



Critical and strategic minerals for the energy transition

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Critical and strategic minerals for the energy transition Report

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Critical and strategic minerals for the energy transition

Public value



This report, titled "Critical and strategic minerals for the energy transition", provides an **integrated analysis** of the Brazilian energy matrix, connecting it to the importance of mining critical minerals.



The publication highlights the essential role of these minerals in **enabling the energy transition**, both in national and international contexts, with a focus **on sustainability and supply security**.



Based on data from the **2034 Ten-Year Energy Expansion Plan**, this report presents **projections for the most demanded minerals** for the Brazilian energy matrix and for electromobility.

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The importance of minerals in the energy transition context and concepts

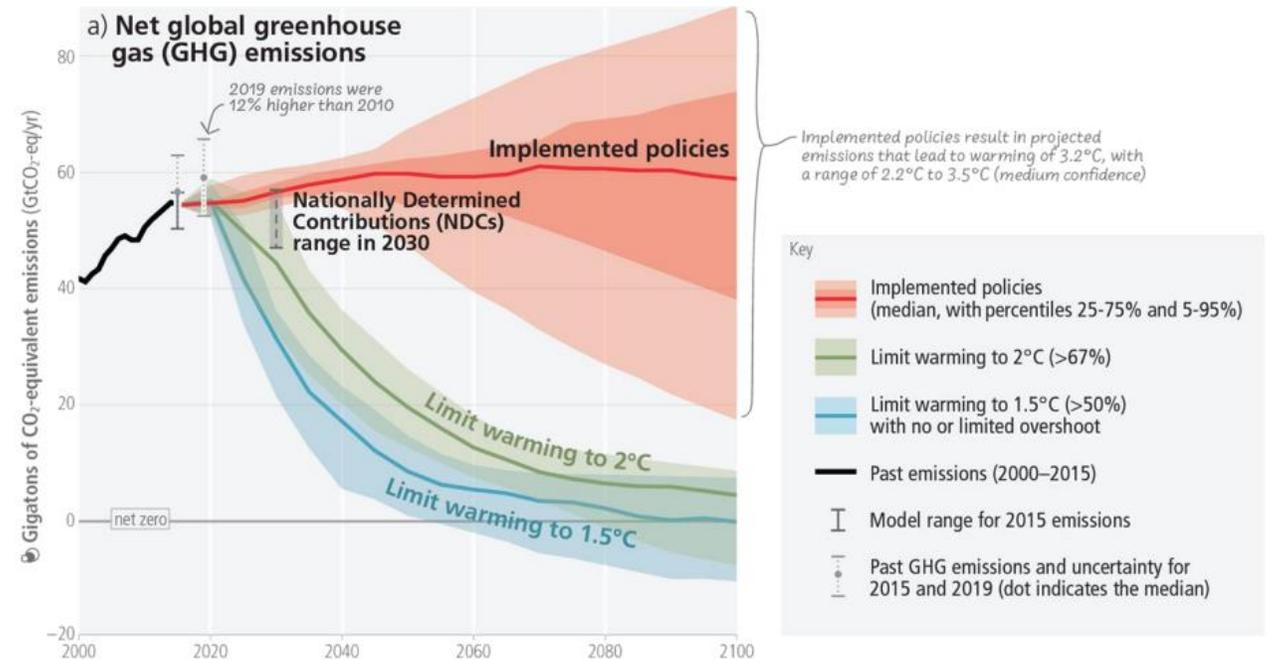


Energy transition in the climate emergency context

The energy transition is vital in the context of the climate emergency we are experiencing. A new global energy infrastructure capable of providing an increase in the supply of renewable energy, energy efficiency and optimization of electricity networks is necessary and urgent to manage global warming.



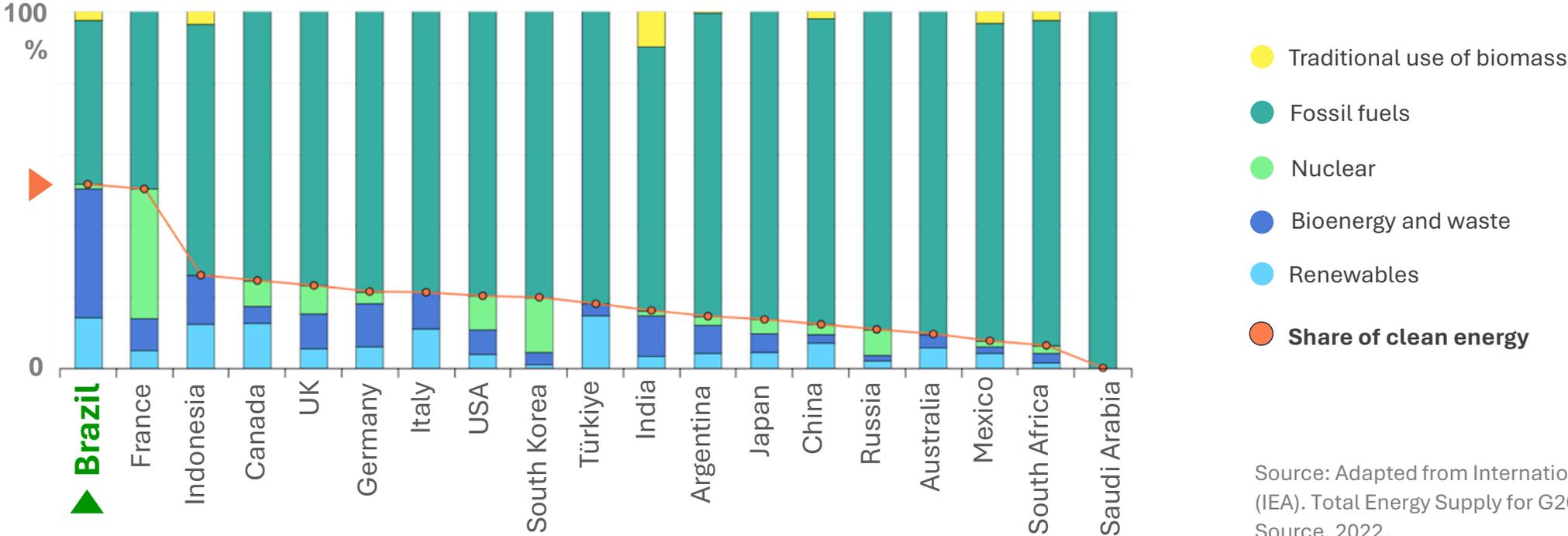
Limiting global warming to 1.5°C and 2°C involves **swift and substantial reductions in greenhouse gas emissions.**



Source: Intergovernmental Panel on Climate Change (IPCC). Sixth Assessment Report (AR6), Synthesis Report, 2023.

What is Brazil's starting point in the global energy transition?

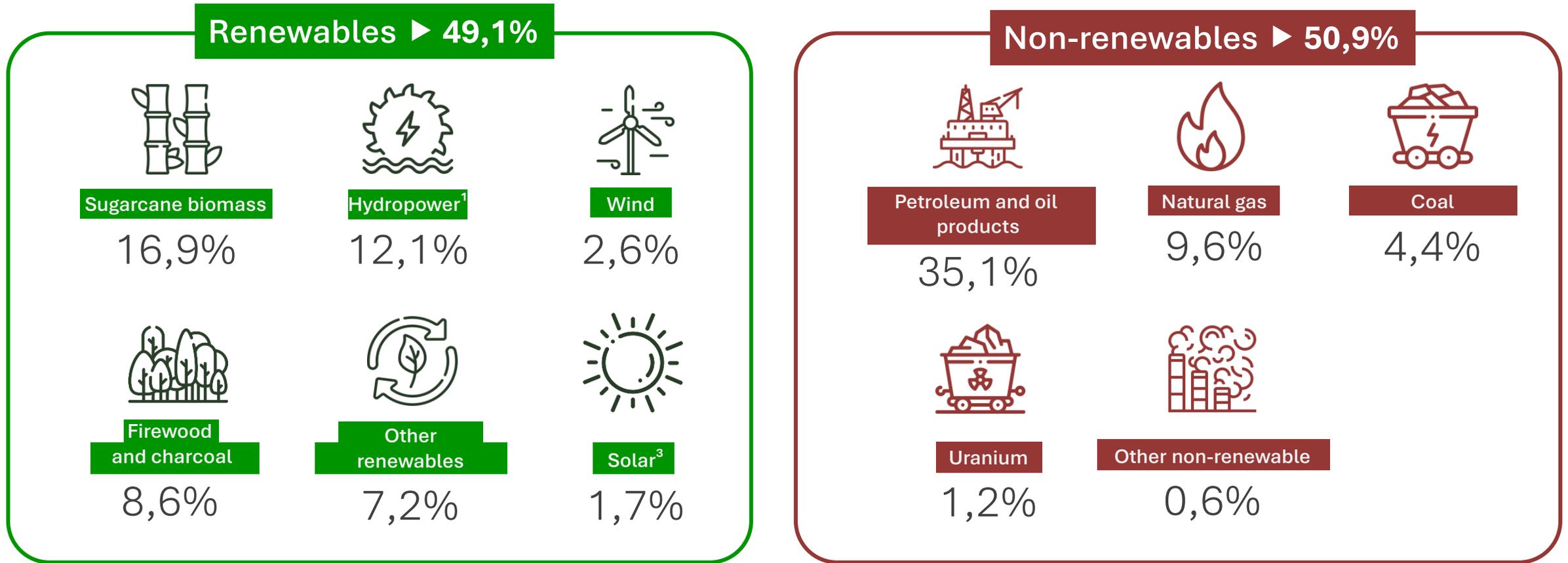
Share of **clean energy** in different countries



Source: Adapted from International Energy Agency (IEA). Total Energy Supply for G20 Countries by Energy Source, 2022.

The current energy transition is a process of transformations towards a low-carbon economy with a smaller environmental footprint. Brazil stands out on the global stage for having the largest share of clean energy sources in its energy matrix among the world's major economies, reflecting a series of energy policies implemented over time.

Renewable share of the energy matrix: biomass and hydraulic energy are highlights

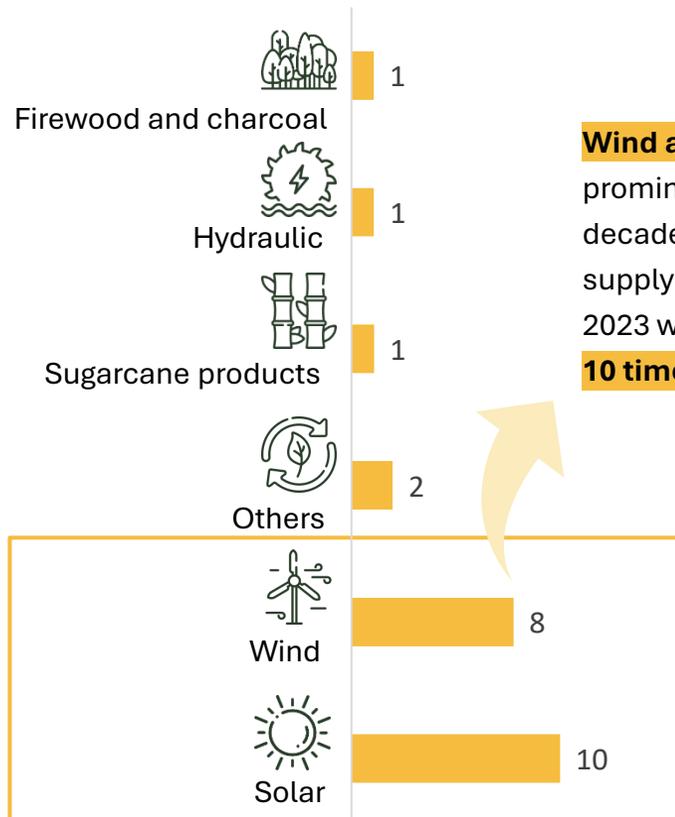


Source: EPE. Brazilian National Energy Balance (BEN) 2024, base year 2023.

Where are we headed? Wind and solar gain prominence in domestic energy supply

History of domestic renewable energy supply

Growth over the last decade (2023/2014)

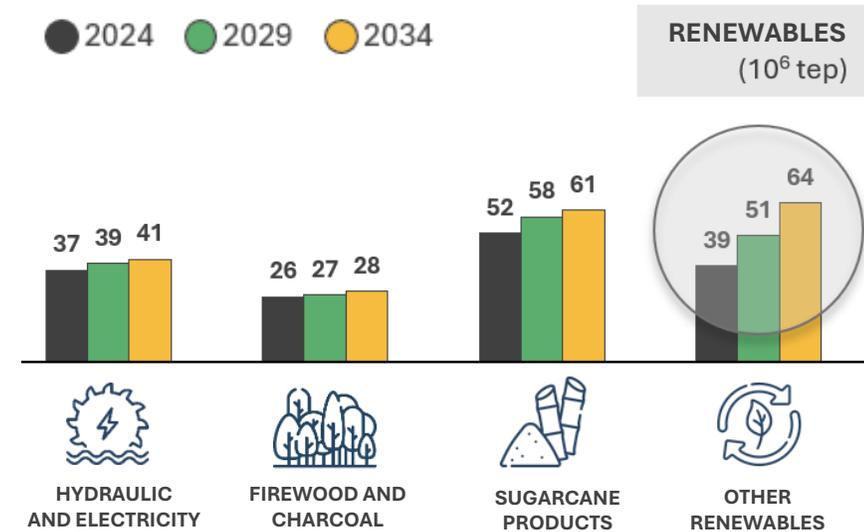


Wind and solar have been prominent over the last decade. Domestic energy supply from these sources in 2023 was, respectively, **8 and 10 times higher than in 2013.**

Source: EPE. Brazilian National Energy Balance 2024 (BEN), base year 2023.

Projection of domestic renewable energy supply

Estimate for the ten-year horizon (2024/2034)



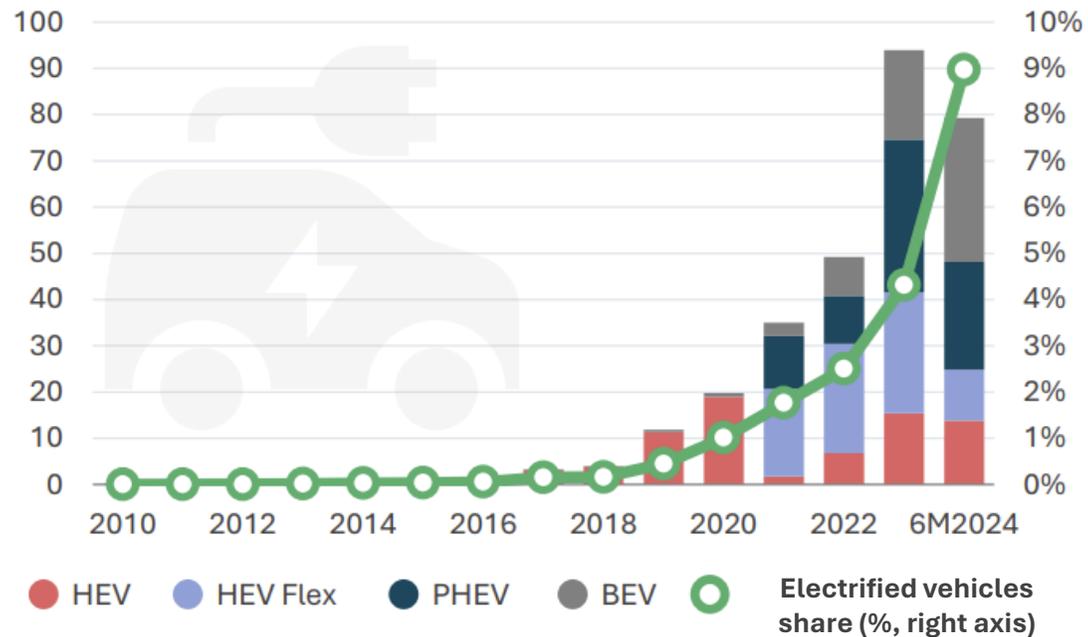
Source: EPE. 2034 Ten-Year Energy Expansion Plan (PDE): Results consolidation Report.

In **2034 Ten-Year Energy Expansion Plan projections**, renewable energies present an average growth of 2.4% per year in the Domestic Supply of Energy, with emphasis on **wind and solar energy**. These technologies demand more minerals than conventional ones.

Electrification of transports also demands more minerals

Annual sales of electrified vehicles in Brazil

Thousand units



Source: EPE. 2034 Ten-Year Energy Expansion Plan. Electromobility: Road transport, data from ABVE and Anfavea.



- Penetration of electrified vehicles **continues to increase rapidly.**



- Public policies that stimulate the decarbonization of the automotive sector, such as Green Mobility and Innovation Program (**MOVER**), may promote an increase in the supply of **these vehicles.**



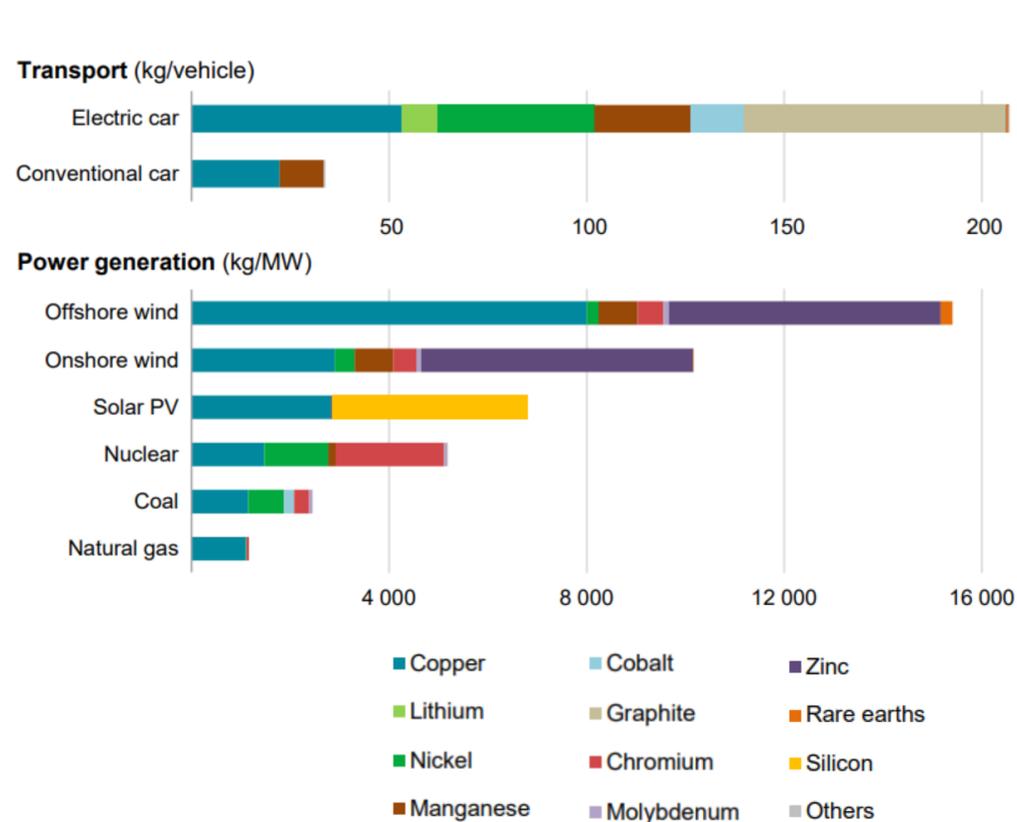
- The growing demand for batteries represents the extraction and mining of larger quantities of **strategic minerals, particularly lithium, cobalt, nickel, and graphite.**



- In the manufacture of electric automotive vehicles, lithium plays a significant role, being used in the anodes, cathodes, and electrolytes of **battery cells**, representing 8.9 kg per vehicle, according to the IEA. This quantity is much higher than in conventional internal combustion light vehicles.

The energy transition is mineral-intensive

Minerals used in clean and traditional energy technologies



Typical electric car = **6x** more mineral inputs than a conventional car*;



Onshore wind farm = **9x** more mineral resources than a gas plant;



Since 2010, the average amount of minerals required for a new unit of power generation capacity has increased by 50% as the share of renewable energy has grown.



Vehicles powered by biofuels do not generate additional mineral demands when compared to vehicles powered by fossil fuels.

Source: Adapted from The Role of Critical World Energy Outlook Special Report. Minerals in Clean Energy Transitions. IEA, 2021.

*The comparison does not consider the amounts required for chassis and bodies, usually made of steel and/or aluminum alloys.

Critical vs. Strategic: How Brazil Classifies Minerals

- **Critical minerals** are essential resources to the economy, that are subject to supply risks. Their scarcity can cause serious economic, environmental, security and social impacts. (Adapted from ISO, 2023)
- A mineral is classified as **strategic** if it meets one of the following criteria:



Category I: The country depends on large-scale imports to supply vital sectors of the economy;



Category II: Its importance is growing due to its application in high-tech products and processes;



Category III: It is essential for the national economy, providing competitive advantages and contributing to the surplus in the country's trade balance.

Source: Adapted from the Brazilian National Mining Plan 2030.

Category I mainly covers minerals used in plant nutrition, which are widely used in agribusiness. Brazil currently depends significantly on imports of these minerals, which reinforces their strategic importance.



Different minerals may have different classifications depending on the country. One example is niobium, considered a critical mineral by the European Union and the United States, while Brazil classifies it as a strategic mineral. This difference influences the treatment of production in each country, especially in terms of access to economic incentives.

Minerals can be classified as critical and/or strategic

	Strategic minerals - Brazil			USA	EU
	Cat. I	Cat. II	Cat. III	Critical minerals	Critical raw mat.
Molybdenum					
Phosphate					
Potassium					
Sulfur					
Cobalt					
Lithium					
Nickel					
Rare earths					
Platinum group					
Silicon metal					
Gallium					
Tantalum					
Tin					
Titanium					
Tungsten					
Vanadium					
Copper					
Graphite					
Niobium					
Uranium					
Aluminium					
Iron					
Manganese					
Gold					

The table shows Brazil's strategic minerals, according to CTAPME Resolution No. 2/2021, and a comparison with the USA and EU.

Brazilian categories: They are not mutually exclusive; minerals such as copper, graphite, niobium and uranium appear in more than one category.

Energy Transition: Critical minerals for the energy transition are mainly in Category II in Brazil and largely coincide with the broader lists of the US (50 minerals) and EU (34 minerals).

Update: The lists should be reviewed frequently; studies such as the one by IRENA/NUPI (2024) suggest 2-year intervals.

Source: Adapted from EPE based on data from the Brazilian list (MME Resolution No. 2/2021); US (DOE - U.S. Department of Energy, last update 2021); EU (Critical Raw Materials - European Commission, last update 2021).

Minerals and technologies for the energy transition

	Copper	Cobalt	Nickel	Lithium	REEs	Chromim	Zinc	PGMs	Aluminium
Solar PV	●	○	○	○	○	○	○	○	●
Wind	●	○	●	○	●	●	●	○	●
Hydroelectric	●	○	○	○	○	●	●	○	●
CSP	●	○	●	○	○	●	●	○	●
Bioenergy	●	○	○	○	○	○	●	○	●
Geothermal	○	○	●	○	○	●	○	○	○
Nuclear	●	○	●	○	○	●	○	○	○
Power grids	●	○	○	○	○	○	○	○	●
EVs and batteries	●	●	●	●	●	○	○	○	●
Hydrogen	○	○	●	○	●	○	○	●	●

The hue indicates the relative importance of minerals for a given technology. The darker the hue, the greater the intensity of the importance.

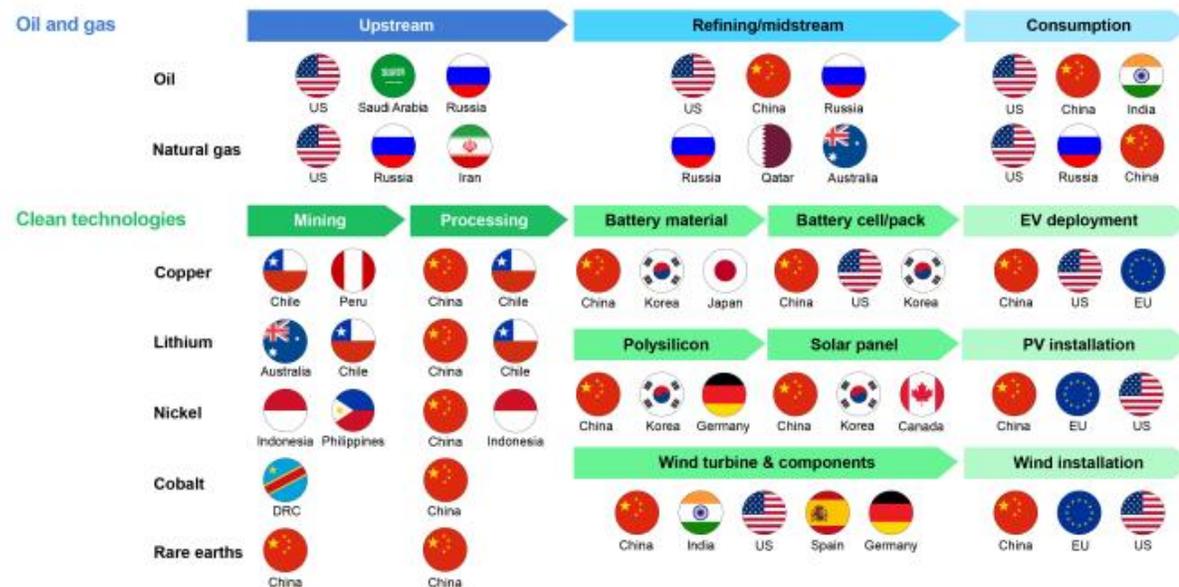
Hydroelectricity and bioenergy stand out as alternative energy sources with low demand for minerals, whose materials are widely applicable to different technologies and are not exclusive to these sources.

Source: Adapted from IEA, 2021

- **Copper and aluminum** are used in a variety of clean energy technologies, highlighting their critical role.
- **Lithium, nickel, cobalt, manganese, and graphite** are crucial to battery performance, longevity, and energy density.
- **Rare earths** are essential for permanent magnets, which are essential for wind turbines and electric vehicle motors.
- Power grids require large amounts of **copper and aluminum**, with copper being the cornerstone of all electricity-related technologies.

Critical minerals supply and geopolitical issues

Oil, gas and clean technology production chains



Source: World Energy Outlook, IEA (2021).

Notes: DRC = Democratic Republic of the Congo; EU = European Union; US = United States; Russia = Russian Federation; China = People's Republic of China. Largest producers and consumers are noted in each case to provide an indication, rather than a complete account.

- Production of minerals required for the energy transition is **more geographically concentrated** than that of oil and gas. Many of the materials are also produced in locations with high water stress (IEA).
- Processing** of these critical minerals is even more concentrated, with China accounting for between 40% and 80% of the production for materials such as copper, nickel, cobalt, lithium and rare earths (IEA).
- Investments in country diversification to mitigate geopolitical risk **may increase production costs**, depending on factors such as labor and the level of control and regulation. Many of the materials are also produced in areas with high water stress.



The new dynamics in the mining market

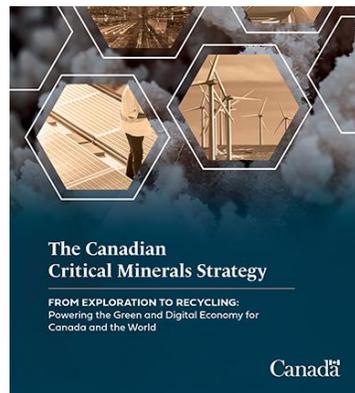


New policies focus on ensuring supplies

Security and diversification of supply chains of critical and strategic minerals in line with sustainability and economic development parameters are among the main objectives of public policies launched in recent years.

Canada

Critical Minerals Strategy 2022



Canada's Critical Minerals Strategy (2022) seeks to accelerate environmental permitting and strengthen geological mapping to attract investment in exploration and processing of critical minerals. The strategy also prioritizes sustainability, energy security, and reducing dependence on foreign suppliers.

USA

Inflation Reduction Act (IRA) 2022

INFLATION REDUCTION ACT OF 2022

Public Law 117-169



IRA provides significant subsidies to produce electric vehicles that use critical materials such as lithium, cobalt, and nickel mined or recycled in the U.S. or in countries with which the U.S. has trade agreements. IRA earmarks about \$500 billion for green investments, with a significant portion going toward R&D in battery-related technologies and electrification.

European Union

Critical Raw Materials (CRM) 2023



Critical Raw Material (CRM) sets benchmarks for national capacities along the EU's raw materials supply chain by 2030. These include the target that by this time, no more than 65% of the annual consumption of each strategic raw material, at any relevant stage of transformation, will come from a single third country.

Actions that stimulate the mining industry in Brazil

SGB/CPRM prepares “**Mineral Production Chains for Energy Transition**” as part of the preparatory studies for the Brazilian **National Mining Plan 2050 (PNM 2050)**

The **Ministry of Mines and Energy (MME)** has reformulated Decree No. 11,964/2024, enabling the **issuance of debentures for strategic mineral projects**, with tax benefits for both investors and issuers, thereby strengthening competitiveness and sustainability in the mineral sector.

The **MOVER Program** was approved, which encourages investment in new technologies and increases the requirements to decarbonize the Brazilian automotive fleet, including cars, buses and trucks.

BNDES and Finep have launched a public call with a budget of R\$5 billion to **promote projects** that develop the **strategic minerals** chain in Brazil.

MME Public Consultation No. 180 seeks to define criteria for **incentivized debentures** in **strategic mineral** projects for the energy transition.



SGB/CPRM launches **Strategic Minerals Series**, the series assesses the Brazilian potential for minerals such as lithium, graphite, phosphate and rare earths, essential for the energy transition.

BNDES and MME launch a call for **proposals for the FIP fund**, which is expected to raise up to R\$1 billion for strategic mineral projects for energy transition, with a contribution of up to R\$250 million from the Bank. In October 2024, the winner who will manage the strategic minerals fund was announced.



The **National Energy Transition Policy (PNTE)** defines the strategic guidelines for the country's transition to a more sustainable, resilient and low-carbon energy matrix.

Car manufacturers and other players

The entry of large vehicle manufacturers and other members of this chain in recent years has translated into new partnerships with mining companies and processors through joint ventures and supply agreements to guarantee the supply of critical minerals.



Volkswagen plans to build its first **battery plant in Canada** and has partnered with mining operations there to secure raw materials supplies.



Mercedes-Benz has opened a raw materials office in Canada to manage procurement efforts and signed a battery materials cooperation agreement with the Canadian government. The company has indicated it is willing to **invest directly in mines** if necessary to secure resources.



General Motors is making a **\$650 million equity investment in Lithium Americas Corp.**, accelerating development of the Thacker Pass lithium project, the largest known source of lithium in the U.S., which is expected to support the production of nearly 1 million electric vehicles annually.

Mine 2023, PwC

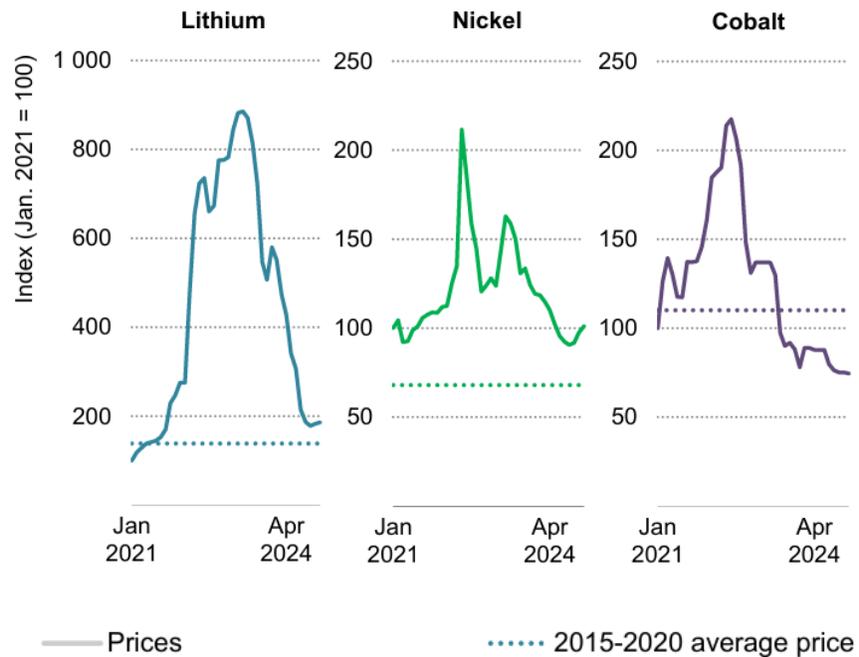


CLARUS Technology, brclarus.com

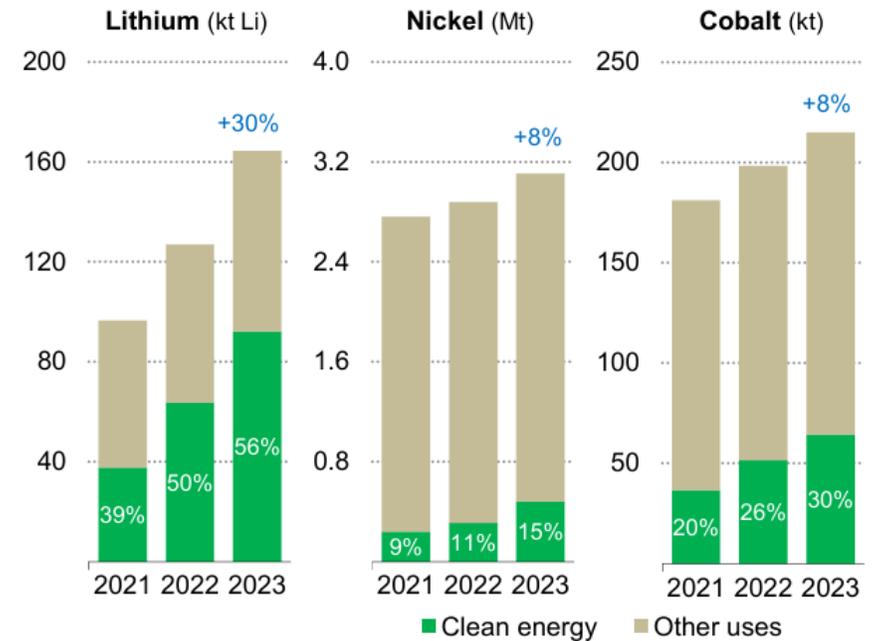
Price volatility

Demand for minerals for the energy transition has grown in recent years and is expected to continue to rise. Minerals such as lithium, nickel and cobalt have shown price volatility, recently falling due to increased global supply (IEA, 2024).

Critical minerals prices, 2021- 2024



Demand for selected minerals, 2021-2023



Source: IEA, 2024 (Global Critical Minerals Outlook 2024)

Impacts on energy transition costs

Increased demand for minerals will put pressure on supply and potential impacts on the transition should not be ignored. A supply crisis could jeopardize the transition to green technologies. A balance between supply and demand is needed (The Economist, 2024).



With global demand growth forecasts, copper and nickel have expected supply gaps of 10-15% through 2030. Other battery metals (cobalt, lithium, graphite) have expected shortages of 30-45% over the same period.



Actions to promote balance between supply and demand:

- Increasing the productivity of existing sources: short-term approach with added quantity constraints.
- Developing new mines: could potentially solve the long-term supply problem. McKinsey estimates that completing 382 cobalt, copper, lithium and nickel mine projects with pre-feasibility studies by 2030 could help balance markets.
- Encouraging greater reuse and recycling of materials, especially aluminum, copper and nickel.
- Embracing the specificities of local potential in the energy transition process (e.g. biofuels vs. electric vehicles).

Source: The Economist, 2022.

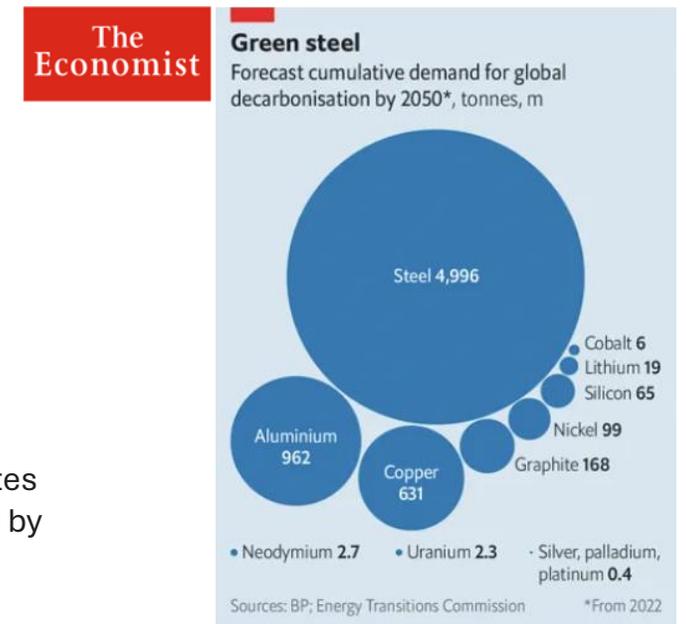


IMAGE: THE ECONOMIST



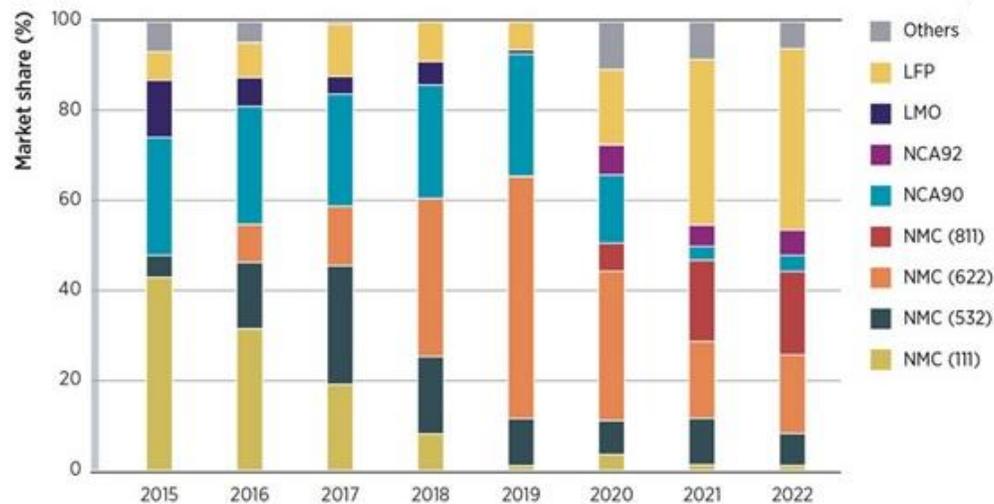
The future of minerals in the energy transition



Innovation and uncertainty: the future of minerals in the technological scenario

The chemistry of electric vehicle (EV) batteries is a significant source of uncertainty in mineral demand. Lithium-ion batteries are currently dominant and changes in this status could lead to supply-demand gaps.

Rapidly changing global EV battery chemistry mix between 2015 and 2022



Source: (BNEF, 2022b).

Note: The numbers following NCA indicate nickels proportion in the NCA battery chemistry, whereas the numbers following NMC indicate nickos proportion in the NMC battery chemistry for example. NMC (622) means 6 parts of nickel 2 ports of manganese and 2 parts of cobalt LFP-thium ion phosphate: UMO-hium manganese oxide NCA-nickel cobalt and aluminium NMC-nickel manganese and cobalt

Source: Irena, 2023.



Importance of anode chemistry

Graphite-based anodes hold a 70% market share. Emerging anodes, such as 100% silicon-based, lithium-metallic and aluminum/alloyed aluminum, have the potential to reduce or eliminate demand for **graphite**.

Importance of cathode chemistry

For cathodes, the most commonly used chemistries include **nickel-manganese-cobalt oxides (NMC)**, **nickel-cobalt-aluminum oxides (NCA)**, and **lithium iron phosphate (LIP)**. NMC and LFP are expected to remain the most prevalent batteries this decade, although it remains to be seen which technology will ultimately prevail.

Risks and price volatility in the minerals chain

Onshore and offshore wind and solar photovoltaic technologies may also undergo innovations, bringing changes to the supply and demand balance of minerals in the coming decades.



Innovation in wind generation

- **Rare earth** elements such as neodymium and dysprosium are used for **permanent magnets** in **wind turbines and electric motors**.
- **Rare earth permanent magnets** are used for both onshore and offshore wind applications and are likely to become more common in **turbines**.
- There are significant efforts to replace neodymium with other rare earth elements or **to develop rare earth-free permanent magnets (electromagnets)**. This could change the demand outlook for neodymium and dysprosium.



Innovation in photovoltaic solar generation

- Innovation in solar PV technology could change the demand for raw materials, leading to a **shift from silicon to conventional crystalline silicon and thin-film technologies**.
- Other promising technologies include **organic solar cells**, copper indium gallium selenide cells, dye-sensitized solar cells, and quantum dot solar cells.
- Although these technologies have significant potential, they are still in the development and commercialization stages, and their performance is still being studied.

A risk matrix can be used by stakeholders and policy makers, allowing minerals to be assessed according to potential threats associated with their demand, considering the level of impact and the likelihood of these occurring.



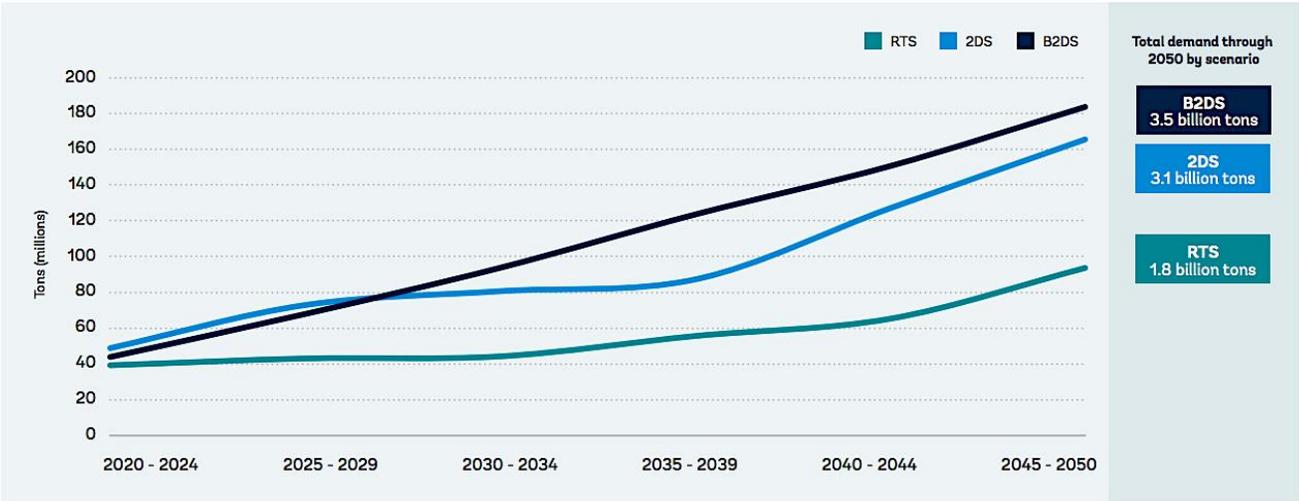
Minerals in long-term scenarios



Growth in demand for minerals associated with scenarios

In the International Energy Agency’s (IEA) 2-degree scenario (2DS), production of graphite, lithium and cobalt will need to be increased by more than 450% by 2050 – compared to 2018 levels – to meet demand for energy storage technologies.

Average annual mineral demand until 2050 - IEA Energy Technology Perspective Scenarios



Note: "Minerals" refers to the 17 minerals included in this analysis plus steel, but excluding concrete. Steel has been included because of the size of demand for the alloy from energy technologies. Average annual demand is the mean demand for minerals across the time periods given. The higher mineral demand under the 2DS than the B2DS before 2030 can be explained by the higher overall generation capacity projected by the IEA to be needed in the 2DS compared with the B2DS. This is especially true of solar photovoltaic in the 2DS in these time periods. Subsequently, the plateau in mineral demand in the 2DS is caused by a relatively slower penetration of renewable generation, followed by a rapid increase in storage capacity from 2035 onward. 2DS = 2-degree scenario, B2DS = beyond 2-degree scenario, IEA = International Energy Agency, RTS = reference technology scenario.

Source: World Bank, 2020

2DS Scenario (IEA)



Solar PV will account for the majority of aluminum demand from energy technologies (87%);



Solar PV and wind power combined account for 74.2% of all copper demand;

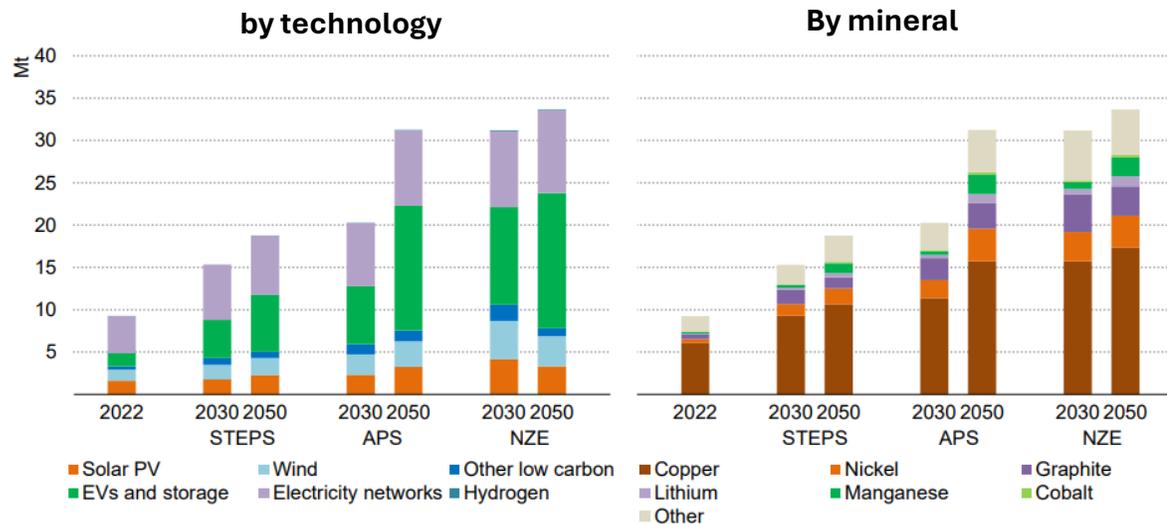


Batteries account for all graphite and lithium demand in this analysis (WORLD BANK, 2020).

Long-term scenarios for mineral demand

The demand for critical minerals for clean energy is expected to grow up to three and a half times by 2030 as the world undergoes energy transitions, according to IEA projections (2023).

Minerals required for clean energy technologies by scenario



IEA. CC BY 4.0.

Notes: STEPS = Stated Policies Scenarios; APS = Announced Pledges Scenario; NZE = Net Zero Emissions by 2050 Scenario. Includes most of the minerals used in various clean energy technologies, but does not include steel and aluminium.

Source: Critical Minerals Market Review (IEA, 2023).

IEA Scenarios

Stated Policies Scenario (STEPS)

It outlines a trajectory that reflects current policy settings, based on a detailed assessment of policies effectively in place worldwide.

Announced Pledges Scenario (APS)

It assumes that long-term emissions targets and energy access goals will be achieved fully and on time, even if the necessary policies have not yet been implemented.

Net Zero Emissions by 2050 Scenario (NZE)

It presents a pathway for the global energy sector to achieve net-zero CO₂ emissions by 2050.



Minerals in the Brazilian energy transition



Ten-Year Energy Expansion Plan 2034

The **Ten-Year Energy Expansion Plan (PDE)** projects Brazil's energy expansion over the next 10 years, taking into account sustainability and cost optimization. It uses scenarios to address uncertainties and guide public policies and investments. To estimate the **quantity of minerals** required for Brazil's energy transition, the **PDE projections** were used.

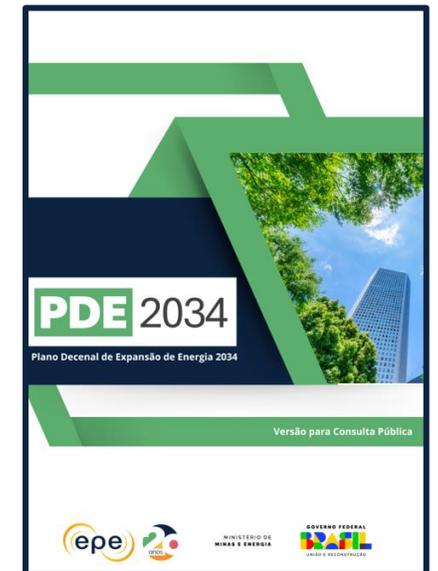
Centralized electricity generation



Electricity transmission



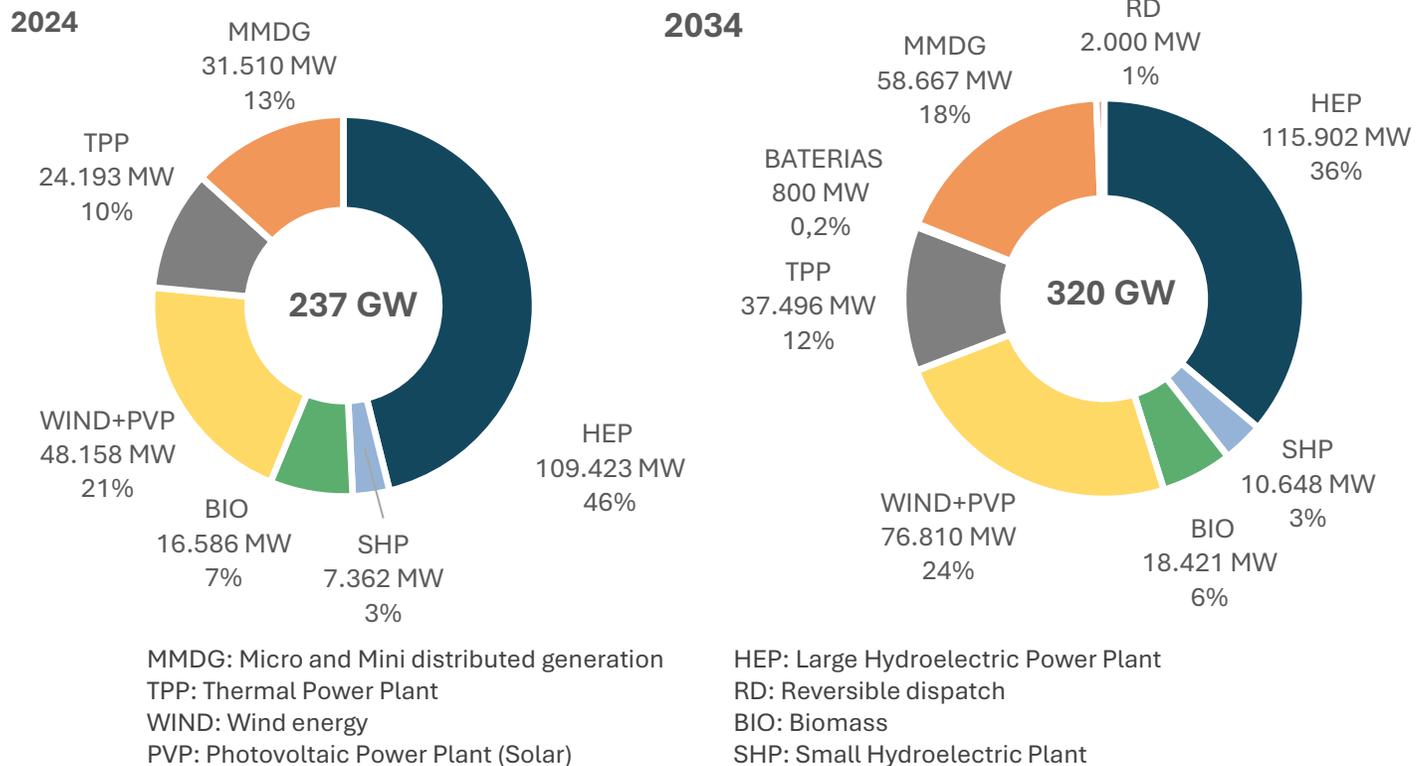
E-mobility: road transport



Brazilian Power Mix in the PDE 2034

The share of **renewable sources** in electricity generation is approximately **90% in 2024** and is expected to **remain at this level through 2034**, driven by a greater share of wind and solar power.

Installed Capacity in Brazil's Power Mix



Source: PDE 2034 (EPE).

Energy Expansion

The proposed expansion by 2034 adds about **84 GW**, with **56 GW** coming from **solar and wind power**.



Storage

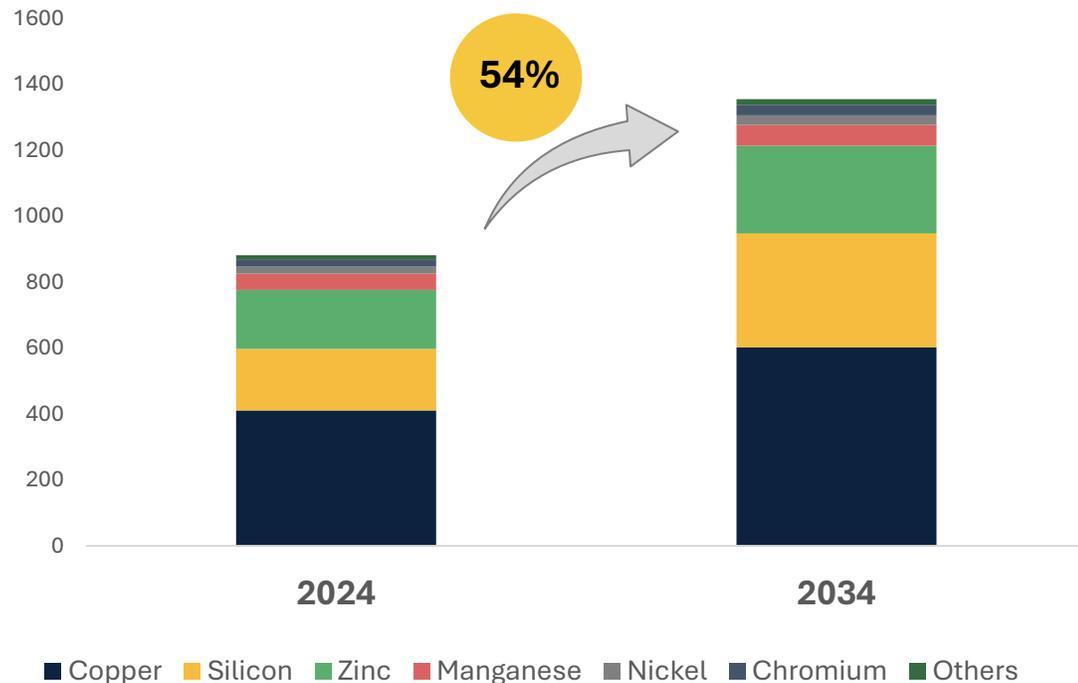
For the first time, the plan includes energy storage via **batteries (800 MW)**, helping to harness renewable energy for high-demand periods.



Mineral Composition of the Power Mix

Installed capacity is projected to grow by 35% between 2024 and 2034.
The estimated increase in mineral use, however, is 54% over the same period.

Mineral Composition of the Power Mix (Thousand Tonnes)



The minerals considered in this estimate include: copper, nickel, manganese, zinc, chromium, titanium, molybdenum, silicon, rare earths, and cobalt.

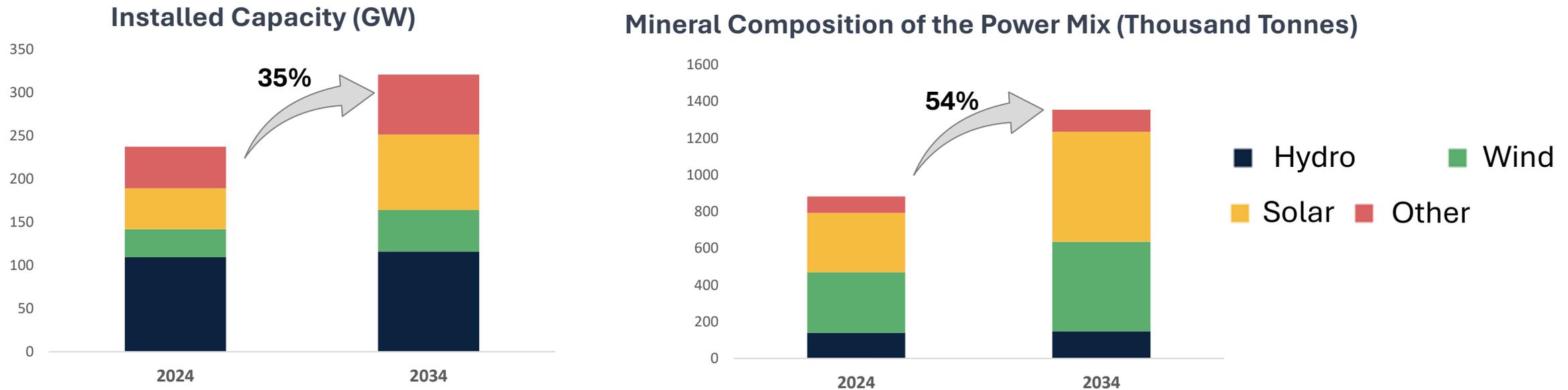
Increase in Mineral Use: The amount of minerals used in the power mix is expected to grow by 54% between 2024 and 2034, while installed capacity will grow by 35%. This indicates that the shift to renewable energy sources, especially solar and wind, requires more mineral resources than conventional sources.

Main Minerals in Use: Copper will remain the most used mineral in both 2024 and 2034, as it is essential for renewable energy technologies (such as solar, wind, and biomass) and for conventional sources (like coal and natural gas).

Silicon on the Rise: Silicon is expected to be the second most used mineral between 2024 and 2034, mainly due to the expansion of solar energy.

Zinc in Wind Power: In 2024, zinc is the third most used mineral, driven by its application in wind power technologies.

Technologies Driving Mineral Demand in the Power Mix



Minerals included in the accounting: copper, nickel, manganese, zinc, chromium, titanium, molybdenum, silicon, rare earths, and cobalt.

Main Technology in Mineral Consumption: Wind power is the largest consumer of minerals, accounting for approximately 40% of total mineral use in both 2024 and 2034.

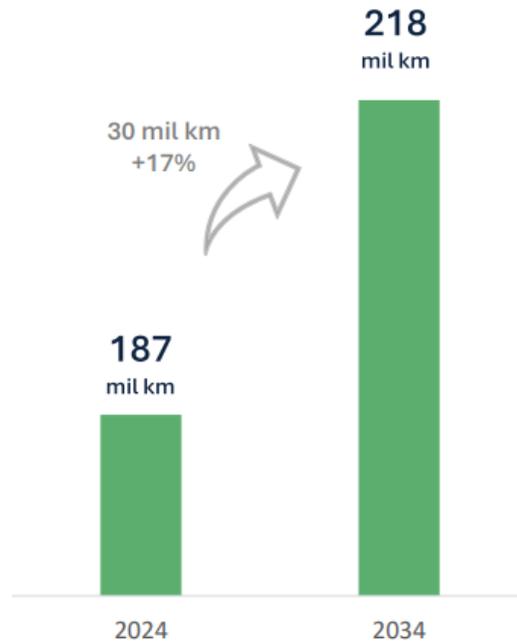
Growth in Mineral Use for Solar Power: Solar energy, both centralized and distributed, was the second largest consumer of minerals in 2024, making up around 30% of total use. It is projected to become the leading mineral consumer by 2034, reaching 41%, driven by the expansion of installed capacity.

Although hydropower will account for nearly 50% of installed capacity in 2024, it contributes to only 18% of total mineral use in that year, and this share is expected to drop to 12% by 2034.

Transmission Lines Growth in the PDE 2034

From 2024 to 2034, the length of **transmission lines** is expected to **increase by 30 thousand km**, a 17% growth, from 187 thousand km to 218 thousand km.

Transmission Lines in the PDE 2034 (thousand km)



Source: PDE 2034 (EPE).

Main Role of Renewables: The growth of wind and solar energy in the free energy market requires new transmission lines to efficiently integrate these sources, overcoming generation unpredictability.

Data Centers: The expansion of data centers, driven by AI, requires robust connections. By 2037, the load is expected to reach 2.5 GW, demanding reinforcements in São Paulo, Rio Grande do Sul, and Ceará.

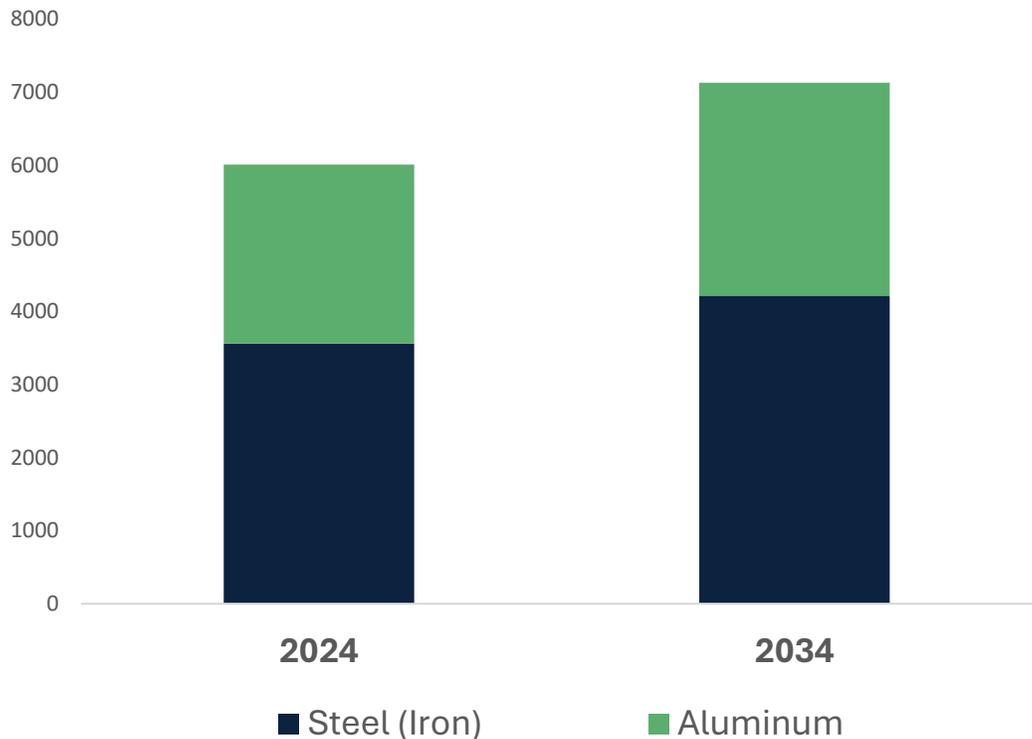
Climate Resilience: Studies indicate the need for new 500 kV lines and resilience strategies, increasing reception capacity to 440 MW for 1,500 MW.

Hydrogen in the Northeast: EPE is studying integrating hydropower into the grid by 2024, with challenges related to load definition and location, potentially requiring new infrastructure.

Minerals in Power Transmission

The length of transmission lines is expected to increase by 17%, while the estimated growth in mineral use is 19%. This indicates an almost proportional relationship, as there is no significant change in material composition.

Minerals in Power Transmission – Thousand Tonnes



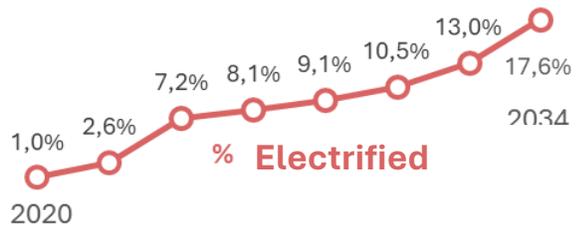
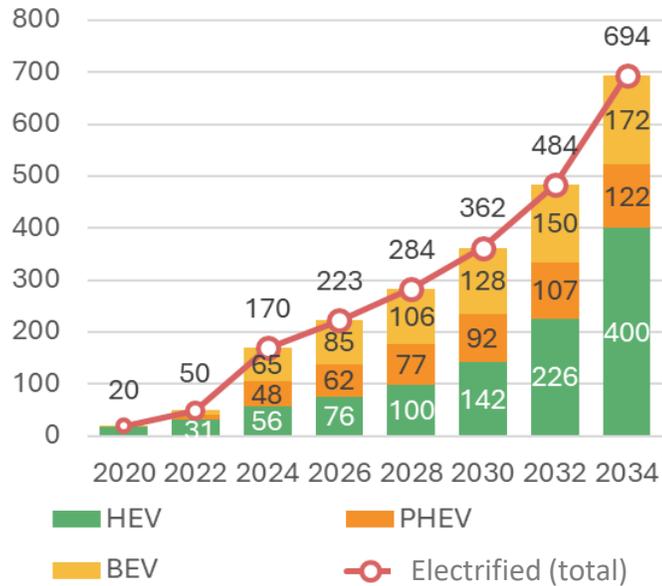
Demand for Steel and Aluminum: An estimated 1 million tonnes of aluminum and steel will be required for the construction of transmission lines and structures by 2034.

Main Components of Transmission Lines: Aluminum and steel (with iron as the main component of steel) are the predominant materials used in towers and transmission lines.

Importance of Aluminum and Iron in the Energy Transition: Although aluminum and iron play crucial roles in the energy transition, especially in transmission and distribution, they are often not classified as critical or strategic minerals in global assessments.

Electric Vehicle Growth in Brazil – PDE 2034

Licensing of light hybrid and electric vehicles (thousand vehicles; % of total)



Vehicle Electrification in Brazil: Relevance has grown, driven by state and municipal incentives such as driving restriction exemptions in São Paulo and tax reductions.

Market Entry Barriers: In the initial stages, demand for electrified vehicles is expected to concentrate among premium segment consumers.

Growth Projections: A progressive penetration of electrified vehicles is expected, with HEV (hybrids) and BEV (battery electric vehicles) fleets surpassing 1 million units by 2030, with a notable share of hybrids.

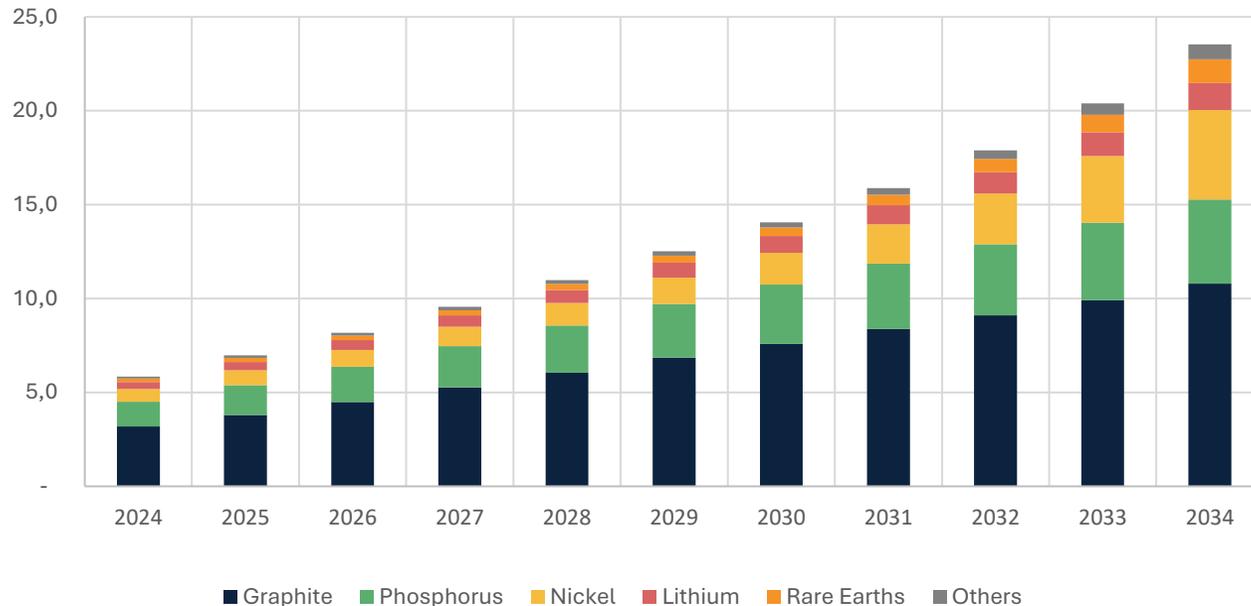
Growth Projection: Licenciamento de veículos eletrificados aumenta de **7% em 2024** para **17% em 2034**

Source: PDE 2034 (EPE).

Vehicle Electrification in PDE 2034

Evolution of the amount of minerals used in electrified vehicle batteries, according to the projected vehicle fleet entry until 2034.

Mineral Demand in Vehicle Batteries (Thousand Tons)



Significant increase in demand: Graphite is expected to have a cumulative demand of 61.3 thousand tonnes by 2034, emerging as the most used mineral in electrification..

Main demanded minerals: Graphite, iron, phosphorus, and nickel are the minerals with the highest projected demand, essential for battery technologies such as LIP and NMC.

Biofuel vehicles were not included in the estimate, but it is important to highlight that they do not generate additional demand for strategic minerals compared to fossil fuel-powered vehicles.

*Outros: Manganês, Cobalto e Zinco

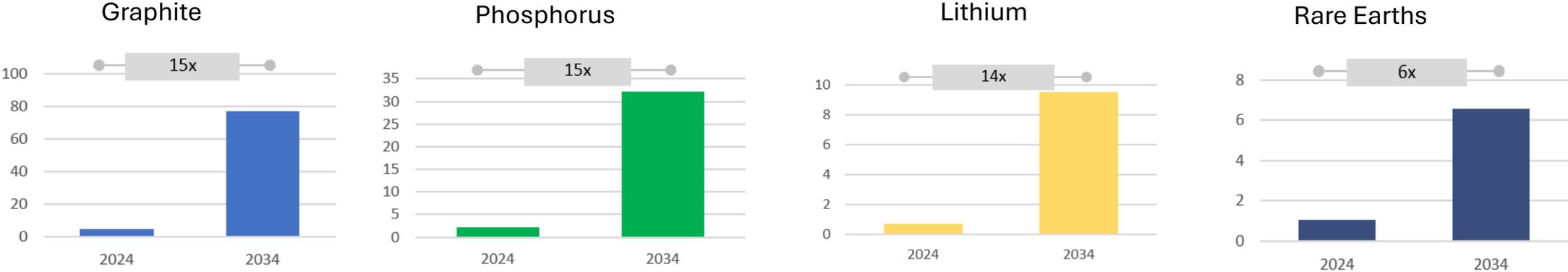
The annual demand for minerals for batteries increases 4 times between 2024 and 2034, rising from approximately 6 thousand to 24 thousand tons over 10 years.

Growth of Critical Minerals

The demand for critical minerals is expected to grow significantly by 2034, driven by the expansion of the power grid and the electrification of vehicles. The values reflect the total accumulated in kton and the proportional increase in minerals demanded for the power grid and vehicle batteries by 2024 and 2034.

The minerals with the highest proportional increases are graphite, phosphorus, lithium, and rare earth elements, with this growth mainly driven by the electrification of the fleet and their use in batteries.

Minerals Used in Energy Technologies (Thousand Tonnes)





Strategic minerals and their challenges and opportunities in Brazil



Strategic Minerals in Brazil: Reserves and Production

Mineral	Reserves - BR (t)	World Reserves (t)	Share-BR	Production- BR (t)	World (t)	Share - BR
Graphite	74.000.000	280.000.000	26%	73000	1.600.000	5%
Rare Earth Elements	21.000.000	110.000.000	19%	80	350.000	0%
Manganese	270.000.000	1.900.000.000	14%	620000	20.000.000	3%
Nickel	16.000.000	130.000.000	12%	89000	3.600.000	3%
Aluminium (bauxite)	2.700.000.000	31.000.000.000	9%	31000	400.000	8%
Lithium	1.370.000	28.000.000	5%	4900	180.000	3%
Cobalt	70.000	8.300.000	1%	0	230.000	0%
Copper	11.200.000*	1.000.000.000	1%	326600	22.000.000	2%
Vanadium	120.000	26.000.000	1%	6400	100.000	6%
Silicon (quartz)	N/A	N/A	-	390000	9.000.000	4%
Niobium	16.000.000	17.000.000	94%	75000	83.000	90%

Reserves and Production: Brazil has reserves and already produces critical minerals for the global economy, being a world leader in niobium.

Mineral Potential: The country's vast territorial expanse, with areas still lacking geological mapping, and its geological diversity, provide Brazil with great potential for the discovery of strategic minerals.

Mismatch Between Reserves and Production: There is a gap between global reserves and production in minerals such as graphite, rare earth elements, manganese, and nickel, highlighting the growth potential in the production of these minerals.

Source: Developed based on the PDE 2034 (EPE).

Strategic Minerals in Brazil: Market Engagement

- The Brazilian mining sector contributes 4% to GDP*;
- The mining industry emits 0.055% of equivalent carbon emissions (12.77 MtCO₂)

Brazilian Exports of Critical Minerals for the Energy Transition (2002-2022)



Brazil is a key exporter of iron, manganese, tantalum, niobium, and bauxite.

Brazil is a major exporter of raw minerals (such as bauxite and alumina) and an importer of processed products (such as aluminum sheets and lithium derivatives).

Source: IPEA, 2024 Brazil's Position in the International Trade of Critical Minerals for the Energy Transition..

*In addition to GDP, mining drives sectors such as trade and services, with a focus on the multiplier effect of iron ore and non-ferrous metals, according to a study by IPEA and MME (2023).

Despite the significant increase in Brazil's exports of critical minerals between 2002 and 2022, the country's market share has declined due to the progress of other nations.

Minerals in the Energy Transition: **Opportunities for Brazil**

Powershoring



Attract investments in industrial chains that leverage Brazil's low-emission energy matrix, focusing on "green" products and expanding industrialization in the long term;

Potential for Production and Quality of Reserves



With vast territory and geological diversity, Brazil has great potential for new mineral reserve discoveries;

Friendshoring



The increase in trade restrictions on strategic minerals leads countries to seek alternative supply sources and partnerships with Brazil, creating investment opportunities and strategic agreements;

Environmental Legal Framework



Brazil's modern environmental legislation promotes sustainable mining, positioning the country as a global leader and attracting investments in responsible practices within the mining sector.

Minerals in the Energy Transition: **Challenges for Brazil**

Availability of Funding for Investment



The mining of critical minerals requires high initial investments, demanding advanced technologies and robust infrastructure, which represents a significant challenge for Brazil;

Processing Chain



Despite its vast natural resources, Brazil faces challenges in advancing the processing of critical minerals due to the technological maturity established in other countries and global dominance in the value chain;

Socio-environmental Challenges



Mineral exploration in Brazil, despite strict environmental legislation, generates significant impacts, requiring sustainable management to minimize damage. Additionally, investment in research is needed to develop alternative materials and promote mineral recycling to reduce pressure on scarce resources.



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