Analysis of portfolio resilience

In 2017, Vale adhered to the recommendations of the Task Force on Climate-Related Financial Disclosures (TCFD) aiming to increase transparency regarding the risks and opportunities related to climate change. The TCFD recommends financial disclosures to incorporate an assessment of the business portfolio under various climate-change scenarios, including one aligned with the Paris Agreement.

We decided to use the International Energy Agency (IEA) scenarios which are recognized industry-wide and have ample international support. At the end of 2019, the IEA updated its scenarios focusing on the Paris Agreement goals and the commitments and policies assumed by various countries. Throughout 2020, it also provided specific publications about the use of batteries[1] and iron ore processing technologies[2]. These materials combined were the basis of the portfolio resilience analysis. Considering the need to complement the IEA's focus on energy with commodity-specific implications beyond thermal and metallurgical coal, specific studies for mining were required.

In order to make assumptions fully transparent and achieve results truly independent, we relied on the support of an external consultancy[3] to unfold the market implications for iron ore, copper and nickel. Based on the results obtained, we assessed the resilience of our strategic portfolio, including simulations of the potential impact on each business' profitability.

There are many uncertainties influencing the decarbonization path in multiple ways, with deep implications for technological choices and resulting demand for mining products. The exercise and the assumptions assumed herein do not necessarily represent our market view, nevertheless they play a fundamental role in the continuous improvement of our strategy.

Note 1: "Innovation in batteries and electricity storage", September 2020, IEA
Note 2: "Iron and steel technology roadmap", October 2020, IEA
Note 3: Wood Mackenzie

International Energy Agency scenarios and their mining implications

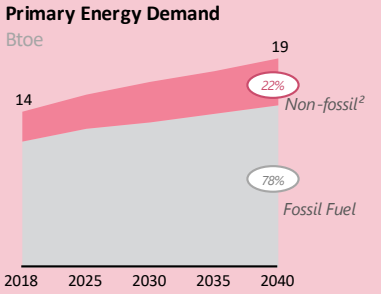
Each year, the International Energy Agency publishes its 'World Energy Outlook' report, presenting different climate-change scenarios focused on the energy sector. While the Current Policies Scenario (CPS) and the Stated Policies Scenario (STEPS) illustrate the consequences of ongoing policies and stated commitments, respectively, the Sustainable Development Scenario (SDS) identifies the policies and assumptions needed to achieve the UN Sustainable Development Goals related to energy i.e., (i) ensure universal access to electricity, (ii) reduce severe health impacts caused by air pollution, and (iii) address climate change. A more detailed description of each scenario and resulting primary energy demand is depicted below, while the supply and demand implications for Vale's various commodities are presented on the following pages.

International Energy Agency Scenarios

Current Policies Scenario (CPS)

Describes the energy sector trajectory assuming there are no additional changes in policies related to climate change[1].

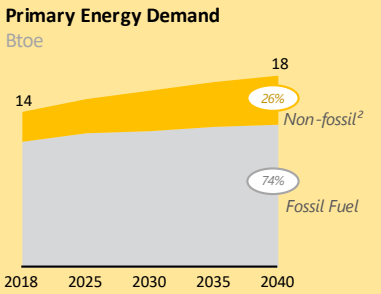
According to the IEA, the effort required for the CPS would result in greater consumption of all fuels and technologies, leading to a continuous raise of emissions and increasing tensions involving different aspects of energy security.



Stated Policies Scenario (STEPS)[3]

It considers intentions and specific policies that have already been announced and foresees an average annual growth of 1% in primary energy demand until 2040.

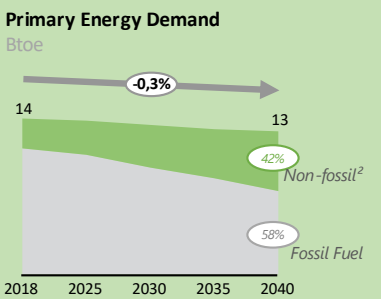
Sharp deceleration in demand for oil after 2025 until its stabilization during the 2030s. The use of fossil fuels for transportation reaches its peak in the late 2020s, even with 70% more cars on the roads between 2018 and 2040.



Sustainable Development Scenario (SDS)

It proposes a narrative that adheres to the ambitions of the Paris Agreement, and addresses the battle for clean air and universal access to energy.

The global economy growth projected for all scenarios is achieved here without any increase in primary energy demand, given the significant development in energy efficiency and the expansion of the circular economy concept.

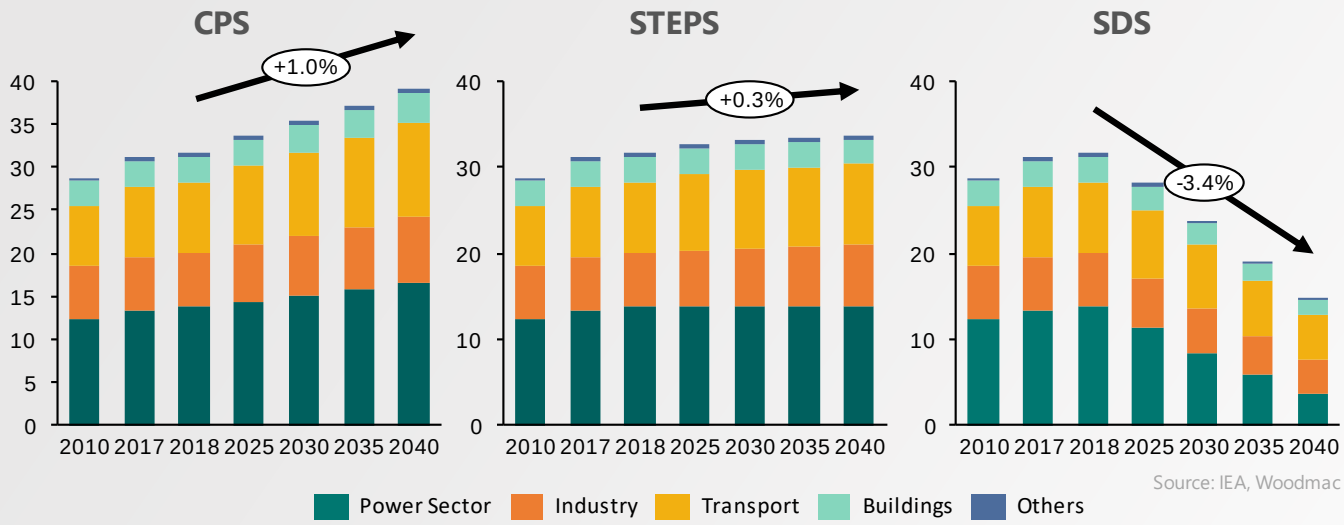


Source: IEA, Woodmac

Note 1: Consider the update date of the 'World Energy Outlook' of November 2019
Note 2: Includes nuclear, hydroelectric, bioenergy and other renewable energy
Note 3: The November 2019 scenario does not include the recent announcements on carbon neutrality from China, South Korea and Japan.

Total energy CO_2 emissions

Gt[1]



Source: IEA, Woodmac

The electricity sector, currently responsible for the emission of approximately 14 Gt of CO_2 (base: 2018) is the biggest offender and will have to offer the sharpest reduction with a projected 73% abatement by 2040 under **SDS**. The Transport and Industrial sectors, which combined emit another 14 Gt of CO_2 (base: 2018), will be able to offer only half of the abatement contributions, however challenging, to achieve of 33% and 40% reductions respectively, under the same scenario.

In this challenging context of decarbonization, our key commodities will be at the forefront of the challenges and opportunities posed by the climate crisis. Copper and nickel will fully support the energy transition, representing key materials for building up the necessary renewable infrastructure and supporting the transport electrification through the electric vehicles (EV). Steel, produced from iron ore and metallurgical coal, will continue to be the material of choice for wind turbines, transmissions lines, and the necessary infrastructure to grant universal access to electricity and alleviate extreme poverty. Thermal coal, among other fossil fuels, will have to be gradually displaced by alternative energy sources while retaining share under special circumstances especially when combined with, and supported by Carbon Capture, Usage and Storage (CCUS) mechanisms.

Copper and nickel will be key to energy transition

Two fundamental premises of the **SDS** – i.e., the shift to a more renewable energy mix, and transportation electrification – are also main demand drivers for copper and nickel. In the next two decades, these two commodities will show significant growth across all presented scenarios.

Copper is subject to both drivers i.e., is critical for renewables and transport electrification applications, and is therefore the most resilient commodity under IEA's various scenarios. Under **SDS**, the higher demand for total refined copper is accompanied by a much deeper focus on circular economy, with a sharp increase in recycled materials and a lower reliance on primary output. As a result, the primary copper demand under this scenario would not be substantially higher than under **STEPS** or **CPS**.

The compounded annual growth for primary copper linked to energy transition reaches approximately 6% under **SDS**, due to use in wind turbines and solar panels, as well as transmission lines and electric vehicles. Along with a 70% car sales penetration in this scenario, EVs are approximately 3 times more intensive in copper than internal combustion vehicles[2].

Nickel, by its turn, is a key commodity in the transport electrification story. It is a material of choice in building high-energy, high-power lithium batteries and will experience a significant demand spur over coming years. Under **SDS**, stainless steel applications even loose their predominance in nickel demand.

Note 1: Considers only emissions of carbon dioxide from energy sources.
Note 2: Reaches approximately 46 kg of copper per electric vehicle.

A fundamental factor for the energy-related sustainable goals achievement, the circular economy concept will also be relevant for nickel. Battery recycling at **SDS** will be greater than at **STEPS**, generating a 145% increase in the supply of recycled nickel by 2040. Battery recycling will play a critical role in reducing demand for primary nickel in the 2030s and represents an important sustainability requirement of the metal supply.

The steel industry decarbonization will lead to an appreciation of high-quality products

The steel industry represents about 7%[1] of global carbon emissions and plays a significant role in the reduction of industrial sector emissions.

In this context, the IEA provides a future view for steel demand across the three scenarios: in **STEPS**, demand grows by 18% between 2018 and 2040, while in **SDS** steel demand remains fairly flat due to building retrofit, alternative options of urban mobility and assumed efficiencies down the value chain.

The biggest emission compression challenge happens under **SDS**, where the steel sector would have to undergo an estimated ~45% reduction in absolute emissions by 2040 when compared to the intermediate scenario, **STEPS**.

In order to address this challenge, the steel industry will have to decarbonize its footprint along three main pillars: (i) circular economy; (ii) operational enhancements, and (iii) technological shifts. All these changes will have to heavily rely on the quality and differentiation of iron ore products.

At the **SDS** scenario, the use of electric arc furnaces (EAF) and the scrap load are maximized in order to reduce the use of coal. Also, the increase in EAF use and scrap load in basic oxygen converters (BOF) leads to a boost in scrap consumption by 2040. As a result, more direct-reduction pellets wil be necessary to guarantee the quality of the steel produced through the EAF route.

Under the second pillar, the increase in operational enhancements opens opportunities to immediate gains through the implementation of energy efficiency measures such as hot charge, top recovery turbines and coke dry quenching. Operational enhancements also encompass using cleaner sources of raw material, including innovative agglomerated products for direct charge to blast furnaces and use of biomass to replace fossil fuels.

The growing use of pellets in the blast furnace, for example, leads to greater productivity, less pollution by harmful elements and better burden. As a result, the demand for pellets is strengthened, intensified by the scarcity of scrap (pressured by greater demand and longer useful life of buildings) and a relative reduction in sinter and lump use. Both the blast furnace pellet and the direct-reduction pellet go through an increase in demand across all scenarios analyzed, with expressive growth rates in both **SDS** and **STEPS**.

The main emerging technologies are based on direct reduction via low-carbon hydrogen and CCUS associated to different commercial or innovative production routes. Among the innovative routes, the concept of *smelting reduction* stands out. However, the adoption of these disruptive technologies will happen slowly according to the IEA, with most of them starting to be viable after 2035 under a CO2 price north of $140/t. In fact, by 2040 the IEA believes that hydrogen-based and CCUS-led technologies will represent a minor share of steel production and only by 2070 would they become a establish reality.

Thermal coal will be severely impacted by the growth of renewables, and metallurgical coal by the decarbonization of the steel industry

In **STEPS**, decarbonization initiatives focused on the energy sector result in a drop in thermal coal demand for electricity, but the impact on its use in industry is quite timid. Under **SDS**, the global demand for thermal coal decreases significantly, displaced by low-carbon technologies that become responsible for around 85% of the global electricity generation. As a result, the share of coal in the electricity mix is lower than 10% by 2040.

Metallurgical coal remains stable under **STEPS** and its reduction under **SDS** would not be as severe as for thermal coal. One of the largest consumers of this commodity will be developing countries like India and those in Southeast Asia.

Note 1: Considers only emissions of carbon dioxide from energy sources.

Impact of climate scenarios on selected commodity markets

	Demand Impact	***Drivers***	***Industry challenges***
	↑↑	EV sales	**Meeting demand growth sustainably**
	↑↑	Energy storage batteries	Need to recycle & reuse Ni in batteries
	↓	EV battery recycling and scrap	Lack of commercial Ni mine projects / deposits
	↑	Stainless steel demand	Reducing Ni mining emissions
			Discover and commercialize new deposits
	↑	EV sales	**Meeting demand growth sustainably**
	↑↑	Wind and solar power gen	Need to increase scrap usage and limit waste
	↑↑	Transmission lines for power access	Environment challenges in many copper countries
	↓	Improved scrap recycling	Discover and commercialize new deposits
	↑	Energy transition focused infrastructure	**Reduce steelmaking emissions**
	↓	Declining car stock (mobility change)	Implement new BF technologies and efficiencies
	↓	Construction efficiencies	Support shift towards cleaner iron ore feedstock
	↓	Scrap recycling and re-use	Promote recyclability of steel vs. other metals
			Iron ore use increasingly replaced by scrap
	↓↓	Changing power mix to renewables	**Develop cleaner coal end-uses**
	↓↓	Announced exits from coal power gen	Develop critical or ultra-critical coal power plants
	↓	Construction efficiencies for steel	Carbon capture initiatives to reduce CO2 emitted
	↓	Steel recycling	Replace met coal by cleaner fuels when possible

Source: IEA, Woodmac

Portfolio Resilience

The different behaviors of supply and demand- under IEA's three scenarios result in changing competitive dynamics that impact the long-term price of our key commodities and our strategy by extension.

For Vale, the **Current Policies Scenario** partially impacts our capacity to generate value. In addition to greater exposure to physical risks, **CPS** does not consider the opportunity for growth in renewables, transport electrification and the need to decarbonize the steel industry, which are today fundamental parts of our strategy.

The SDS, in turn, creates an ecosystem that encourages our growth options and amplifies the relevance of our strategic pillars i.e., Base Metals Transformation and the Maximization of flight to quality in Iron Ore.

We want to be the preferred supplier of high-quality, low-carbon products

All scenarios analyzed showed that the steel industry decarbonization will put a high value in high-quality, lower-emission products. **Vale's current strategy already considers a portfolio with a 90% share of these products by 2024.**

To reinforce our position and offer additional solutions to the steel industry, we are focused on increasing the supply of our high-quality sinter feed from the North System, offering higher grade products using New Steel technology, leading the world production of pellets and other direct-charge products, and finally, promoting Metallics, which through partnerships and in an asset light platform provides low-carbon solutions.

Portfolio Resilience (cont.)

We are leaders in providing nickel for a sustainable energy transition

Our Class 1 nickel assets already place us in a unique position with competitive operations in the North Atlantic. The base metals transformation follows a low-carbon agenda geared towards recycling electric vehicle batteries, using biofuel and biomass, decarbonizing rotary kilns and electrification from renewables.

In addition, as part of Vale's Nickel strategy, investment opportunities in Indonesia through JVs in the Bahodopi and Pomalaa projects, production stabilization in the South Atlantic and other projects ensure options capable of sustaining a significant EBITDA increase in 2040 in **SDS**.

We have organic growth potential in copper, taking advantage of the robust market fundamentals

With the high penetration of EV in transport, the expansion of renewables infrastructure and transmission lines, the bottleneck will be the sustainable supply of this ore.

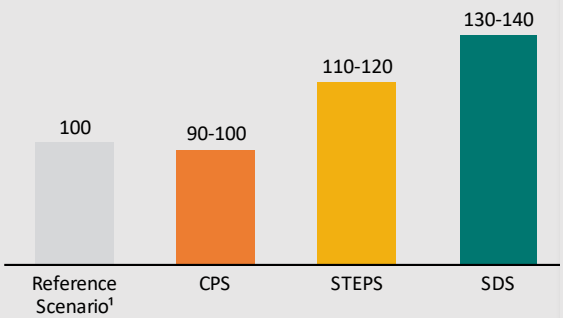
In view of this, recent studies on the Hu'u project, which indicate great potential in Indonesia, join the existing portfolio of projects in the Carajás basin which will support our growth in the future while preserving rainforests.

Finally, it is important to highlight that our coal assets will be negatively impacted by STEPS and SDS. However its impact will not be severe as coal represents a tiny fraction of our portfolio. In our path towards carbon neutrality, we are reevaluating our assets' portfolio that may not fit into this greener future, however, no formal decision has yet been taken.

In summary, under several climate change scenarios, Vale's EBITDA performs in a range of 90% to 140% in relation to base case. **Such resilience is the result of a flexible portfolio; capable of adapting to different market conditions and well aligned with energy transition trends.**

Vale's EBITDA in 2040

Base Case[1] = 100



- This analysis was performed based on the production volume considered in the Strategic Plan in 2040;
- The simulations considered, in addition to the volume, other implications from each scenario, such as commodity prices and cost impacts;
- The STEPS and SDS scenarios embrace the maximization of high-quality ferrous products and opportunities for additional volumes in nickel and copper.

Note 1: Base case - Volumes from Strategic Plan in 2040, considering prices from Wood Mackenzie in September 2020.