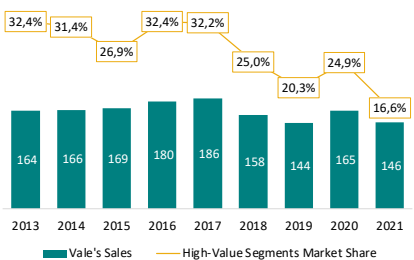


Figure 52 - Vale's sales (figures in kt) and market share in high-value segments

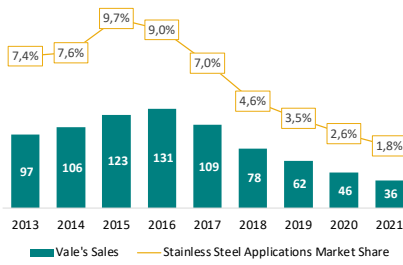


Figure 53 - Vale's sales (figures in kt) and market share in stainless steel applications

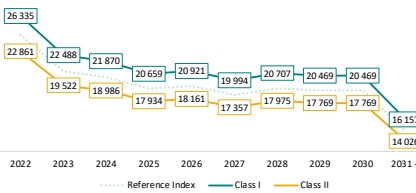


Figure 54 - Nickel price relative to the benchmark index (\$USD per tonne)

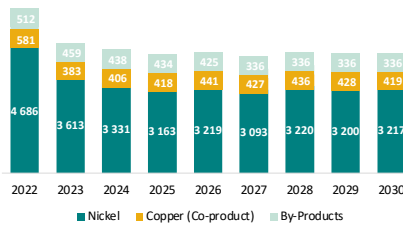


Figure 55 - Nickel operations' sales in the STEPS (figures in \$USD million)

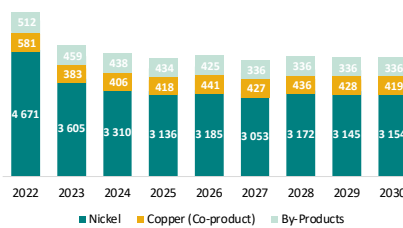


Figure 56 - Nickel operations' sales in the SDS (figures in \$USD million)

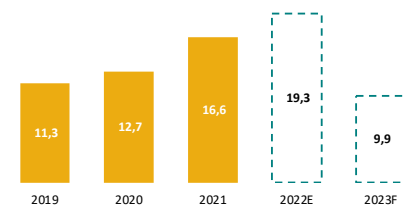


Figure 57 - Nickel operations' COGS/ton (figures in \$USD thousand)

53) since the outbreak of the pandemic. In line with its strategic positioning, it is forecasted that Vale will attempt to recover its pre-pandemic market share in stainless steel applications and gradually replace sales for high-value segments with surging EV battery-grade nickel sales arising from the long-term contracts signed in 2022, bringing more volume stability to its nickel revenues.

Prices On average, Vale has been able to realize 103.3% of the reference LME Nickel Official Cash Price, capturing a premium by focusing on higher-value segments' sales. For instance, in 2021, 80% of the company's refined nickel sales were made into non-stainless steel applications, compared to the industry average of nickel producers of 31%. Once nickel sales' forecasts are split into EV battery-grade procurement, high-value segments and stainless steel applications, the corresponding products' prices are set according to historical Class I and Class II price realization relative to the index mentioned above (Figure 54).⁷⁰

Revenues In FY2022, nickel operations' revenues should increase by 7.5%, from approximately \$5.4B in FY2021 to \$5.8B, \$4.7B being the contribution of nickel sales and the remaining portion arising from co-product (i.e., copper) and by-product (i.e., gold, palladium, platinum, cobalt) sales. Nickel sales volume in FY2022 will be in line with FY2021 (185 kt *vis-à-vis* 182 kt in the previous year), with a positive price effect justifying the higher revenue figures. Vale's nickel sales are forecasted to be relatively flat over the decade in either scenario (Figures 55 and 56), in line with Vale's goal of targeting between 20% to 30% of its sales towards battery-grade nickel and achieve higher volume stability. Nevertheless, against the company's view of being in a privileged position to fuel the electric mobility revolution, Vale's low carbon nickel assets and production capacity are not enough to cope with announced long-term supply deals, ensuring the contracts performance only up to 2031 (in both scenarios) and exhausting Sudbury project more than 10 years earlier than predicted. However, Vale is forecasted to continuously grow its nickel sales to stainless steel applications, benefitting from its vast Class II nickel endowment.

▪ **Operating Expenses**

COGS Without a detailed cost breakdown available, the best approach to forecast nickel cost of goods sold (excluding by-product credits)⁷¹ are normalized pre-pandemic figures, reaching \$9,932/ton (Figure 57).

Other Operating Expenses "SG&A & Other Operating Expenses", "R&D Expenses" and "Pre Operating and Operational Stoppage Expenses" have been

⁷⁰ Sources: S&P Capital IQ, Goldman Sachs

⁷¹ Includes both direct cash costs (i.e., mining, processing,...) and indirect cash costs (i.e., royalties/production taxes)

relatively constant as a percentage of revenues. These are assumed to maintain the historical average percentage of revenues over the entire period.

- **CapEx**

Expansion CapEx Voisey's Bay underground mine expansion (VBME) project, to extend the mine life and annual production, will end by H2 2022. A final \$565M cash outflow will occur in 2023 to meet the planned \$2.69B investment.

Maintenance CapEx Based on historical values, yearly sustaining CapEx is estimated to be \$1,7 million/kt of finished production for the entire period.

Copper Operations and Product Portfolio

Copper Mining Operations and Products Vale conducts its copper operations primarily at the parent company level and through its wholly owned subsidiary Salobo Metais S.A. in Brazil, and through its subsidiary Vale Canada. In Brazil, the company produces copper concentrates in the open-pit mining operations of Sossego and Salobo, with no expiration date. It produces copper concentrates, anodes and cathodes in conjunction with its Canadian nickel mining operations of Sudbury and Voisey's Bay. It is conducting technical studies for two additional mining sites, the Alemão Project (Brazil) and the Hu'u Project (Indonesia).

Pricing Mechanism Copper is an exchange-traded metal, being priced in terminal markets like the LME, the SHFE and the COMEX. In the case of intermediate goods, such as the copper concentrates and copper anodes making up most of the company's sales, treatment and refining charges above the prevailing copper market price are negotiated with each customer.

Market Overview

- **Long-Term Outlook**

Copper-Intensive Clean Energy Transition Similarly to other minerals, copper demand during the coming decades will be driven by the massive deployment of clean energy technologies. Copper will be the cornerstone of the energy transition, given its cost-effective electrical and thermal conducting properties. Ripple effects into non-green energy sources mean the 2020s will witness the strongest phase of volume growth in global copper demand in history, surpassing the incremental Chinese-generated demand during the 2000s. However, a decade of poor returns and ESG concerns, coupled with the uncertainty generated by the COVID-19 pandemic, have frozen companies' greenfield investment projects. The compounding of growing demand and sticky supply reinforce the prediction of large deficits from 2025 onwards. Having a strong

portfolio of copper assets and multi-year copper expansion plans in Salobo, Sossego ⁷² and Alemão, Vale is well positioned to capture value as copper prices are expected to trend above \$9,000/ton by the mid-decade.

▪ Short-Term Outlook

Challenging Times Ahead Copper’s short-term outlook is deeply influenced by the recessionary prospects that affect the metal demand in various economic activities, from construction to the automotive industry. Surging energy prices in Europe and ongoing inflation hurt copper demand, but in China pandemic stimulus have supported a resurgence in demand amid stagnant supply.

Forecasts

▪ Revenue Forecasts

Copper Demand in the Context of the Clean Energy Transition Resorting to the same benchmark scenarios provided by the IEA, the STEPS and the SDS, future copper consumption is also forecasted according to five different sources of demand: low-carbon energy generation, EV and battery storage, electricity networks, hydrogen-based technologies and other sectors.⁷³ Under the STEPS, global copper consumption is set to increase at a CAGR of 1.4% between 2021 and 2040, from 24.4 Mt to 31.7 Mt. Demand is set to increase at a CAGR of 1.7% over the same period under the SDS, peaking at 33.5 Mt by 2040. Although copper usage in construction, infrastructure and equipment manufacturing is still predicted to account for most global consumption,⁷⁴ the increase is mainly driven by electricity network developments, with a CAGR of 2.1% and 3.5% in the STEPS and the SDS, respectively.

Market Share It is expected that Vale will be able to sustain its pre-pandemic 2% share of the global copper concentrate market in the short-run.

Mineral Assets As of FY2021, the company reported copper 2P reserves amounting to 1,299.4 mmt and averaging 0.66% Cu content, of which 262.9 mmt were proven reserves and 1,036.5 mmt were probable reserves. As the company runs its copper operations in Brazil and Canada, it is required to report and make a clear distinction between measured (265.2 mmt), indicated (1,548.9 mmt) and inferred (1,098.9 mmt) resources. Given measured resources’ prospects of being economically extracted in the future, for valuation purposes, the average recovery rate per mine was applied to the corresponding 2P reserves (Figure 60) and measured resources (Figure 61), reaching a total marketable nickel tonnage

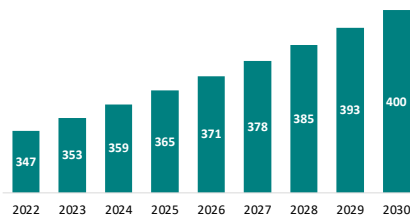


Figure 58 - Attainable copper demand in the STEPS (figures in kt)

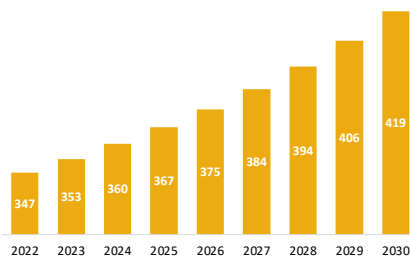


Figure 59 - Attainable copper demand in the SDS (figures in kt)

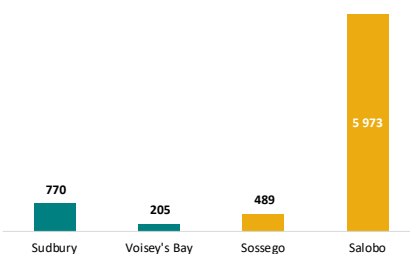


Figure 60 - Marketable copper reserves by mining complex (figures in kt)

⁷² Cristalino deposit

⁷³ Construction, infrastructure and equipment accounted for 76% of global copper consumption in 2021

⁷⁴ Approximately 68.5% and 54.8%, in the STEPS and the SDS, respectively

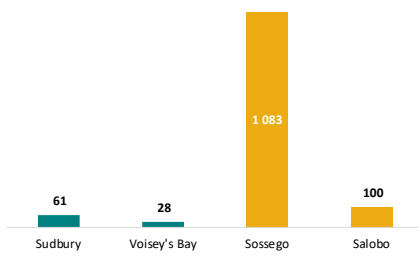


Figure 61 - Marketable (measured) resources by mining complex (figures in kt)

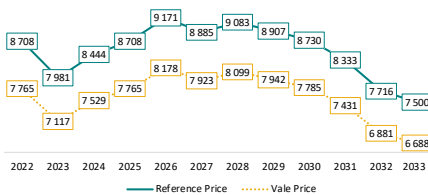


Figure 62 - Copper price relative to the benchmark index (\$USD per tonne)

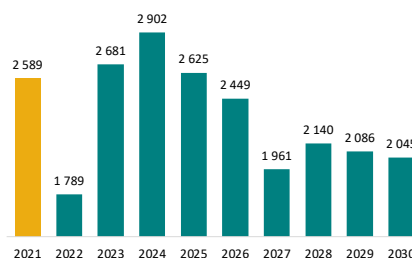


Figure 63 - Copper operations' revenues in the STEPS (figures in \$USD million)

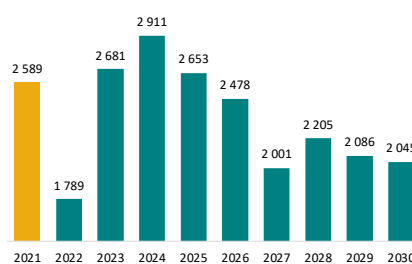


Figure 64 - Copper operations' revenues in the SDS (figures in \$USD million)

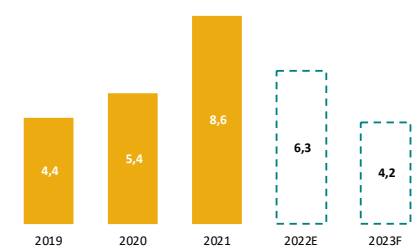


Figure 65 - Copper operations' COGS/ton (figures in \$USD thousand)

of 8.7 mmt. It is assumed that each mine's measured resources are extracted in their entirety until the corresponding exhaustion date at a fixed yearly rate.

Production capacity Current capacity stands at 344 ktpy. After the completion of the Salobo III project, aimed at expanding Salobo operations' output, the run rate capacity will be c.410ktpy until the exhaustion of Sossego in 2028.

Prices Copper price forecasts are set according to historical price realization against the reference LME Copper Official Cash Price, with the company's products being sold, on average, at a 10.8% discount (Figure 62).

Revenues Copper operation's revenues are expected to plummet 30.9% yoy in FY2022, from approximately \$2.6B in FY2021 to \$1.8B, recovering thereafter in FY2023 to \$2.7B. Adding to a negative volume effect decurrent from the recessionary dynamics, decreasing from 216 kt to 168 kt (22.2% decrease yoy), copper prices are also expected to drop 16.6% yoy by the end of FY2022. Over the long-run, revenues are expected to increase at a CAGR₂₂₋₂₈ of 3.0% and 3.5% in the STEPS and SDS, respectively, until mineral assets in Sossego are exhausted (Figures 63 and 64). Past 2028, it is expected that Vale will be unable to benefit from increasing copper demand driven by the energy transition losing its ability to sustain the 2% share of the global copper concentrate market.

- Operating Expenses

COGS Without a detailed cost breakdown available, the best approach to forecast copper cost of goods sold (excluding by-product credits)⁷⁵ are normalized pre-pandemic figures, reaching \$4,361/ton from 2023 onwards (Figure 65).

Other Operating Expenses "SG&A & Other Operating Expenses", "R&D Expenses" and "Pre Operating and Operational Stoppage Expenses" have been relatively constant as a percentage of revenues. These are assumed to maintain the historical average percentage of revenues over the entire period.

- CapEx

Expansion CapEx Despite Salobo III project ramp-up in H2 2022, a final \$48M cash outflow is forecasted for 2023 to meet the planned \$1.056B investment.

Maintenance CapEx Based on historical values, yearly sustaining CapEx is estimated to be \$1,7 million/kt of finished production for the entire period.

⁷⁵ Includes both direct cash costs (i.e., mining, processing,...) and indirect cash costs (i.e., royalties/production taxes)

Valuation

DCF Methodology

Valuing a mining company, first and foremost, is valuing its current mineral assets. Since we deal with finite reserves, the DCF methodology is the best approach to capture the value generated in each year until the exhaustion of the last mining project, with an explicit forecasting period of 67 years being used for the effect. Unlike most valuation exercises, resorting to the Gordon Growth Model at a certain stage of the forecast is a misleading approach in the context of the mining industry, since it assumes that a company will be able to replenish its mineral assets in perpetuity, which is physically impossible.

Cash Flows

Iron Ore Cash Flows In the STEPS, forecasted operating cash flows for FY2023 stand at \$10.005B, only 0.80% below the estimate for FY2022. Operating cash flows are projected to decrease at a CAGR₂₂₋₃₈ of -4.1% until the exhaustion of the Serra Norte project, averaging a 55.7% EBITDA conversion rate (Figure 66). In the SDS, FY2023 operating cash flows are forecasted to be down -1.31% yoy, plummeting at a CAGR₂₂₋₃₈ of -4.8% thereafter (Figure 67).

Base Metals Cash Flows In FY2023, \$1.813B operating cash flows have been forecasted under the STEPS, up 14.2% yoy (Figure X). Operating cash flows are also projected to decrease at a CAGR₂₂₋₃₁ of -3.8% until the exhaustion of the low-carbon nickel project of Sudbury, averaging a 55.3% EBITDA conversion rate (Figure 68). In the SDS, FY2023 operating cash flows are forecasted to be up 15.0% yoy, plummeting at a CAGR₂₂₋₃₈ of -3.8% thereafter as well (Figure 69).

Discount Rate

Capital Structure To calculate the WACC, no changes to Vale's capital structure are forecasted, given its maturity and no further publicly available information.

Cost of Debt To compute Vale's cost of debt, the longest publicly traded bond issued by the company, a 30-year bond maturing in 2034 with a corresponding YTM of 6.05%, has been considered. Moreover, based on S&P BBB- and Moody's Baa3 credit rating assessments, a corresponding 10-year average cumulative probability of default of 2.94%⁷⁶ and a senior unsecured bonds' recovery rate of 51%⁷⁷ were used, leading to a cost of debt of 4.61%.

Cost of Equity was estimated using the CAPM model. Despite being incorporated in Brazil and operating across the globe, as cash flows are

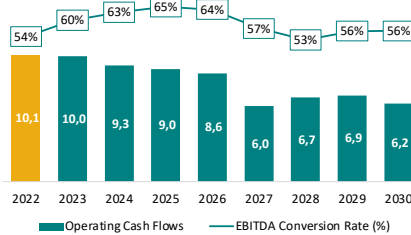


Figure 66 - Iron ore operating cash flows in the STEPS (figures in \$USD billion)

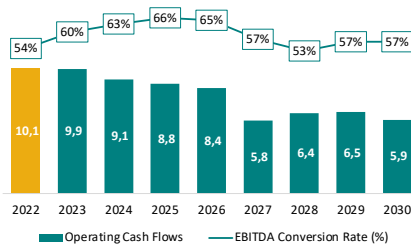


Figure 67 - Iron ore operating cash flows in the SDS (figures in \$USD billion)

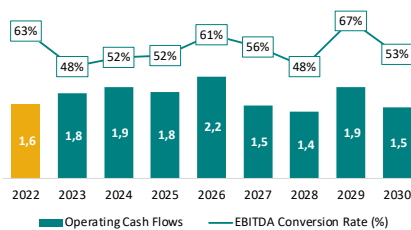


Figure 68 - Base metals operating cash flows in the STEPS (figures in \$USD billion)

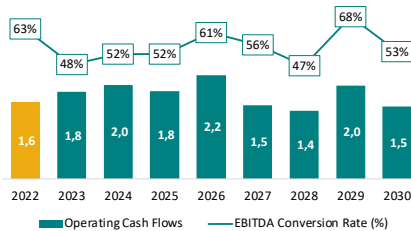


Figure 69 - Base metals operating cash flows in the SDS (figures in \$USD billion)

⁷⁶ Source: S&P 2021 Annual Global Corporate Default and Rating Transition Study (default rate for emerging and frontier markets)

⁷⁷ Source: Moody's Annual Default Study 2021

estimated in US dollars, the risk-free rate used for valuation purposes, 3.56%, is the 90-day average yield on a 10-year US Treasury Bond. Similarly, as the price recommendation concerns the American Depositary Shares traded in the NYSE, the S&P500 is the marginal investor's diversified portfolio alternative, using the index's equity risk premium, 6.01%, as the MRP. The levered beta of the company was calculated by regressing Vale's monthly stock returns against the S&P 500's, from November 2017 until the present, using 60 data points as it is common in the industry. This approach resulted in a levered beta coefficient of 0.89, with a confidence interval of [0.86, 0.91]. The narrow confidence interval allows to use the regressed coefficient without further analysis. To exclude the effect of the capital structure, the regressed beta was unlevered using the average D/E ratio from the last fiscal years, resulting in an unlevered beta of 0.79. The CAPM output is an estimated 8.29% cost of equity.

WACC With the Brazilian corporate tax rate of 34% and a constant target capital structure (D/E) of 0.04, the WACC is estimated to be 7.42%.

Equity Value The scenarios outlined in this report's forecasting analysis, the Stated Policies Scenario (STEPS) and the Sustainable Development Scenario (SDS), are two benchmark development scenarios that translate the uncertainty regarding the accomplishment of the climate action targets set forth by the international treaties. Decurrent of this doubtful framework, for valuation purposes, both scenarios are forecasted to be equally likely to occur. A \$65.732B Equity Value is then obtained by averaging the Enterprise Value in the STEPS (\$75.551B) and in the SDS (\$72.812B), as well as adjusting for Net Debt of \$6.980B and Noncontrolling Interests of \$1.470B.

- **Dividend Policy**

In March 2018, the board of directors approved a new dividend policy under which the company would distribute 30% of its adjusted EBITDA less sustaining CapEx in dividends from the six-month results, to be paid in two semiannual installments. Forecasting a \$20.285B adjusted EBITDA and sustaining CapEx around \$2.683B, the expected dividend payment for FY2023 stands at \$0.73/share, corresponding to a 5.2% dividend yield.

- **Sensitivity Analysis**

Despite the company's strategy of aiming to be more than an iron ore mining company, leveraging the development of its Base Metals division on the energy transition dynamics, its core business is mature and lacking growth opportunities, as already outlined in this report. Then, Vale's operating performance must be mainly affected by movements in iron ore prices, which has been identified as the

most significant input risk built into this report's valuation. Additionally, it has been assessed how sensitive the share price is to changes in the discount rate.

		WACC				
		6,48%	7,29%	8,10%	8,91%	9,72%
Iron ore price	70,20	14,61	13,41	12,36	11,43	10,60
	74,10	15,75	14,40	13,21	12,17	11,25
	78,00	16,89	15,38	14,06	12,91	11,90
	81,90	18,03	16,36	14,91	13,65	12,55
	85,80	19,17	17,34	15,76	14,40	13,20

Figure 70 - Share price sensitivity analysis (figures in USD)

From the sensitivity analysis, it can be concluded that the share price is both exceptionally sensitive to changes in the long-term iron ore price input as to changes in the discount rate, strengthening the thesis that Vale's iron ore business maturity is a risk under volatile market conditions. Second, under the 8.10% discount rate used for valuation purposes, not even a 10% higher long-term iron ore price forecast would change the recommendation set in this report. It is then believed that the aforementioned fact reinforces the recommendation set forth in this report.

▪ Final Recommendation

Pursuant the DCF valuation performed, Vale's American Depositary Shares should be traded at \$14.06 as of December 14th, 2021. No other valuation method has been used in the issuance of the recommendation below. Given the lack of public comparable companies with such a diversified product portfolio and geographical reach, the value-added of performing a multiples analysis was questionable. The price recommendation translates two main concerns on Vale's current business model. First, the iron ore business's maturity that may be challenged in the context of the steelmaking transformation strategy. Second, the questionable value captured by having a base metals segment within a company whose performance swings with marginal changes in iron ore prices, a point that is reinforced by the company's intention of spinning off the division. The company is considering the creation of a new entity comprising the nickel and copper assets, in which Vale would hold a 90% stake and the remaining be sold to a strategic partner during 2023.

Given the concerns on the company's true ability to seize the opportunities heading the global energy transition and the carbon neutrality pathway, the issued recommendation is SELL, with the 14.3% capital loss and 5.2% dividend yield culminating in a -9.1% total shareholder return.

Appendix

Financial Statements

Income Statement

US\$ million	2021A	2022F	2023F	2024F	2025F	2026F	2027F	2028F	2029F	2030F
+ Net Operating Revenues	54 502	40 095	36 656	34 383	32 812	32 250	28 477	30 770	30 028	28 742
- COGS	(18 872)	(17 375)	(14 961)	(14 878)	(14 657)	(14 479)	(14 522)	(14 564)	(14 492)	(14 463)
= Gross Profit	35 630	22 721	21 695	19 505	18 155	17 772	13 955	16 207	15 536	14 279
- SG&A & Other Operating Expenses	(795)	(757)	(685)	(638)	(610)	(600)	(530)	(574)	(560)	(535)
- R&D Expenses	(548)	(333)	(306)	(291)	(276)	(272)	(240)	(258)	(252)	(243)
- Pre Operating and Operational Stoppage Expenses	(514)	(469)	(418)	(389)	(372)	(367)	(326)	(352)	(344)	(329)
= EBITDA	33 773	21 162	20 286	18 188	16 897	16 533	12 858	15 022	14 380	13 172
- Depreciation, Depletion and Amortization	(3 034)	(2 999)	(3 065)	(3 140)	(3 141)	(3 115)	(3 084)	(3 057)	(3 034)	(3 003)
= EBIT	30 739	18 163	17 220	15 048	13 756	13 418	9 774	11 965	11 345	10 169
- Operating taxes	(7 625)	(5 024)	(4 703)	(3 965)	(3 525)	(3 411)	(3 323)	(4 068)	(3 857)	(3 457)
= NOPLAT	23 114	13 139	12 517	11 083	10 230	10 007	6 451	7 897	7 488	6 711
- Non-operating result	410	0	0	0	0	0	0	0	0	0
- Financing result	(1 055)	(368)	(358)	(348)	(338)	(339)	(335)	(328)	(324)	(321)
Net income (loss)	22 468	12 771	12 159	10 735	9 892	9 668	6 116	7 569	7 164	6 391
Items that will not be reclassified to income statement	(1 302)	0	0	0	0	0	0	0	0	0
Items that may be reclassified to income statement	(3 946)	0	0	0	0	0	0	0	0	0
Total comprehensive income (loss)	17 220	12 771	12 159	10 735	9 892	9 668	6 116	7 569	7 164	6 391

Balance Sheet

US\$ million	2021A	2022F	2023F	2024F	2025F	2026F	2027F	2028F	2029F	2030F
Operating cash	1 090	802	733	688	656	645	570	615	601	575
Accounts receivable	3 914	3 530	3 227	3 027	2 889	2 840	2 507	2 709	2 644	2 531
Inventories	4 377	3 010	2 371	2 605	2 805	2 721	2 651	2 667	2 253	2 236
Prepaid income taxes	0	0	0	0	0	0	0	0	0	0
Recoverable taxes	862	2 298	2 151	1 814	1 613	1 560	1 520	1 861	1 764	1 581
Operating current assets	10 243	9 641	8 483	8 133	7 963	7 765	7 248	7 853	7 262	6 923
Suppliers and contractors	3 475	3 690	3 177	3 159	3 113	3 075	3 084	3 093	3 077	3 071
Taxes payable (current portion)	2 177	1 293	1 210	1 020	907	878	855	1 047	992	890
Operating current liabilities	5 652	4 982	4 387	4 180	4 020	3 952	3 939	4 139	4 070	3 961
Operating working capital	4 591	4 658	4 096	3 954	3 943	3 813	3 309	3 713	3 192	2 962
Fixed assets	48 085	47 388	48 710	48 840	48 463	48 029	47 637	47 309	46 858	46 433
Core invested capital (including goodwill)	52 676	52 046	52 806	52 794	52 406	51 842	50 946	51 022	50 050	49 395
Non-operating assets	11 758	10 607	8 596	7 445	6 293	5 142	5 142	5 142	5 142	5 142
Non-operating liabilities	24 938	23 963	23 343	22 722	22 102	21 482	19 037	18 758	18 758	18 758
Total invested capital	39 496	38 690	38 059	37 516	36 597	35 502	37 051	37 406	36 434	35 779
Net debt and debt equivalents	10 850	6 874	6 691	6 512	6 322	6 343	6 262	6 141	6 050	5 997
Operating deferred income tax assets	(346)	(346)	(346)	(346)	(346)	(346)	(346)	(346)	(346)	(346)
Non-operating deferred income tax assets	(6 314)	(6 314)	(6 314)	(6 314)	(6 314)	(6 314)	(6 314)	(6 314)	(6 314)	(6 314)
Shareholders' equity	35 306	38 476	38 028	37 664	36 935	35 819	37 449	37 925	37 044	36 441
Equity and equity equivalents	28 646	31 816	31 368	31 004	30 275	29 159	30 789	31 265	30 384	29 781
Total sources of funds	39 496	38 690	38 059	37 516	36 597	35 502	37 051	37 406	36 434	35 779

Cash Flow Map

US\$ million	2021A	2022F	2023F	2024F	2025F	2026F	2027F	2028F	2029F	2030F
Adjusted EBIT	30 739	18 163	17 220	15 048	13 756	13 418	9 774	11 965	11 345	10 169
- Operating cash taxes	(7 625)	(5 024)	(4 703)	(3 965)	(3 525)	(3 411)	(3 323)	(4 068)	(3 857)	(3 457)
= NOPLAT	23 114	13 139	12 517	11 083	10 230	10 007	6 451	7 897	7 488	6 711
+ Depreciation, Depletion and Amortization	3 034	2 999	3 065	3 140	3 141	3 114	3 084	3 057	3 034	3 003
= Gross Cash Flow	26 148	16 138	15 582	14 223	13 371	13 122	9 535	10 954	10 522	9 714
+ Decrease (increase) in NWC	1 453	(67)	563	142	11	130	504	(404)	522	230
- CapEx (net of disposals)	(3 740)	(2 302)	(4 387)	(3 270)	(2 763)	(2 680)	(2 692)	(2 729)	(2 583)	(2 578)
+ Foreign currency translation adjustments	(1 256)	0	0	0	0	0	0	0	0	0
= Gross Investment	(3 543)	(2 369)	(3 825)	(3 128)	(2 753)	(2 551)	(2 189)	(3 133)	(2 062)	(2 348)
= Operating Unlevered Free Cash Flow	22 605	13 769	11 757	11 095	10 618	10 571	7 346	7 821	8 461	7 366
+ Non-operating result	410	0	0	0	0	0	0	0	0	0
- Decrease (increase) in non-operating assets	(23)	1 151	2 011	1 151	1 151	1 151	0	0	0	0
+ Increase (decrease) in non-operating liabilities	(1 942)	(975)	(620)	(620)	(620)	(620)	(2 445)	(279)	0	0
Cash flow hedge	3	0	0	0	0	0	0	0	0	0
Adjustment for other comprehensive income non-cash losses (gains)	(3 995)	0	0	0	0	0	0	0	0	0
= Non-operating Unlevered Free Cash Flow	(5 547)	176	1 390	531	531	531	(2 445)	(279)	0	0
- Financial expenses	(1 599)	(557)	(542)	(528)	(512)	(514)	(507)	(498)	(490)	(486)
+ Tax shield	544	189	184	179	174	175	173	169	167	165
+ Increase (decrease) in net financial indebtedness	1 404	(3 976)	(183)	(179)	(190)	21	(80)	(121)	(91)	(53)
+ Increase (decrease) in debt equivalents	(1 313)	0	0	0	0	0	0	0	0	0
= Debt Financing Cash Flow	(965)	(4 343)	(541)	(527)	(528)	(318)	(415)	(450)	(415)	(373)
+ Increase (decrease) in operating deferred income tax assets	10	0	0	0	0	0	0	0	0	0
+ Increase (decrease) in non-operating deferred income tax assets	632	0	0	0	0	0	0	0	0	0
- Cash transactions with Vale's shareholders	(16 735)	(9 602)	(12 607)	(11 099)	(10 621)	(10 784)	(4 486)	(7 092)	(8 046)	(6 993)
= Equity Financing Cash Flow	(16 093)	(9 602)	(12 607)	(11 099)	(10 621)	(10 784)	(4 486)	(7 092)	(8 046)	(6 993)

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Buy	Expected total return (including expected capital gains and expected dividend yield) of more than 10% over a 12-month period.
Hold	Expected total return (including expected capital gains and expected dividend yield) between 0% and 10% over a 12-month period.
Sell	Expected negative total return (including expected capital gains and expected dividend yield) over a 12-month period.

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