CRITICAL MINERALS FOR ENERGY TRANSITIONS IN LATIN AMERICA AND THE CARIBBEAN

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CREDITS

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Foreword

There is no energy transition without minerals from Latin America and the Caribbean.

The Latin American Energy Organization (OLADE) presents this research showing Latin America's unique contribution to the global market for critical minerals.

The critical minerals market in the region is around US$ 180 billion, or 25% of the world market. The main minerals are copper (US$ 700 billion), iron ore (US$ 50 billion), gold (US$ 30 billion) and silver (US$ 10 billion).

In order to decarbonize our economies by 2050, Latin America will need to double copper production and increase recycling in the sector. Some 20% of refined copper is produced by recycling, which saves up to 80% of energy compared to energy from mining. As for lithium, the region has almost 60% of the resources and production is expected to increase at least tenfold over the next 20 years.

As global demand for minerals for sustainable technologies and renewable energy increases, this study highlights the importance of anticipating this demand to avoid supply imbalances. As a strategic mineral exporter, Latin America faces unique challenges and seeks to improve its socioeconomic situation through investment and sustainable economic growth.

In a global context that prioritizes sustainable energy and clean mobility, Latin America has the potential to gradually make progress in production chains through extractive resources. OLADE emphasizes the urgent need to coordinate global energy demand scenarios and create a common agenda for the extraction and processing of strategic minerals to promote socioeconomic development in the region.

Andrés Rebolledo Smitmans,
Secretario Ejecutivo OLADE

About OLADE and Mining

The Latin American Energy Organization (OLADE) is an intergovernmental public body of cooperation, coordination, and technical advisory established on November 2, 1973, through the Lima Agreement ratified by 27 countries in Latin America and the Caribbean (LAC) whose core objective is to promote the integration, conservation, rational use, commercialization and defense of the region's energy resources. OLADE plays an active role in creating and disseminating publications related to energy issues in LAC. At the end of 2022 and following the 52nd Meeting of Ministers (LII), for the first time, an agreement was made to move forward with the study and analysis of critical minerals needed for energy transitions towards low-carbon systems in LAC.

Acknowledgments

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He had the honor of serving as Director of Resources and Technology within the Secretary of Energy of the Argentine Republic, contributing to the development of renewable energies in the country. In recent years, he has focused his career on research and consulting, starting at the Inter-American Development Bank (IDB) with agendas for mining development, gender, and regulatory compliance.

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I. INTRODUCTION

A. Structure & Approach

Latin America and the Caribbean have a sustained production of minerals and significant reserves that will be critical for development and meeting emission reduction targets. Can we coordinate regional policies and strategies that allow our region to diversify its role as a raw material supplier and begin adding value locally?

This study, organized into four chapters, creates a space for discussing this new problem and drafting proposals for developing strategic minerals in Latin America and the Caribbean. The first chapter provides the introductory framework for the document, outlines the global context of critical minerals, and sets out a series of definitions necessary for subsequent chapters. Some definitions have consensus, such as what constitutes a critical mineral and which minerals are critical. In contrast, other definitions are more disruptive and reflect the view on critical minerals from producing countries' perspectives.

The second chapter presents a preliminary selection and description of ten critical minerals detailing their production and primary uses. This chapter illustrates their importance in terms of their applications and connection to reserves and production across the region.

The next chapter focuses on the specific perspective of LAC. It exposes the situation regarding critical minerals from the point of view of producers, reflecting the concept of strategic minerals introduced in Chapter 2. The methodology used to select those first ten critical minerals (considered now as strategic) from an initial list of over fifty minerals is discussed. This selection is a preliminary proposal for the region, and each country, given its characteristics, may make a slightly different choice based on its context, resources, production, and opportunities.

The study concludes with a road map, including actions and proposals to promote the exploration and production of critical minerals, which would allow for contributing to the region's socio-economic development by mining these metals. It also includes an outlook on the main challenges faced by this sector in our region and the next steps necessary to ensure the sustainability and growth of this activity.

B. Global Context

There is a global consensus on the need to move toward cleaner, more sustainable, and inclusive economies, and every country is undergoing its energy transition. However, all solutions share one commonality: they require a more considerable amount of minerals than fossil fuel-based energy solutions do.

Technological advances have increased the consumption of specific minerals such as nickel, lithium, or copper, and this applies not only to electricity generation but also to digitalization, electronics, the residential sector, the evolution of the automotive industry, and sustainable mobility in all its variants and to almost all sectors of activity.

The literature specific to the topic has grown exponentially over the last ten years. It is now so vast that before starting any new study, it is vital to conduct an updated summary of available documentation to avoid repeating recent studies or presenting similar conclusions on topics that have already been widely addressed.

The academic and research approach to the supply of raw materials is the consequence of political positions. The supply of raw materials has always been a point of contention in global geopolitical relations, and when demand projections far exceed the supply capacity, alarms go off.

During the last century, the need for hydrocarbon reserves became crucial. Albeit different, the situation regarding critical minerals may become just as critical now and is the subject studied in this paper.

For industrialized markets, the restriction of supplies is a critical point to analyze. The World Bank[1] estimates that over 3 billion tons of minerals and metals would be needed to implement clean technologies to meet the target of reducing temperature below 2°C by 2050. These production volumes and refining can reach up to 40 times the values of 2020 if we take, for example, the case of lithium and its projection to meet the goals of the Sustainable Development Scenario (SDS) produced by the International Energy Agency (IEA)[2].

Studies carried out by the governments of the developed countries and multilateral organizations seek to use parameters to study the issue that missing raw materials poses for their industries and sectors and propose, based on those parameters, a series of solutions to mitigate this shortage in the future and reduce the gap between supply and demand without restricting the upcoming sustainable expansion of the following decades.

The main issues to solve and urgent priorities for LAC are radically different. LAC is a distinct mineral exporting region. Instead of discussing demand restrictions or pricing conflicts, we should mention the need to increase efforts to explore, invest, and produce. The challenges are different, and a potential increase in production would bring about the pressing need to improve our capacity to care for resources, the environment, and especially the communities from areas adjacent to current or future projects.

This study has a differential approach centered on analyzing how LAC, through its strategic mining resources, may improve the socio-economic situation of its people while caring for regional resources, maximizing the channeling of investments, generating economic growth, and developing a long-lasting infrastructure. From the LAC perspective, that is the issue, and that is what this document seeks to solve. Creating a regional agenda that includes the scaled-up and coordinated production of these strategic minerals is an opportunity that will allow LAC to contribute to the socio-economic growth of its people.

1.- World Bank (2020) - Minerals for Climate Action: The Mineral Intensity of the Clean Energy Transition
2.- IEA (2021) - The Role of Critical Minerals in Clean Energy Transitions

C. Energy Scenarios & Projections

All countries draft their long-term energy plans since investment time frames for the electricity sector (distribution networks, high voltage lines for transmission, or new capacity installation) are very long, and the associated sums are too high.

In recent years, the increase in capacity associated with demographic and industrial growth has been closely linked to the growth in global electrification, a by-product of technological demand. In the future, it will be even more closely related to sustainable mobility and global decarbonization.

This energy planning is based on scenarios one may consider more realistic, pessimistic, cost-effective, or with a lower margin of error, depending on how such planning is established. In any case, these plans will always have higher or lower thresholds, margins of error, and levels of uncertainty when projected at 15 or 30 years.

The demand for some minerals is closely linked to the increase in electrical power of a specific technology, such as the example of neodymium, a rare earth element (REE) essential for manufacturing magnets for wind turbines. Evidently, an energy plan associated with increased wind power will impact the need for this mineral. The increase in wind power from a single Latin American or Caribbean country may not alter the supply-demand balance of neodymium. Still, an exponential global increase in the installation of wind farms would lead to an incredible imbalance between the current production of neodymium and the future needs of wind turbine technologists. And if that increase in demand is not supported by exploration and exploitation projects, at some point, the supply of this mineral may not be fully guaranteed.

This example illustrates the importance of consolidating energy demand projections globally and the need to report, along the entire supply chain and mineral by mineral, the requirements of each stakeholder involved in the energy demand projection to run different scenarios and evaluate how changes in global projections impact on the demand for what is known as critical minerals.

Given this latent concern, several non-governmental organizations embarked on the arduous task of supplementing their energy scenarios with an associated mining demand to anticipate disruptions in the supply of raw materials essential for decarbonization, the reduction of greenhouse effect gases, and complying with the objectives of the Paris Agreement.

In line with these concepts and the three scenarios in the World Energy Outlook (WEO), the IEA drafted appendices or projections for the different mineral requirements. For information purposes, these scenarios differ mainly by the hypotheses posed concerning government policies.

1. The Stated Policies Scenario (STEPS) shows the pathway implied in current policies.
2. The Announced Pledges Scenario (APS) assumes that all targets announced by governments, including long-term energy access and zero emissions targets, are met in full and within the established deadlines.
3. The Net Zero Emissions by 2050 Scenario (NZE) outlines how to stabilize the global temperature rise by 1.5°C and guarantee universal access to electricity and modern energy systems by 2030.

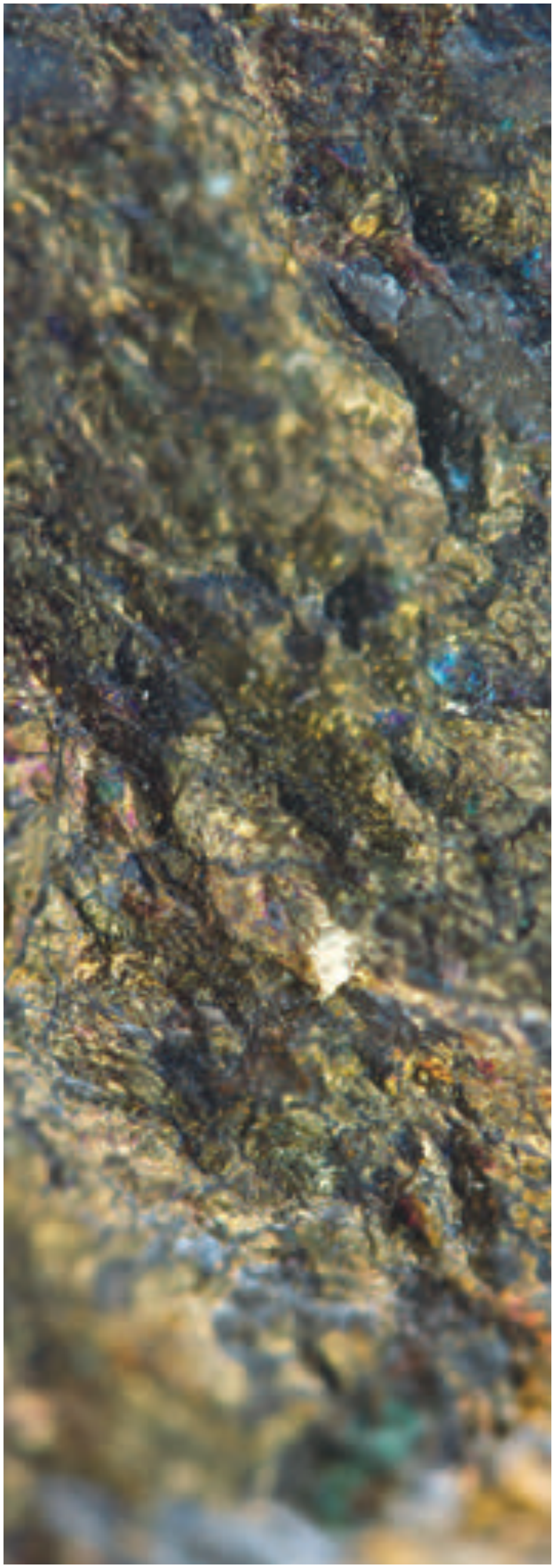
In the case of the projections of the Energy Outlook for Latin America and the Caribbean published annually by the OLADE, the document does not include the demand for minerals for the region, which adds a step in the simulation of scenarios. This is why strategic scenarios like this one or others shared by the International Renewable Energy Agency (IRENA) are key to understanding future energy demand projections rather than for projecting the mining demand.

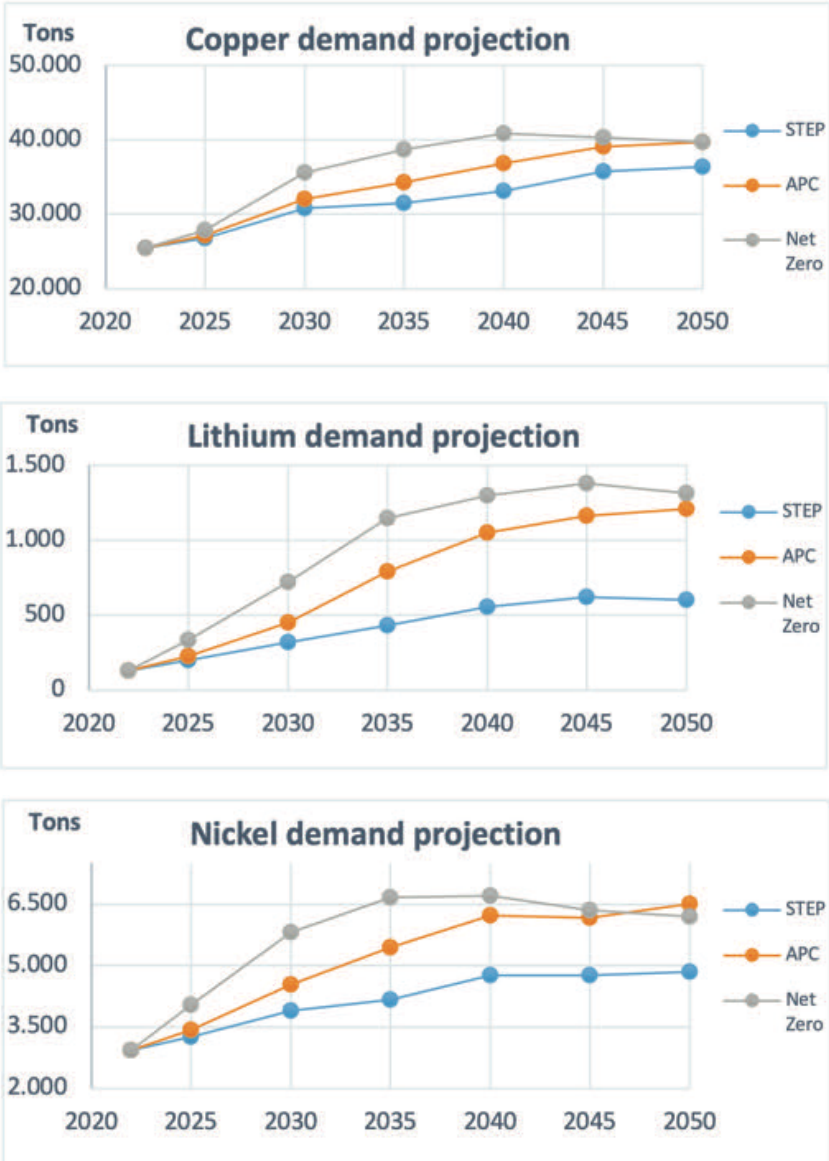
There is difficulty in translating a program to incorporate renewable power and an expansion of the sustainable mobility fleet in a mineral demand chart, which should also be globally compiled to contemplate the entirety of demands to corroborate the availability of raw material or lack thereof. This additional difficulty generated when using any scenario or projection that fails to include an associated minerals demand model led to using the IEA's Global Energy and Climate (GEC) model instead of any other energy modeling program.

Based on the previous scenarios the IEA has simulated to obtain the generation mix, emissions, industry growth and other information, demand projections were also obtained for the primary minerals and metals needed for the transition.
To conduct these exercises, the IEA mainly used two approaches that allowed for estimating the demand for critical minerals in the different countries. The first approach, the bottom-up approach, involves assessing the material requirements for each technology, modeling their growth individually, and obtaining an estimated projection for each of the critical minerals loaded in the model during the projected period. On the other hand, the top-down approach involves estimating the growth rate of each technology and then estimating the minerals for which there is a demand based on this growth.

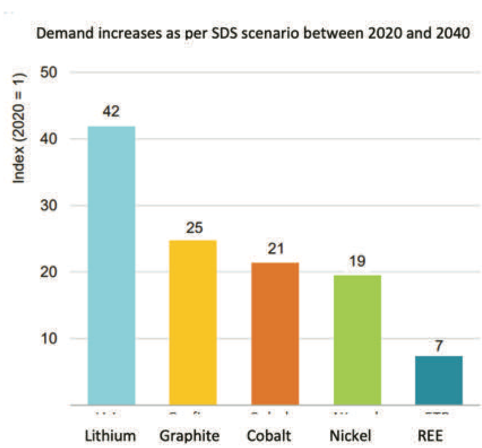
For both methodologies, it is necessary to parameterize the demand for minerals by technology; with these data, the need for energy transitions could be estimated correctly. This is one of the biggest challenges and the primary reason for divergence between the main reports.
Another variation in the reports pertains to differences in scenarios, specifically the projection of the efficiency in using minerals from here to 2050. This projection explains why, in several cases, the demand for minerals decreases in some more optimistic scenarios. This is due to increased efficiency and reduced consumption of these highly demanded minerals rather than the slowdown in the growth of sustainable technologies.

Some of the following graphs can be drafted using the data obtained.





Graph 1 - Demand Projection (based on IEA, 2021)



Graph 2 – Increase in Mining Demand (based on IEA, 2021)

These are some of the projections for the global consumption of copper, lithium, and nickel, where it is also interesting to understand how this demand varies with respect to itself. The growth in demand for lithium is closely linked to the production of batteries, either for e-mobility or electrical energy storage. The other uses of lithium will be relatively irrelevant to this use.

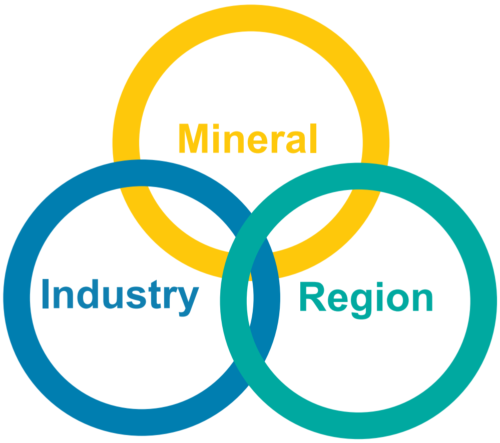
II. CRITICAL MINERALS

A. Definitions

1. Critical Minerals

This section proposes a series of definitions that would allow for reaching a consensus on concepts pivotal when defining the critical minerals for the energy transition that the LAC region can focus on. It makes sense to concentrate the region's efforts on exploring and producing these minerals but following a path geared toward activities with a higher local added value.

The adjective "critical" refers to a crisis. In this context, a mineral is critical when, as essential for developing an industry, an activity, or a sector, its supply is not guaranteed safely and sustainably. Therefore, it becomes critical. This definition considers three elements and hence depends on the following:



1) The industry or activity sector

2) The availability of the mineral

3) The region that issues the criticality list.

Suppose you take a mineral with minimal production concentrated in a single country, a highly volatile price, or a mineral not vital for any specific activity, sector, or industry. In that case, it will not be deemed critical, for it is unnecessary for any productive or technological development. At the same time, if a mineral is vital for an activity but is locally supplied, its supply does not represent a bottleneck now or in the future, its production is geographically distributed and not managed by very few stakeholders and its price does not suffer variations, then, if these conditions are met, the mineral will not be deemed critical.

Finally, if a mineral is scarce, only produced by one or very few countries, is vital for an entire industry or sector, but the region creating the list is not involved in that activity, or if that activity is not related or connected to local productions or the priorities set by this region, then that region will not include it in its list of critical minerals.

The shortage of critical minerals is a significant problem because it can lead to disruptions in the supply of these products. It can also make these products more expensive. Additionally, the scarcity of critical minerals can increase the dependence of nations on other countries to obtain these resources.

This shows that diverse lists of critical minerals may exist. We may find as many lists as markets there are, where each region or industrialized country can make internal considerations and define, according to its priorities, which materials and minerals are to be included in the select list of critical minerals.

Clearly, these lists will each depend on their own industry, and the same minerals will not be critical in all markets for their criticality will depend on the industry developed in each country or region. Nevertheless, several minerals can be found in more than one list.

2. Main lists of critical minerals

While these lists have been made for decades, since raw materials fundamental for local economies have always existed, the current format and diversification came about in recent years. As introduced at the beginning of this document, raw materials such as nickel, tin, oil and, for the last few years, natural gas (given the war between Russia and Ukraine) have been at the center of interest of international geopolitics. UN studies argue that over 40% of all internal armed conflicts in the last 60 years are linked to natural resources[3].

Hence, it is interesting to consider the evolution of lists throughout the years based on historical progress and the relationship between the main economic blocks. According to the IDB, from the perspective of consumers and export destinations of critical minerals, including the US, China, Japan, and Europe, there is an essential focus on how and where these minerals are produced for their industries and how vulnerable their supply chains are[4].

Through its Geological Survey (USGS), the US government often updates its list of critical minerals, which in its latest version includes 50 minerals, among which are zinc, lithium, magnesium, manganese, nickel, platinum, cobalt, aluminum, and graphite. In its 2023[5] update, the country added a list of minerals critical to the energy sector, including aluminum, cobalt, copper, dysprosium, steel, fluorine, gallium, iridium, lithium, magnesium, graphite, neodymium, nickel, platinum, praseodymium, silicon, silicon carbide, and terbium.

In turn, the European Union[6] has its list, which includes 34 minerals and other raw materials and is updated every two years. In its last update, Japan identified 32 minerals, and the list of critical minerals that China drafted many years ago without recent updates is the shortest, with only 28 minerals, 16 of which are rare earths.

As industry and technology advance, critical mineral lists are almost automatically updated. The global consensus[7] on the requirement for cleaner energy systems has increased the need for several minerals critical to low-carbon technologies such as solar or wind. There are currently several minerals found in most of the lists, and most of them are used in the energy sector for technological developments or e-mobility.

3.- https://www.unep.org/es/noticias-y-reportajes/reportajes/el-conflicto-y-el-deterioro-del-medio-ambiente-en-el-sudan-van-de

4.- https://blogs.iadb.org/energia/es/america-latina-y-los-minerales-criticos-para-la-transicion-energetica/

5.- https://www.energy.gov/cmm/what-are-critical-materials-and-critical-minerals

6.- https://www.consilium.europa.eu/es/infographics/critical-raw-materials/

7.- https://www.g20.org/content/dam/gtwenty/about_g20/previous_summit_documents/2018/Energy_communique.pdf -- Energy Ministers Communiqué – G20 (2018)

3. Strategic Minerals

In this sense, when a list of critical minerals appears for a market, a strategic minerals market automatically arises for those who can supply them. Unlike critical minerals, strategic minerals for each country or region are minerals whose resources, reserves, or production are interesting enough to be deemed strategic. Just as the classification of critical minerals depends on who drafts the lists, the same will be valid for strategic minerals. Minerals will be strategic for a region or country according to their assessment. Throughout this document, we propose a methodology to develop a list of strategic minerals for Latin America and the Caribbean based on the minerals critical for the main industrialized markets. The more a mineral is listed, the higher its criticality and, therefore, the more strategic it can become if a country has that mineral among its resources.

B. Main Uses

Critical minerals have different uses, often directly and proportionally related to clean energy development. Others, such as iron or steel, are fundamental for this and many other industries.

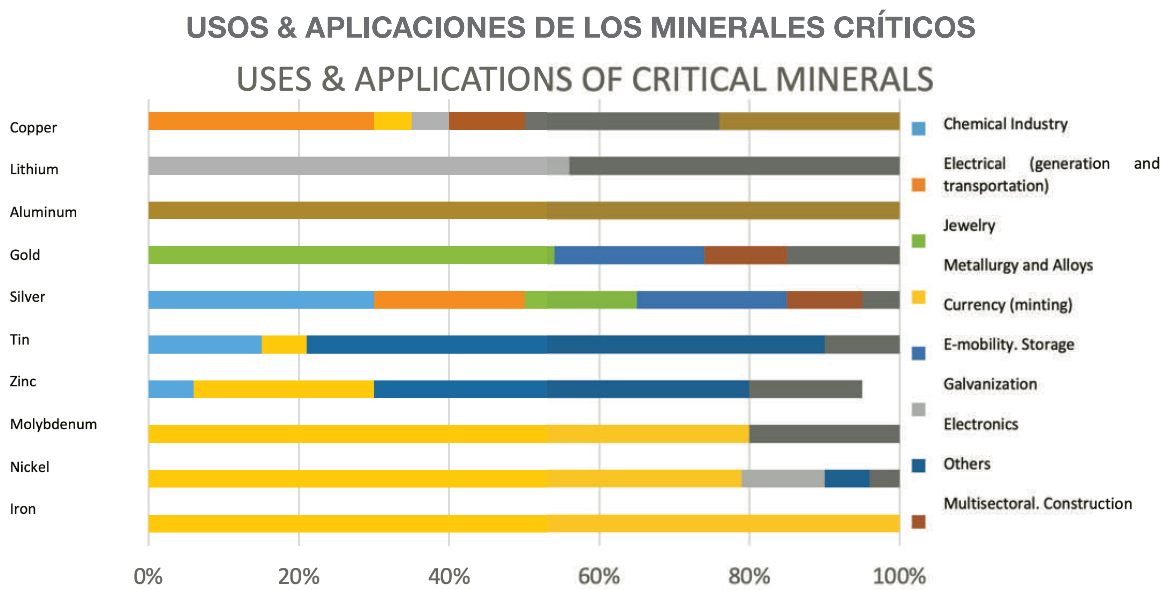
Currently, nickel is essential to manufacturing stainless steel. Still, in the next few decades, depending on the selected scenario, it shall play a more prominent role, given its use in nickel-based batteries.

The following table summarizes the primary uses of clean technologies and was prepared using data from the IEA, 2021.

MINERALS	SOLAR	WIND	HYDROPOWER	GRID	E-MOBILITY STORAGE	HYDROGEN
Copper	High	High	Medium	High	High	Medium
Lithium	Low	Low	Low	Low	High	Low
Silver	High	Low	Low	Low	Medium	Low
Molybdenum	Low	Low	Low	Low	Low	Low
Nickel	Medium	Medium	Low	Low	High	Medium
Aluminum	High	Medium	Medium	High	High	Medium
Gold	Low	Low	Low	Low	Low	Low
Tin	Low	Low	Low	Low	Low	Low
Zinc	Medium	High	Medium	Low	Low	Low
Steel	High	High	High	High	High	High

Table 1- Concentration of Critical Minerals by Technology

1. Detail by mineral



Graph 3 – Uses and Applications of Critical Minerals (compiled by author)

This graph introduces a summary of the current main uses of various strategic minerals for LAC.

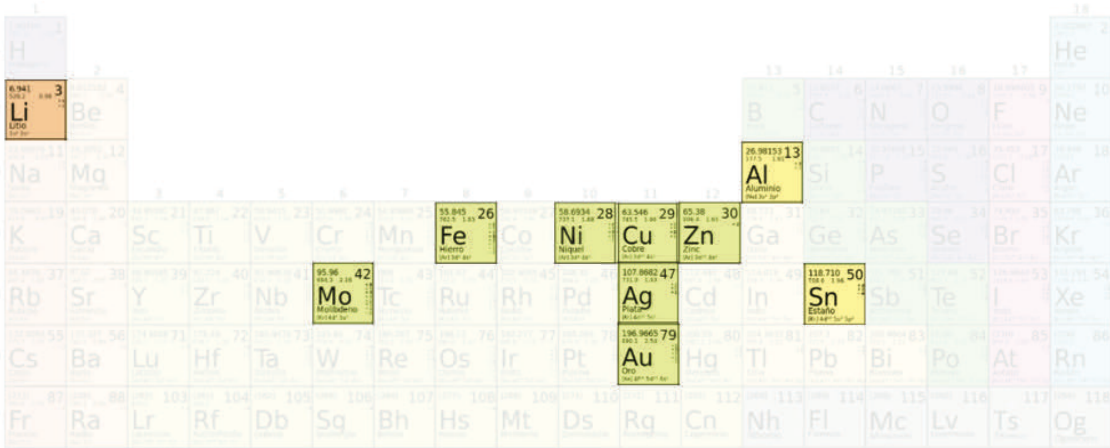


Figure 2 – Location of critical minerals in the periodic table

When placing these selected strategic minerals in Mendeleyev's periodic table, to the left we see lithium, an extremely light alkaline metal; then, there is the group of metallic minerals (iron, nickel, copper, zinc, molybdenum, silver, and gold) and finally, to the right, we see the transition minerals (in no way related to the energy transition), such as aluminum and tin. Given their current low production in the region and limited knowledge about them due to lack of exploration, this first study does not specify other critical minerals, such as cobalt or rare earth elements.

Aluminum is included in these tables and figures since bauxite is not an element of the periodic table. Instead, it is made up of aluminum oxide Al3O2, which is refined to obtain alumina and then, by electrolysis, aluminum since, unlike gold or silver, aluminum is never found in its pure state due to its high degree of reactivity.

Copper is the most widely used element for conducting electric currents and, on average, in recent years about 30% of copper has been used for the electricity sector (generation and transmission and electrification), 5% for transportation and storage, 5% for manufacturing bronze and brass, 10% for electronics and the rest for the building industry and all other industries.

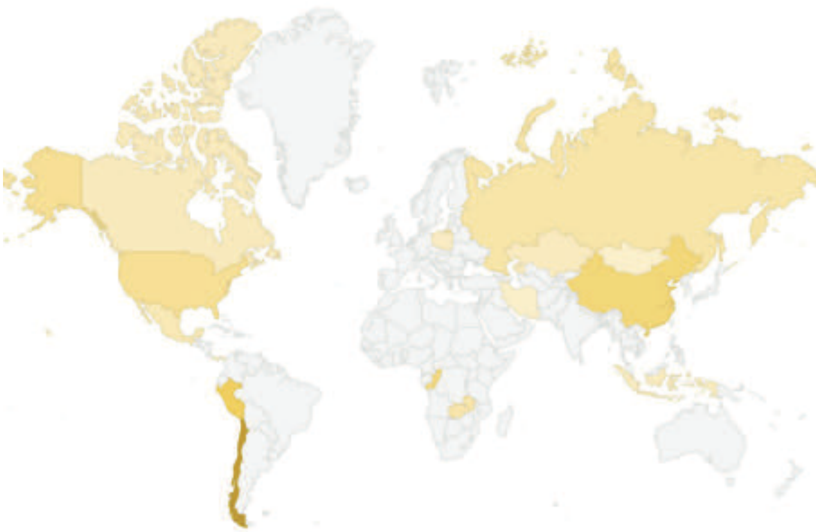
Regarding lithium, 56% is currently used in sustainable mobility and power storage. However, this proportion will radically change in the coming decades, and almost all the lithium will be used for those purposes.

The same criterion can be applied to aluminum and iron. These are structural minerals vital for all industries and sectors. In relative terms, the increase in their demand is not directly linked to renewable generation. It may not be excessive as in the case of lithium or cobalt (the latter not detailed in this study as it is not a strategic mineral for LAC, although it is one of the most critical minerals for other countries due to its concentration in production and its exponential increase in demand.) However, in absolute terms, steel and aluminum consumption growth is on another scale compared to the rest of the metallic minerals in this study.

The same is true today for nickel, tin, zinc, and molybdenum, whose applications are more closely linked to manufacturing steel, galvanizations, and alloys for various uses. However, this is one of the equations that changes with the massive advent of sustainable technology, turning current concentrated uses and diversifying them.

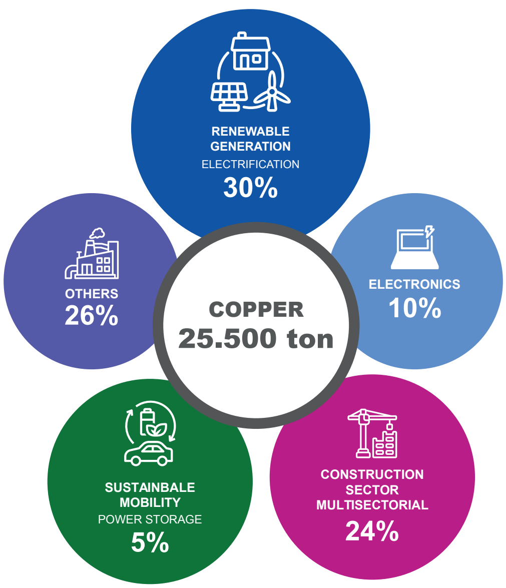
a) Copper

According to the USGS[8], it is estimated that in 2022, over 25 million tons of copper were refined worldwide. A first estimate shows that over 40% of global copper consumption is destined for direct electrical and electronic applications. About 70% of that consumption is used in electrical power applications, including the entire thermal generation system.



Map 1 - Copper Production

Copper is one of the strategic minerals for LAC as it plays a central role in the energy transition toward a more sustainable and carbon-neutral future. Its electrical conductivity makes it essential in crucial technologies driving the transition, such as renewable energies and electrification. It also has a wide range of uses thanks to its qualities regarding thermal conductivity, corrosion resistance, and malleability.



APPLICATIONS (%)	
Renewable generation Electrification	30%
Construction Multisectoral	24%
Electronics	10%
Metallurgy Alloys (Bronze & Brass)	5%
Sustainable Mobility Storage	5%
Others	26%

Figure 3 – Main Uses of Copper (compiled through author's research)

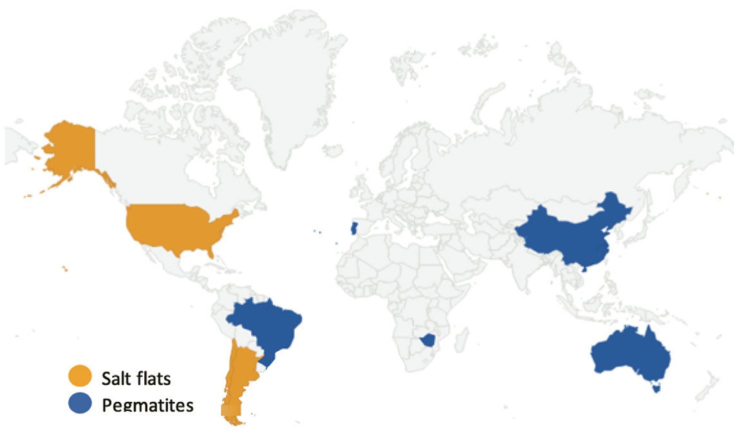
8.- https://www.usgs.gov/publications/mineral-commodity-summaries-2023

A significant reduction in global greenhouse gas (GHG) emissions can be achieved by harnessing the potential of copper in a wide range of technology solutions. By improving energy efficiency in electrical and electronic systems, copper reduces energy consumption and, therefore, the carbon emissions associated with generating that energy.

The copper industry includes copper mines, smelters, refineries, recycling facilities, and manufacturers of semi-processed copper and copper alloy products such as tubes, wire rods, and rods. Copper significantly contributes to the domestic economies of developed, newly developed, and developing countries. Mining, processing, recycling, and transforming metal into multiple products generate work opportunities and wealth. Almost one million people work directly for the global copper industry, and at least one million more are indirectly employed by this industry[9].

b) Lithium

The current global production of lithium is concentrated in a few countries. It can be extracted from salt flats, as in Bolivia, Chile, and Argentina, or from rocks (pegmatites), as in Australia or China. Combining the top four products, Australia, Chile, China, and Argentina account for over 96% of production.



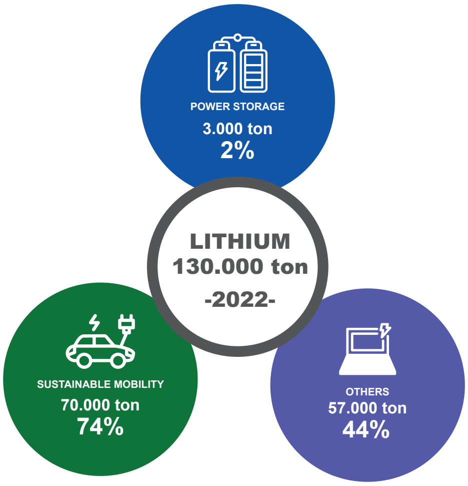
Map 2 - Lithium Production

COUNTRY	PRODUCTION (ton)
Australia	61,000
Chile	39,000
China	19,000
Argentina	6,200
Brazil	2,200
Zimbabwe	800
Portugal	500
Canada	500
Bolivia	600

Figure 4 - Lithium-producing countries

9.- International Copper Association (2023) - Copper: The Pathway to Net Zero

Its current most significant use is e-mobility, with 54% of the resource used in this sector. This, in turn, is the main reason why, if we take 2020 as the reference year, the demand for this mineral will see a fortyfold increase as per the SCS scenario of the IEA for 2040.

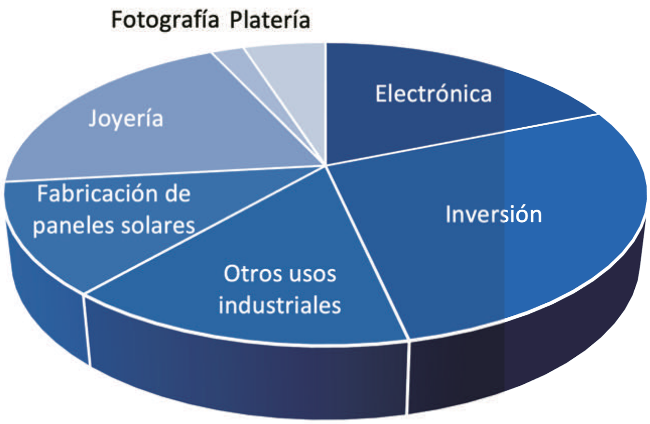


APPLICATIONS (%)	
E-mobility	54%
Storage	2%
Others	44%

Figure 5 – Main Uses of Lithium (compiled by author using IEA data (2021))

c) Plata

Around 25,000 tons of silver are produced worldwide, and, according to the annual publications of the Silver Metal Institute[10], 19% is allocated to the electronics industry, 12% to the manufacturing of solar panels (which increases every year) and 15% to other industrial uses. On the other hand, its use for jewelry is around 20%, and its use as an investment remains over 28%. As for the uses in decline, the last decades saw a marked decrease in its use for silverware and photography.

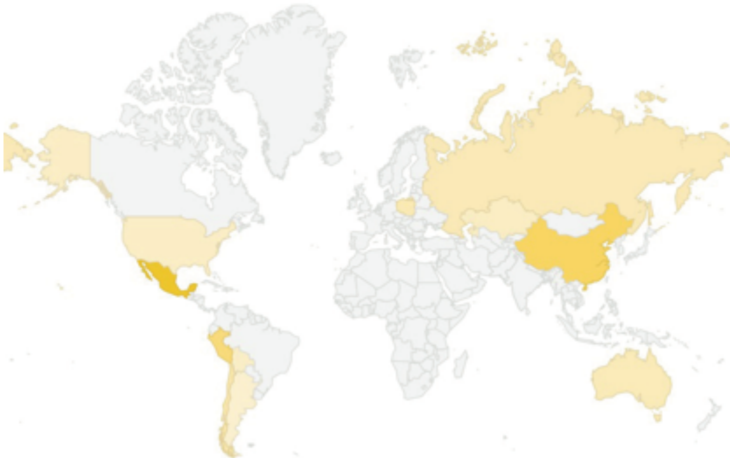


APPLICATIONS (%)	
Electronics	19%
Solar panels	12%
Other industrial uses	15%
Investment	28%
Jewelry	20%
Photography	2%
Silverware	5%

Figure 6 - Main Uses of Silver (compiled based on the World Silver Survey, 2023)

In most deposits, the extraction of silver is carried out as a mining by-product of another main element. This means that only 25% of all exploited silver comes from mines whose main product is silver. The remaining 75% of silver is combined with other minerals more relevant to that deposit. This model diversifies the concentration of production to the maximum. Consequently, a large number of countries in the region produce this mineral.

10.- Silver Metal Institute (2023) – World Silver Survey



Map 3 – Silver Production

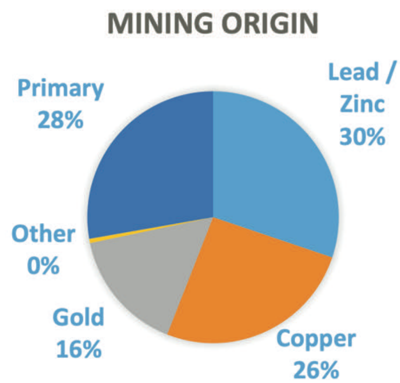


Figure 7 – Mining Origin of Silver

The exponential growth of the solar industry will lead to even more significant concentrations of silver in the panel industry.

d) Molybdenum

Molybdenum is a ubiquitous mineral in Latin America and the Caribbean (LAC). The region accounts for almost 40% of global reserves and is only behind on reserves of copper and lithium. Chile, Peru, Mexico, and Brazil are the countries with the largest reserves in LAC.

APPLICATIONS (%)	
Metallurgy	80%
Others	20%

Table 2 - Main Uses of Copper (compiled through author's research)

Map 4 - Molybdenum Production

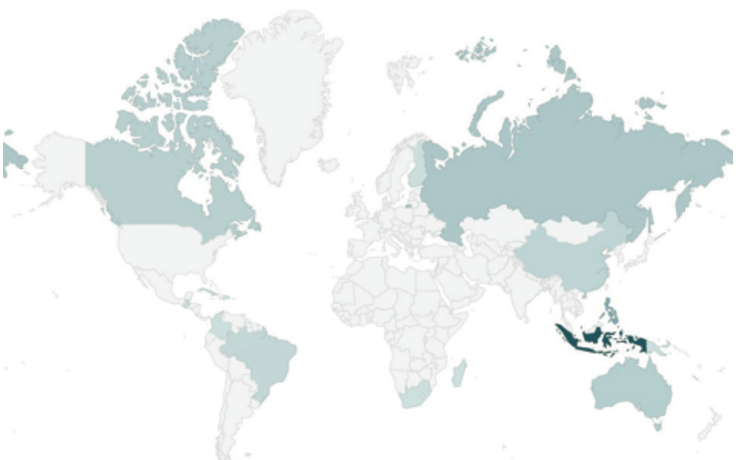
Molybdenum production often occurs as a by-product of mining other minerals (in LAC, it appears as a by-product of copper), and its production fluctuates depending on market conditions and investments in the mining industry.

Over two-thirds of molybdenum production is used for manufacturing steel alloys. Hence, as the demand for iron grows, so does the demand for molybdenum. Its presence in steel makes it more resistant. It is also used as a component of superalloys and nickel alloys and, to a lesser extent, as a catalyst to remove sulfur in other chemical industries.

It is not a strategic mineral directly and exclusively connected to clean technologies. Yet, it is fundamental for them since steel is a structural component in every energy project.

e) Nickel

Nickel has numerous physical and chemical properties, making it an essential mineral for various applications. It is fundamental for stainless steel alloys, manufacturing medical equipment, cell phones, wind turbines, and, increasingly, batteries. This material has excellent corrosion resistance and is therefore used to coat other metals, thus protecting them. Nickel is a hard, malleable, ductile metal with good thermal and electrical conductivity.



Map 5 - Nickel Production

At the market level, the global nickel market is projected to grow from $37.7 billion in 2021 to $59.14 billion in 2028 in the forecast period of 2023-2028

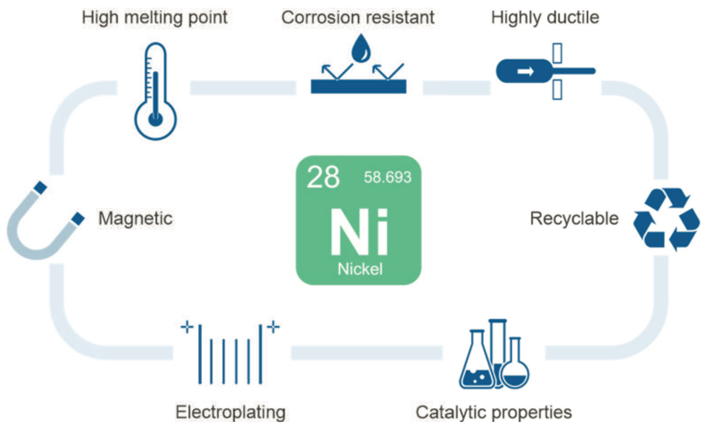


Figure 8 - Main Characteristics of Nickel

APPLICATIONS (%)	
Metallurgy Stainless steel, alloy and castings	77%
Galvanization	9%
Storage Batteries	3%
Others	1%

Table 3 – Main Uses of Nickel

(source: https://nickelsearch.com/nickel/)

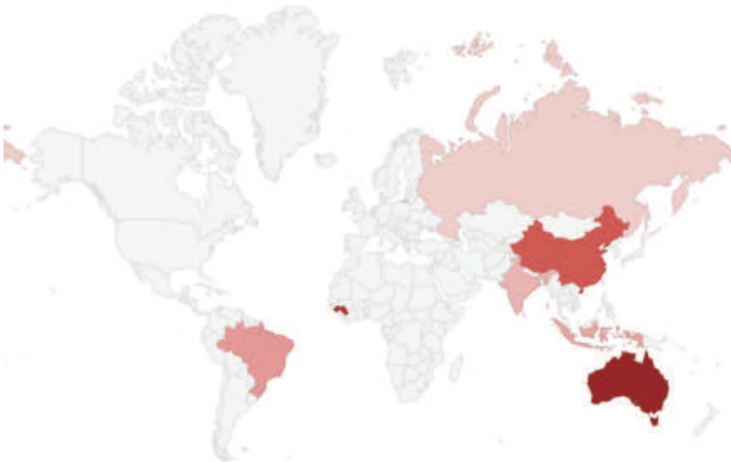
Nickel is mainly used in the steel industry where, together with chromium, it is instrumental for stainless steel and currently represents 68% of the market for this mineral. To a lesser extent, it is also used for other alloys and galvanization, and it is also essential for several types of batteries. While only 3% of nickel is currently used for batteries, this use will grow markedly.

f) Bauxite

Bauxite is the mineral from which aluminum is obtained. It is mainly made up of aluminum oxides. Resources are not concentrated in a single country or region; however, the largest reserves are usually found in tropical and subtropical areas. Aluminum is widely used in various industrial and consumer applications, such as constructing lightweight structures, packaging production, and manufacturing kitchen products, among others. While extracting and purifying bauxite, alumina (aluminum oxide) is obtained and then electrolyzed to obtain metallic aluminum.

During these processes, large amounts of energy are consumed, so, in many cases, the manufacturing of aluminum is not geographically linked to the extraction of bauxite directly, with the price of power and the market being the determining factors in deciding on the location of aluminum refinery and production plants.

Like molybdenum, gold, tin, and iron, bauxite is a strategic (and therefore critical) mineral whose demand will grow as global development increases. However, as it is not closely linked to any specific green industry or sole technology, its growth shall be more constant and less volatile.



Map[11] 6 - Bauxite Production

g) Gold

Gold is a precious metal used for thousands of years as currency, jewelry, and a symbol of wealth and power in various cultures throughout history. Even today, gold is considered a safe investment and used to manufacture jewelry and valuable objects.

In addition to its primary use for jewelry (54%), gold is also used as a store of wealth (20%), with some central banks keeping gold reserves as a backup for their currencies and economic stability.

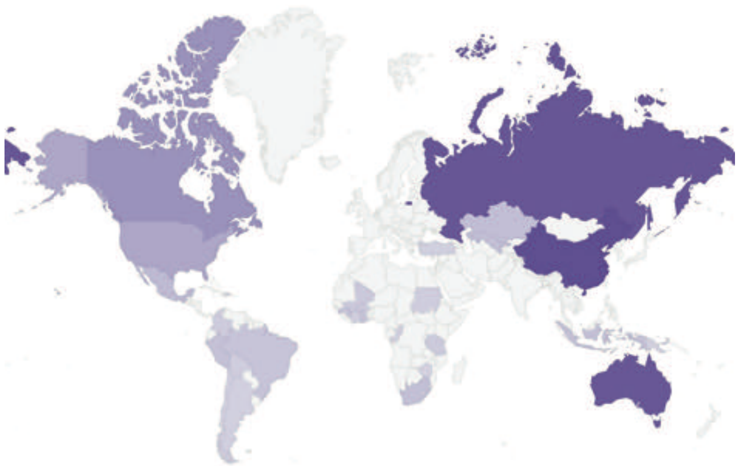
Lastly, it is also used as a central mineral to manufacture electronic components (11%) since its physical qualities as an excellent conductor make it highly important, and the remaining 15% is used in aeronautical, dentistry, and medicinal applications, as well as in other industries.

MAIN USES (%)	
Jewelry	54%
Store of wealth	20%
Electronic components	11%
Others	15%
Total	**100%**

Table 4 - Estimates compiled by author based on annual averages

Gold mining in Latin America is an economic activity of great relevance in several countries, such as Peru, Mexico, Brazil, Chile, Colombia, and Argentina. Gold mining is versatile since gold can be found as nuggets or veins in underground and alluvial deposits, and it may be extracted through various techniques ranging from large-scale mining, using heavy machinery and advanced technology, to artisanal and small-scale mining, using more straightforward, less efficient methods and employing a large number of people.

11.- Mining production maps and reports were drafted for copper, lithium, silver, molybdenum, nickel, bauxite, gold, tin, zinc and iron, based on mining reports published by the LAC countries and with contributions from the World Mineral Production 2017 to 2021 prepared by the British Geological Survey (BGS), and the Mineral Commodity Summaries (2023) published by the United States Geological Survey (USGS) for the countries of Europe, Asia, Africa and Oceania.

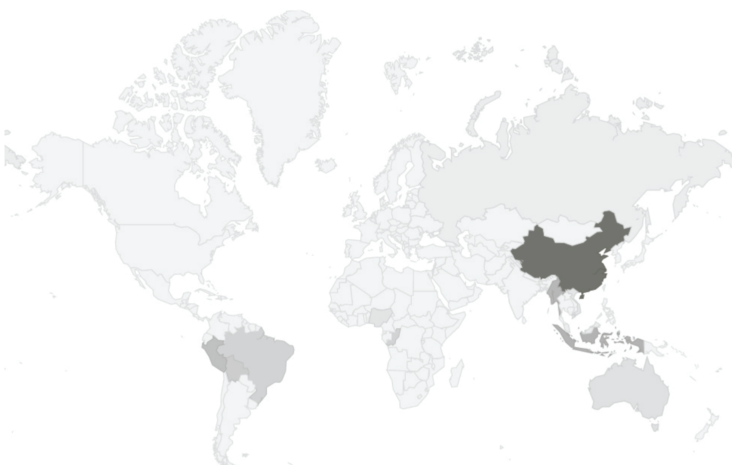


Map 7 - Gold Production

A significant issue with gold mining is that its extraction also entails critical political and, above all, socio-environmental challenges, with latent risks such as soil and water degradation, deforestation, mercury pollution, and other risks associated with social conflicts and tensions caused by the forced relocation of local communities or unwanted migrations due to the emergence of illegal extractive activities.

h) Tin

Tin is a transition metal (not to be confused with minerals critical for the energy transition) found in nature in various forms, with cassiterite (tin oxide, SnO_2) being exploited for tin extraction.



Map 8 - Tin Production

This metal has been known since ancient times and has been widely used to manufacture goods and alloys, such as bronze. Tin is commonly used in alloys (bronze), for galvanization (tinplate), and, given its low melting point, as a metal for welding in multiple applications (industrial or electronic). Tin and lead alloys bind metals in applications such as electronics and plumbing.

APPLICATIONS (%)	
Welding alloys	54%
Chemical industry	15%
Galvanization (tinplate)	15%
Others	10%
Bronze	6%

Table 5 - Main Applications of Tin

(Compiled by author based on annual averages)

Finally, tin is also used in the chemical industry to manufacture pigments for paints, ceramic enamels, and catalysts.

Growing demand for tin, iron, gold, or aluminum will correlate more with socio-economic development than with any specific technology.

i) Zinc

Zinc has an ample variety of industrial and biological applications. It has corrosion resistance properties and is used chiefly in galvanization to protect other metals from corrosion. It is also used in alloys to make brass (with copper) and castings in the chemical industry, and it is also beginning to be used in batteries. It has other uses, both in the medical and the aerospace industry.

APPLICATIONS (%)	
Galvanization	50%
Brass	17%
Smelting	16%
Others	15%
Chemical industry	6%

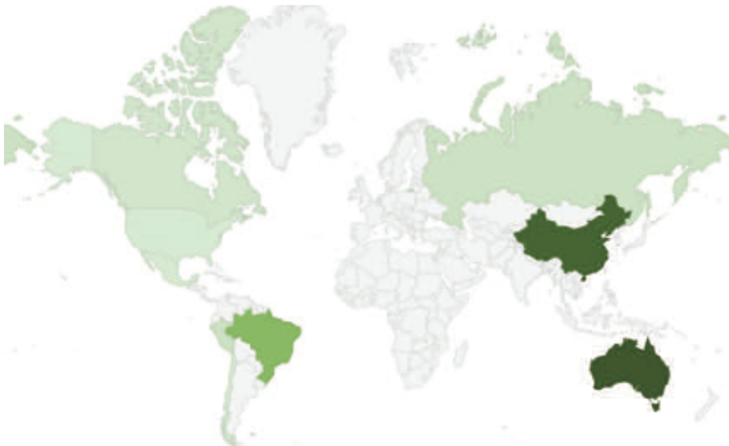
Table 6 - Main applications of tin

Map 9 - Zinc Production

j) Iron

Iron is one of the most abundant elements on Earth and is found in minerals such as hematite, magnetite, and siderite. The knowledge about and use of iron date back to prehistoric times, with evidence of wrought iron objects dating back to around 2000 BC. It is a transition metal with physical properties such as malleability, electrical conductivity, and ferromagnetism. Iron is used in steel manufacturing, which is essential in the construction and automotive industries, and it is also used in many other industrial applications.

World production averages around 3 billion tons, with China being the largest producer, followed by Australia, Brazil, India and Russia.



Map 10 - Iron Production

k) Rare Earth Elements

Rare earth elements, also known as lanthanides, are a group of chemical elements with unique properties. There are 17 rare earth elements in total, including scandium, yttrium[12] and the 15 elements of the lanthanides group (lanthanum, cerium, praseodymium, neodymium, promethium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium and lutetium).

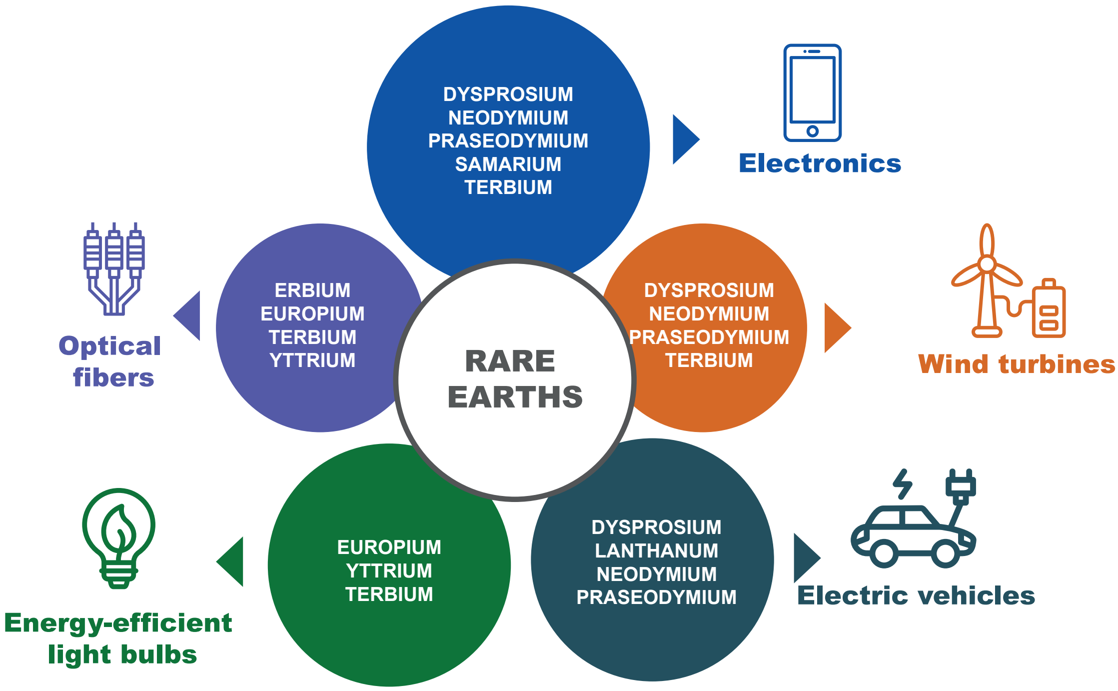


Figure 9 – Main Uses of Rare Earth Elements (compiled by author)

In LAC, Chile and Brazil are moving forward with prospecting studies of some of these elements.

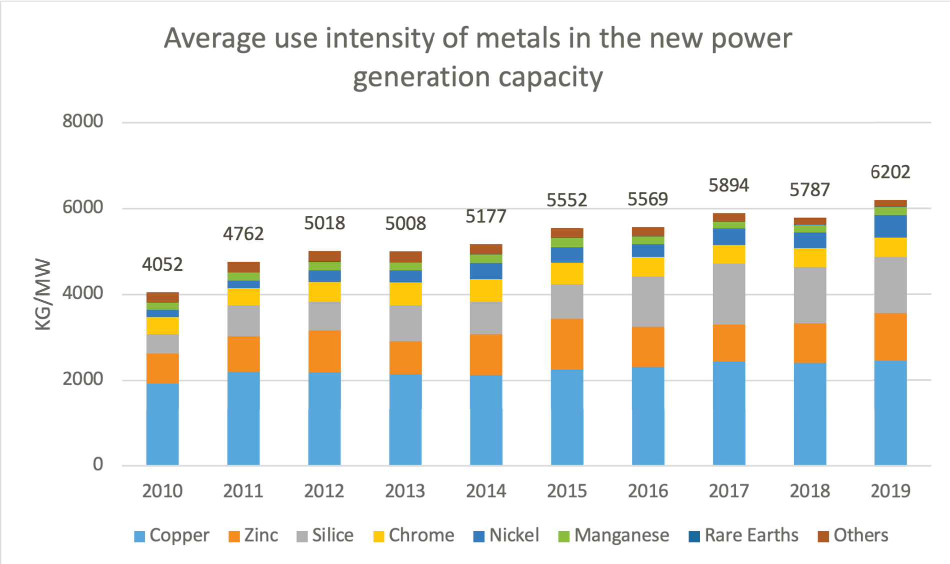
l) Other critical minerals

The list of critical minerals expands, including cobalt, chromium, manganese, and graphite. It is possible to get more details in the documents listed in the bibliography.

12.- Scandium and yttrium are included among rare earths because they appear frequently mixed with lanthanides in the same deposits.

2. Electricity generation

Critical minerals are essential to energy transitions, with ample diversified uses, including manufacturing generation equipment for all technologies and storage equipment for power applications or sustainable mobility.



Graph 4 – Average Intensity in the New Generation Capacity (based on IEA)
Source: Compiled by author based on IEA data

Implementing new, clean, sustainable technologies is an undisputed pillar of energy transitions. However, as can be analyzed in the previous graph, this renewable growth brings about a greater need for critical minerals measured by the total installed capacity (kg/MW)[13]. Between 2010 and 2019, the need for minerals increased by over 50%.

For example, among the elements called rare earths, neodymium and praseodymium are indispensable for the production of permanent magnets used in wind turbines and high-efficiency electric motors. This work has delved into implementing these elements for mining, which is of the utmost importance for Brazil.

Several chemical alternatives for the design of electric batteries are under development. Lithium is a critical component for most alternatives. Cobalt is also used in lithium-ion batteries and is a crucial element of power electronics.

In the field of solar energy, silicon is the primary material used in photovoltaic cells of solar panels that convert sunlight into electricity. Furthermore, other minerals, such as tellurium and indium, are used in thin-film solar cells.

The demand for critical minerals also extends to the electronics industry, where rare earths, such as cerium and europium, are essential for various devices and components. Graphite, the raw material for making graphene, is a carbon composite material and is being researched to improve the efficiency and capacity of batteries, making it a mineral with a potentially significant impact on power generation.

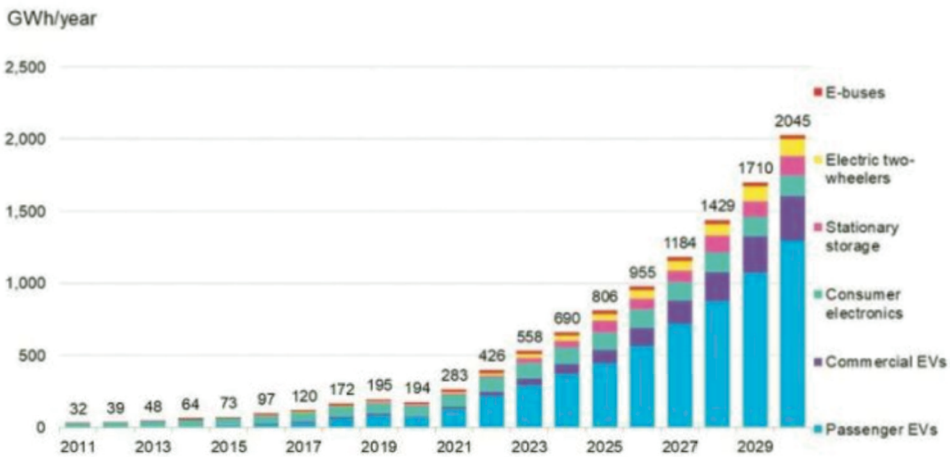
Given the growth of renewable energies, copper has also gained an even more vital role. To a large extent, wind turbines used to generate wind power rely on copper cables and components to transmit the power generated by the blades to the transformers and, eventually, to the grid. Moreover,

13.- Ashby M. (2013) – Material and the Environment copper also plays a crucial role in photovoltaic plants, where it is used in the electrical connections of solar panels to guarantee the efficient transfer of energy captured from the sun.

3. Electric Vehicles // E-Mobility // Batteries

In addition to lithium, copper is essential in energy storage technologies. Lithium-ion batteries, widely used to store energy in backup systems and electric vehicles, use copper in their electrodes and connections. The conductivity and durability of copper help improve these batteries' efficiency and shelf life, which is crucial for grid stability.

Multiple batteries that use nickel, cadmium, and even tin are being developed. We will only reach a more accurate projection once one of these technologies (including lithium batteries) comes on top.



Graph 5 - Growth Projection for E-Mobility (Source: Bloomberg NEF)

4. Electrification

When we mention electrification, we mainly refer to copper. Copper is one of the oldest known metals and has been used for thousands of years. The first signs of its use date back to around 9000 BC in what is now the Middle East. Throughout history, diverse cultures have taken advantage of the unique properties of copper to manufacture tools, utensils, and jewelry. In ancient Egypt, copper was widely used to manufacture ornaments, jewelry, and tools, and it was one of the first metals to be worked and used in metallurgy.

Today, this reddish metal is vital for developing modern power generation and electrification. Its superb electrical conductivity makes it an irreplaceable material for electrical infrastructures and various energy transmission and distribution technologies due to its high electrical conductivity and ability to transport electric currents with low resistance.

C. Mining Production

1. Context

As of 2022, the global GDP amounted to $103 trillion, a quarter of which corresponds to the GDP of the United States and 50% of which is contributed by the three leading global powers. LAC has an area of about 20 million km2, representing 13% of the world's surface and 8% of the world's population and contributing only 6% of the world's GDP (according to IMF projections for 2023.) Mining is a critical primary activity for sustainable development, and this region has great potential to grow and develop this industry. It is necessary to understand which diverse axes would allow the region to grow, and mining is one of the tools available here.

According to the IDB, almost 4% of Latin America and the Caribbean's gross domestic product (GDP) comes from the extractive sector, a figure equivalent to the value generated by agriculture. This sector is expected to grow even more in the near future since the energy transition will only be possible with an increased availability of many more minerals, especially copper and lithium.
First, before discussing details on the production of each mineral, we must know the orders of magnitude for the world's metal mining production to understand market dynamics and the current importance of each mineral. This first table does not represent the production in a particular year or contemplate dissimilar projections depending on the selected mineral. Still, it is advantageous to appreciate the quantities produced.

Mineral	Production (ton)
Iron	3,000,000,000
Bauxite	350,000,000
Copper	25,000,000
Nickel	2,500,000
Lithium	150,000
Silver	25,000
Gold	3,000
Indium	900

Table 7 – Orders of Magnitude for Metal Mining

(Compiled based on statistical averages)

Chile, Brazil, Mexico, Peru, and Bolivia are the main countries producing and exporting critical minerals in Latin America and the Caribbean. This is also a relevant activity in Colombia and Argentina, yet, in Colombia, coal production is more relevant, as is the production of hydrocarbons in both cases.

The following table represents the world's leading producers of these ten minerals.

	WORLD PRODUCERS		
MINERALS	FIRST	SECOND	THIRD
Copper	Chile	Peru	China
Lithium	Australia	China	Chile
Silver	Mexico	China	Peru
Molybdenum	China	Chile	USA
Nickel	Indonesia	Philippines	Russia
Bauxite	Australia	Guinea	China
Gold	China	Russia	Australia
Tin	China	Peru	Congo
Zinc	China	Peru	Australia
Iron	Australia	China	Brazil

Table 8 - Main Producing Countries (Source: USGS)

For each of these ten minerals, the top 3 worldwide producers were listed based on the 2022 production data, as were the leading LAC producers.

		MAIN LAC PRODUCERS			
MINERAL	LAC RESERVES (%)	1st	2nd	3rd	OTHERS
Copper	38%	Chile	Peru	Mexico	BR, PN, AR
Lithium	52%	Chile	Argentina	Brazil	BO
Silver	39%	Mexico	Peru	Chile	BO, AR
Molybdenum	38%	Chile	Peru	Mexico	
Nickel	17%	Brazil	Guatemala	Cuba	CO, DR
Bauxite	15%	Brazil	Jamaica	Guyana	VE, CO
Gold	14%	Mexico	Peru	Brazil	CO, BO, AR, CH, DR
Tin	20%	Peru	Bolivia	Brazil	
Zinc	17%	Peru	Mexico	Bolivia	BR, HO, CH
Iron	20%	Brazil	Peru	Mexico	CH

Table 9 - LAC Production for the 10 Strategic Minerals

III. STRATEGIC MINERALS FOR LAC

A. Mineral Selection Methodology

With the first outlook on the production and demand of critical minerals for the upcoming decades available, the next step is to establish a methodology to prioritize the minerals that will be strategically contributing to the socio-economic and energy development of the region's countries. It is essential to devise criteria that help in this assessment and subsequent selection.

Out of all the factors one may use to analyze these minerals, we find those related to the growth of demand, markets, diversification or concentration of stakeholders, price volatility, etc. On the other hand, we find parameters related to the supply, the investment for exploration and exploitation, the increase in infrastructure that can be generated, and, above all, the availability of reserves and resources in terms of mineral concentration and quality.

This document proposes using four selection criteria, each connected to an aspect to consider when assessing a significant investment such as the exploitation of a deposit:

- Criticality: Number of criticality lists that include this mineral
- Markets: Current mining volume (traded volume and price)
- Mineral production in the region
- Mineral reserves in the region

This first approach does not pose a more complex criterion, including the ecosystem necessary to shift from resources to reserves and reserves to production. However, this is a crucial criterion to assess in the future.

We propose a simple scale from 1 to 5 to assess and weigh each criterion:

Very high	5 points
High	4 points
Medium	3 points
Low	2 points
Very low	1 point

Table 10 - Assessment criteria

While this assessment is conducted comprehensively for the region, some minerals will likely be more or less strategic for some countries due to their specific production or reserves; market and demand criteria are identical for all countries.

The appendices include the entire methodology and the assessment with all four criteria.

B. Assessment conclusions

Finally, having assessed all four criteria and obtained an average, the critical minerals classification for LAC is as follows:

	MINERALS	SCORE	LAC PRODUCTION	LAC RESERVES	CRITICALITY	MARKETS
1	Copper	4.8	5	5	4	5
2	Lithium	4.5	5	5	5	3
3	Silver	4.5	5	5	4	4
4	Molybdenum	4.0	5	5	4	2
5	Nickel	3.8	3	3	5	4
6	Bauxite	3.5	3	3	4	4
7	Gold	3.5	3	5	1	5
8	Tin	3.5	4	6	2	2
9	Zinc	3.3	4	3	2	4
10	Iron	3.0	3	3	1	5
11	Graphite	3.0	3	4	4	1
12	Manganese	3.0	1	3	4	4
13	Lead	3.0	3	5	1	3
14	Cobalt	2.5	1	1	5	3
15	Chromium	2.3	1	1	4	3
16	Indium	2.3	2	1	5	1
17	REE	1.5	1	1	2	2

Table 11 – Conclusion of the Strategic Minerals Assessment for LAC

To continue with the analysis and road map, we propose limiting the number of strategic minerals for the region to 10.

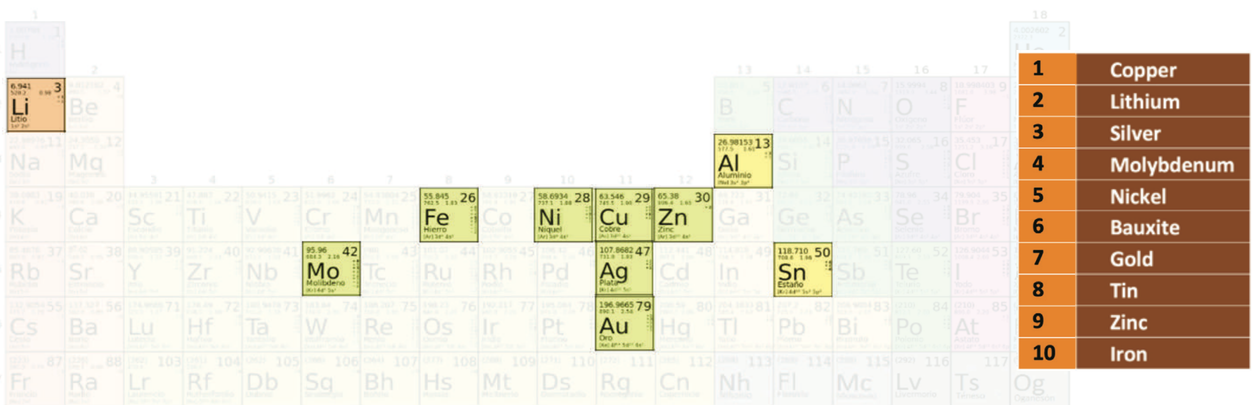


Figure 10 – Location of Strategic Minerals in Mendeleyev's Table

In Mendeleyev's periodic table, to the left, we find lithium, a lightweight alkali metal; then, we see the metallic minerals; and, lastly, to the right, we see the group of transition minerals, such as aluminum[14] and tin.

14.- Aluminum is included since bauxite is not a periodic table element. Instead, it is made up of aluminum oxide Al3O2, which is refined to obtain alumina and then, by electrolysis, aluminum since, unlike gold or silver, for example, aluminum is never found in its pure state due to its high degree of reactivity.

1. Production Analysis

The following table compares strategic mineral production for LAC and five major producer/ consumer markets: China, Russia, the USA, Canada, and Australia. This comparison allows us to know how concentrated production and consumption are.

	MINERALS	Worldwide	LAC		BIG 5 (China, Russia, Canada, USA, Australia)		LAC Reserves (%)
1	Copper	20,600,000	45%	9,190,778	21%	4,387,230	38%
2	Lithium	100,000	29%	28,700	55%	54,900	61%
3	Silver	24,563,000	48%	11,820,395	24%	5,996,205	39%
4	Molybdenum	250,000	38%	96,218	58%	144,670	38%
5	Nickel	2,510,000	10%	253,562	18%	458,305	17%
6	Bauxite	368,000,000	11%	41,031,357	45%	165,643,249	15%
7	Gold	3,190,000	17%	545,757	33%	1,065,581	14%
8	Tin	278,000	19%	52,259	37%	102,581	20%
9	Zinc	11,500,000	23%	2,680,234	49%	5,604,401	17%
10	Iron	3,016,000,000	17%	521,662,000	62%	1,861,222,795	20%

Table 12 – Comparison of Mining Production (compiled based on USGS, 2021)

For copper, silver, and nickel, the production of LAC is above 45%, and the production of these five large markets together does not exceed 25%, which decidedly illustrates their criticality for these markets. The same applies to cobalt, platinum, or iridium, where the producers are the Democratic Republic of the Congo and South Africa.

MINERALS	Main World Producer	Participation
Copper	LAC	45%
Silver	LAC	48%
Nickel	Indonesia	49%
Cobalt	DR Congo	70%
Platinum	South Africa	74%
Iridium	South Africa	89%

Table 13 – Mining Concentration (compiled based on USGS, 2021)

For LAC, copper and silver (and, given its reserves, maybe lithium in the future) are minerals that allow the region to dominate without dealing with the tensions caused by monopolies, such as those faced by South Africa, Indonesia, or Congo, who concentrate a large share of the production.

THE GLOBAL GOALS

for sustainable development

IV. ROAD MAP

The energy transition is propelling the demand for several critical minerals, which, in several cases, will be highly intensive. Many of these minerals, such as nickel or silver, have diversified or unrelated energy markets. However, as the transition processes move forward in each country, the demand for many of these minerals will grow exponentially, and the consumption for the transition will be much more relevant.

A. Challenges

1. Global

The race for the supply of critical minerals by developed countries poses a core objective: to ensure the supply of critical minerals to priority industries in a responsible, sustainable, and economically viable manner without affecting the value chains of associated sectors downstream.
This global goal raises three questions or challenges that the mining sector and industry must solve to avoid affecting the decarbonization path being mapped out worldwide. The three challenges are combined, and it is vital to address them in coordination. The challenges revolve around availability, sustainability, and viability.

First, the need for resource availability introduced the race to explore new resources and optimize existing deposits. The aspects linked to sustainability are becoming more relevant every day as they ensure projects follow their ordinary course. Projects must first ensure that their emission levels do not overlook decarbonization efforts at the other end of the chain and then guarantee that the extraction is mindful of the environment and communities and makes responsible use of resources, such as water. Finally, this new mining we seek to achieve must be economically viable within current parameters to not drive up the price of products that depend on these minerals. We face the challenge of containing the fluctuations generated by the market due to a disproportionate increase in demand, which automatically increases the supply. An aspect of this challenge is that new deposits discovered may have lower concentrations or require more advanced, expensive extraction technologies, which would translate into higher extraction and production costs that then become the leading cause of a price increase.

The process must be carried out in line with the 17 Sustainable Development Goals (SDGs) to face this triple challenge posed by developed markets to ensure the availability, sustainability, and viability of the extraction of critical minerals.

In particular, and for the extractive sector, sustainability must be guaranteed, at least in the social, environmental, and economic fields.

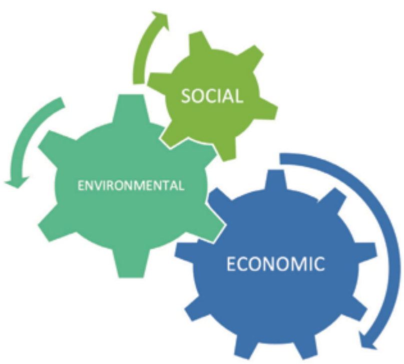


Figure 11 – Principles of Sustainability

Figure 12 – Sustainable Development Goals (SDGs)

Including the regulatory and legal dimensions encapsulating governance aspects is advisable to classify the challenges established below.

SOCIAL SUSTAINABILITY CHALLENGES

1. Ensure that mining is naturally assimilated into the territories and that communities are integrated into the value chain, thus avoiding potential displacements.
2. Prevent new mining projects from disproportionately increasing the cost of living, which leads to exclusion, poverty, and migration.
3. Guarantee that mining exploitation does not generate internal migrations with negative impacts on the local population, such as child labor, forced labor, prostitution, violence, or harassment against women.
4. Improve the safety of workers who often face poor working conditions and risks in mines (accidents, exposure to toxic chemicals, unstable mines.)

ENVIRONMENTAL SUSTAINABILITY CHALLENGES

1. Minimize the use of fossil fuels with a higher cost and more emissions, fostering the development of renewable energies that integrate sustainable electric energy.
2. Reduce emissions from critical mineral mining and pursue sustainable mining with a limited and controlled carbon footprint to avoid transferring emissions from one sector to another.
3. Ensure that mining is naturally integrated into the territory, promoting a positive legacy for nature, minimizing adverse impacts on biodiversity, and implementing the highest environmental standards in mining.
4. Care for natural resources such as drinking water and reduce water volumes in operations.

TECHNICAL-ECONOMIC SUSTAINABILITY CHALLENGES

1. Improve access to financing for the mining activity. Promote an understanding of the sector and the presence of local banks to mitigate the lack of funding for SMEs.
2. Connect mining areas with the main export corridors to facilitate the integration of mining. Develop accesses and routes.
3. Develop mining areas with services and infrastructure to generate short- and long-term opportunities.

GOVERNANCE CHALLENGES

1. Reduce administrative delays for environmental clearances and permits.
2. Minimize waste from the extraction and refining activity.
3. Ensure the fair redistribution of mineral royalty revenues to support socio-economic and industrial growth.
4. Avoid a rise in corruption in countries with significant reserves and promote regional transparency in both the public and private sectors.

These challenges for mining add to the structural challenges of the region, where mining is not the main issue but can help mitigate them. This study does not seek to provide a full assessment of the region but rather to highlight the main challenges that may be related to mining.

LAC faces structural challenges that the development of strategic mining may help mitigate, challenges for the metal mining activity that impact the development of strategic minerals, and intrinsic challenges inherent to the development of strategic minerals.

Our region has suffered decades of low economic growth, making tax revenues insufficient to compensate for this economic dynamic and address our urgent social issues. Poverty and inequality are the most explicit expressions of the situation that Latin America and the Caribbean are experiencing, a problem that the pandemic and the global energy crisis have accentuated.

The region remains among the most unequal in the world regarding income distribution and access to opportunities. Reducing economic and social inequality remains a significant challenge. Pursuing sustainable economic growth is essential to reducing poverty and promoting regional financial stability.

B. Actions & Recommendations

To tackle these challenges, below is a series of proposals for the Development of Strategic Minerals in Latin America and the Caribbean (ProDMELAC, by its Spanish acronym), which may be applied in their entirety, partially, and following different criteria depending on each country's context and level of development. This first list is proposed as a guide to creating a development strategy for strategic minerals.

The actions were grouped into five thematic axes. The first focuses on the facets of SOCIO-ENVIRONMENTAL SUSTAINABILITY, where aspects such as communication, dialog, green mining, and recycling are central. The second is established around ENERGY TRANSITIONS linked to renewable energies and powershoring, infrastructure proposals necessary for mining development, and associated productive chains. The third work axis is connected to the RECONFIGURATION OF THE STATE, where efforts are proposed to accelerate the modernization of the State and its regulatory frameworks and increase transparency and understanding about the subsoil. The fourth axis is structured around ECONOMIC and FINANCIAL RECOVERY, the fiscal reality of each country, and the feasibility and profitability of projects. Proposals from this group include access to financing, the need for investment, and coordination with the private sector. Finally, the fifth axis groups together proposals related to technical advances, TECHNOLOGY APPLIED to mining and research, and the actions directly associated with mining diversification, polymetallic mining, and value-added in the territory focused on refining in the territory in the future.

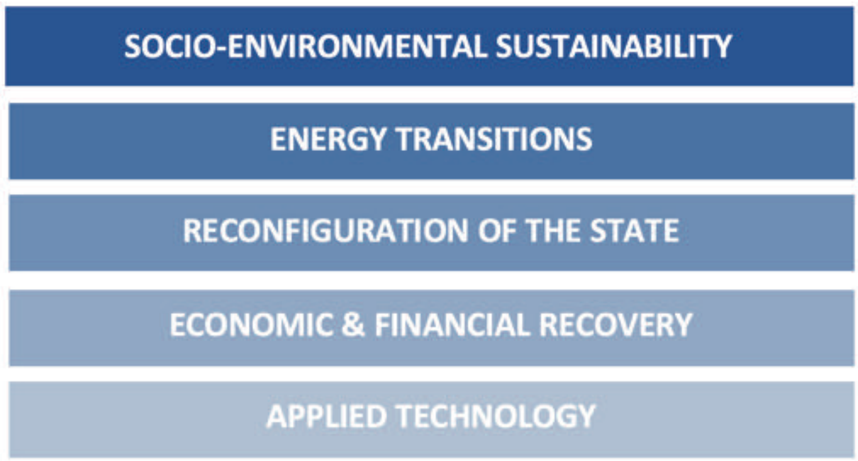


Figure 13 – Work Axes

It is paramount to understand that the proposed actions impact all areas, and it is impossible to connect them to only one aspect. Although this classification may be deemed artificial, it was made to identify an initial commonality between actions and, in the event of their application, to be able to group them based on the entity in charge of executing them.

1. Socio-Environmental Sustainability Action Plan

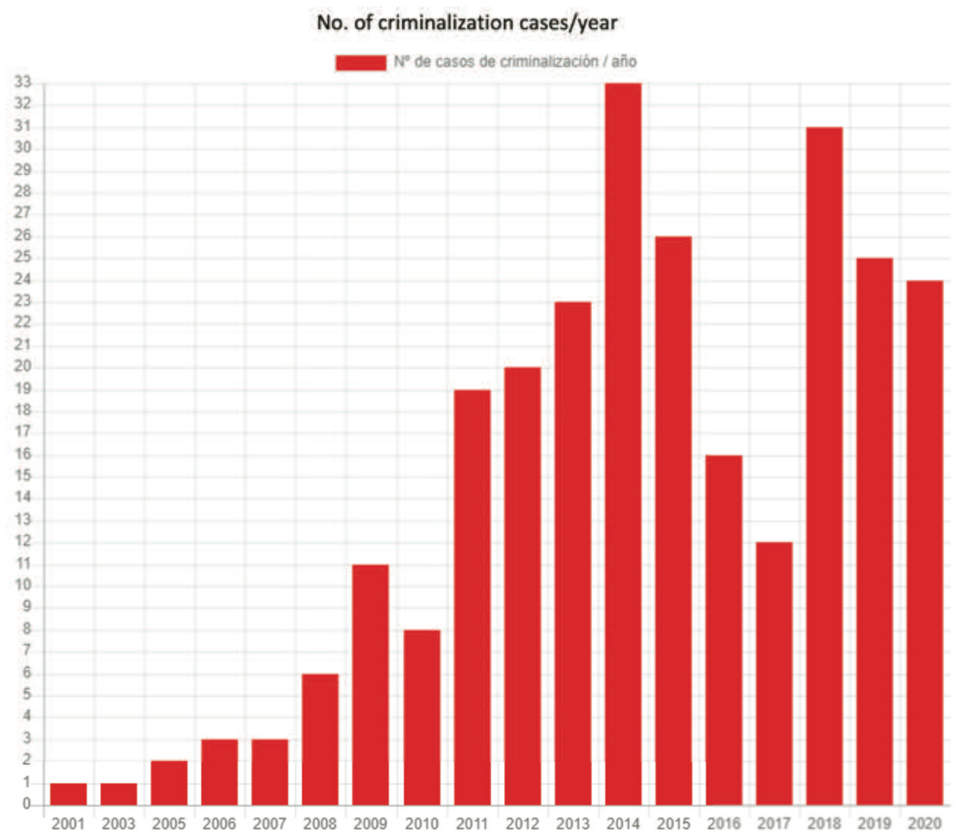
a) Communication and Dialog

Listening to diverse cultures, communicating, and establishing conversations is fundamental for the development of mining due to the potential impact this industry can have on the environment and society. Active listening is the first step, even before communicating, for it helps us understand the perspective of the local stakeholders from their cultures and their main concerns to build on communication and develop the means to make things happen.

Mining often triggers debates and controversies due to its history and inherent risks. Many countries have suffered spills, damages to the environment, left behind significant environmental liabilities, or caused ecological disasters due to mismanagement. Therefore, as negative impacts have existed in the past, any project seeking to obtain and maintain a social license today must pay close attention to preventing any incident of this nature.

Communication facilitates cooperation among all interested parties, including local communities, the government, mining companies, and environmental groups. Dialog is essential to prevent conflict and promote sustainable development by seeking equitable solutions. This dialog must begin early, almost simultaneously with the exploration, to lead the communities in every step of the project's life.

LAC is a region with significant levels of conflict caused by mining. According to the Observatory of Mining Conflicts of Latin America (OCMAL, by its Spanish acronym), over 280 conflicts have been recorded in the last two decades.



Graph 6 - Mining Conflicts in LAC

These conflicts are often related to environmental concerns, unequal distribution of benefits, absence of the state, lack of governance and transparency, competition for resources, and cultural and territorial issues.

Transparency and trust are fundamental pillars in this industry. Open and transparent communication among all stakeholders contributes to building and maintaining trust. It includes disseminating information about mining projects, their impacts and benefits, and mitigation and social responsibility plans. Transparency is vital for communities and society at large to trust mining management.

Dialog is essential to allow local communities and other groups to express their concerns about the negative impacts of mining. It can lead to the implementation of appropriate mitigation and compensation measures to address these problems and ensure a more sustainable development.

Constant communication among stakeholders can foster the adoption of best practices in the mining industry, which, in turn, contributes to reducing negative impacts and improving environmental and social management. It is vital to accompany civil society on its learning and internalization journey.

The long-term dialog can establish agreements and policies that benefit mining companies, local communities, and the government. It prevents impulsive decision-making and promotes strategic and sustainable planning. Civil society must always be an ally and promoter of projects, as happens with copper in several areas of Chile. Eventually, this fosters an environment free of social or political disturbances and opens the floor to efficient, transparent dialog and communication. This allows for building trust and attracting investments since investors often prefer countries with stable regulatory frameworks and a socio-environmental context conducive to investing.

Examples of round tables and spaces for planning and consensus-making have been held in the region recently. They can serve as a guide, such as the GDIAM[15] in Colombia, or the PEDMA[16] in Argentina. The discussion should revolve around how mining is conducted rather than whether the country should move forward with this activity. For this, promoting a broad, informed debate on mining and its impacts is necessary to achieve public consensus and develop balanced policies. Many energy studies and studies on academic research, such as those cited in this document, showcase future scenarios, models, and simulations with significant increases in mineral demand due to the integration of clean technologies that consume critical minerals intensively. This demand should be translated into similar increases in the exploration and exploitation sector to avoid bottlenecks and disruptions in the supply of minerals for industries. However, has the opinion of the private mining sector been requested with the same frequency and zeal with which new studies are created? One proposal to apply in LAC is understanding the interests of mining groups and project developers. In the round tables mentioned in the previous point, the participation of the private sector allows us to gauge the interest and measure to what extent projections made worldwide are accurate.

Along the same lines, these mining chambers from the countries in the region could create a workgroup or commission to articulate the advances in the sector, gather suggestions and recommendations for the public sector, and consolidate a vision for implementing the actions. Other countries have created critical mineral associations, so we could analyze the creation of a strategic mineral LAC alliance to share a common front.

15.- The Dialog Group on Mining in Colombia (GDIAM, by its Spanish acronym) is made up of people with diverse perspectives and interests around the use of mining resources in Colombia, who carry out an informed, respectful conversation from different perspectives and with a desire for public advocacy. It seeks to reach agreements on how mining contributes to the sustainable, inclusive development of the country and is geared towards caring for the country's ecological, ethnic, and cultural uniqueness, as well as for social inclusion, socio-economic development, and peacebuilding.

16.- The PEDMA is made up of national and provincial government agencies, civil society and religious organizations, scientific institutions, trade unions, businesses, and professionals and was established to bring together all voices in an open dialog to develop an inclusive, competitive, integrated and environmentally sustainable mining for the next 30 years.

b) Sustainable Mining

Mining extracts limited resources, consumes large amounts of energy in areas often facing energy poverty, and uses large amounts of water in areas with frequent natural water stress.

Green mining, also known as sustainable mining, responsible mining, or mining that generates sustainability, refers to the extraction of natural resources, such as minerals and metals, in a more sustainable way and with a lower environmental and social impact. It aims to balance the need to obtain these resources to meet the demands of society with the preservation of the environment and the well-being of local communities.

The main features of green mining include:

1.- Efficient use of resources: Green mining seeks to optimize the use of natural resources, minimizing water and energy consumption in the extraction and processing activities.

2.- Emission reduction: It seeks to minimize greenhouse gas emissions and other pollutants using cleaner, more efficient technologies.

3.- Reclamation of affected areas: After exploitation, restoration, and rehabilitation activities are carried out to return the land to its original state or turn it into a valuable space for the community.

4.- Compliance with social and labor standards: Green mining is committed to respecting the rights of workers and local communities, preventing labor exploitation, and ensuring safe working conditions, both in production and throughout the value chain.

5.- Promotion of the local economy: Green mining seeks to contribute to the economic development of the regions where it is carried out, promoting employment generation and investment in the community.

6.- The nature legacy, also known as Nature Positive, refers to the most suitable management of biodiversity and the care for the ecosystem and endemic species.

7.- Transparency and accountability: Green mining companies are often transparent in their operations and willing to take responsibility for any negative impact they may have on the environment or local communities.

In short, green mining seeks to be a more sustainable and responsible alternative to traditional mining practices to minimize adverse effects on the natural and social environment. The objective, then, is to analyze different approaches in the region's countries to implement these concepts in mining strategic minerals.

Water

As an example of the scale of water use, gold extraction requires about 1,000 liters per gram. However, water can be reused in these processes, which radically changes the equation. Water consumption for mining is one area where the region can still improve. In Argentina, mining consumes only 1% of the country's water, compared to agriculture, which consumes around 70% of water available worldwide.

Here, the private sector can also collaborate, implementing international standards that exceed the requirements established by the countries. Additionally, this strategic decision would allow the private sector to strengthen its connection to civil society and work on the axes of transparency. As is clear, the actions are not silos, but rather many of them are interconnected, and applying several simultaneous actions brings about a virtuous circle of economic and socio-environmental growth and development.

Emissions

According to Chile's government, in 2021, the recorded greenhouse gas (GHG) emissions amounted to 17,016 kt CO2 eq., 34% of which stemmed from copper extraction. These total emissions can be distributed in direct emissions, representing 37.1% and 62.9% of the total indirect emissions. This shows the importance of tracking the carbon footprint and focusing on all emissions, not just direct emissions.

Direct or scope 1 emissions are those produced by fuel combustion by the emitter. Indirect emissions include Scope 2 emissions generated by electricity consumed and purchased by the emitter. Scope 3 emissions come from the value chain of a mining company and are not under the company's control.

When studying what actions should be implemented to mitigate these emissions, attention should be focused on the electricity generation mix. The entire industry, including mining, reduces emissions by reducing thermal capacity and increasing renewable power. And this must once again be analyzed as an opportunity. Since mining is an energy-intensive activity and the global consensus is to reduce emissions, more mining requires more renewable power in the mixes of producing and exporting countries.

Other axes

on which sustainable mining is based and which this study will discuss further are social matters and matters related to soil use and restitution, production chains, and transparency.

c) Recycling

As a technique or system, recycling has been around for decades. However, scaling up this recycling is the primary issue. That said, one goal is to reach the highest possible recycling levels, yet that will only reduce rather than eliminate the need to continue investing in production.

Unlike other non-renewable resources such as hydrocarbons, whose use is irreversible since it entails combustion that also generates CO2, in most cases, the mineral industrialization and use processes keep the composition of minerals intact, do not generate CO2 during their operating life (but they do at recycling, refining, and manufacturing) and can be primarily recovered and reused in a new cycle by using a suitable recycling system.

The questions to be asked to design a recycling strategy for LAC are:

1. How much can be sustainably recycled in my region?
2. What role can recycling play in the recycling of each mineral?
3. What are the first steps to be implemented to recycle in the future?

As a circular concept, recycling must be established and materialized from the onset together with the design of the mining exploration and production project, for it is a critical component of resource reutilization and aligns with the sustainable objectives of green finance funds.

Highly recyclable minerals

Mineral	Recycling %
Copper	30%
Lithium	0%
Silver	> 20%
Molybdenum	NA
Nickel	NA
Bauxite	50% (aluminum in Europe)
Gold	5%
Tin	NA
Zinc	NA
Iron	40% (steel)

Table 14 - Current Recycling Rate

The World Bank estimates that over 3 billion tons of metals and minerals will be required by 2050 to meet the COP targets established in Paris. In addition to being a moral and ethical obligation of societies and industries, recycling remains a big business. In the United States alone, the price of scrap amounts to $32 billion.

The case of copper

As awareness of sustainability increases, copper stands out as a highly recyclable material, for it can be recycled limitlessly without losing its properties, and the copper obtained is of the same quality as that extracted and refined at the source. Copper recycling is the secondary source to obtain copper. It is a common and efficient practice that reduces the need to extract new resources and minimizes the environmental impact associated with mining.

According to the latest study by the ICA in 2023 and based on research by McKinzie, over the past 20 years, copper recycling remained, on average, close to 15%. Over the next 30 years, this value is estimated to rise to 23% and reach a maximum of 25%, representing up to 3 million tons of copper that we would not need to extract.

Recommendations

Apart from having the will to develop this activity in the short and medium term, several measures, together with technical and economic feasibility can help simplify this development. These measures exceed the mining sector but should still be mentioned in this report, as their implementation could have a direct impact on metal mining needs.

On the one hand, we must work on designing products and components. The design must ensure the recycling and recovery processes of the metals in the different elements. Maximizing material recovery in end-of-life products should be considered a priority for manufacturing new devices.

If specific standardized components were available and round tables or communication between manufacturers and recycling systems were implemented, we could optimize the recovery of metals. A significant difficulty lies in needing more knowledge and the absence of labeling and standardization.

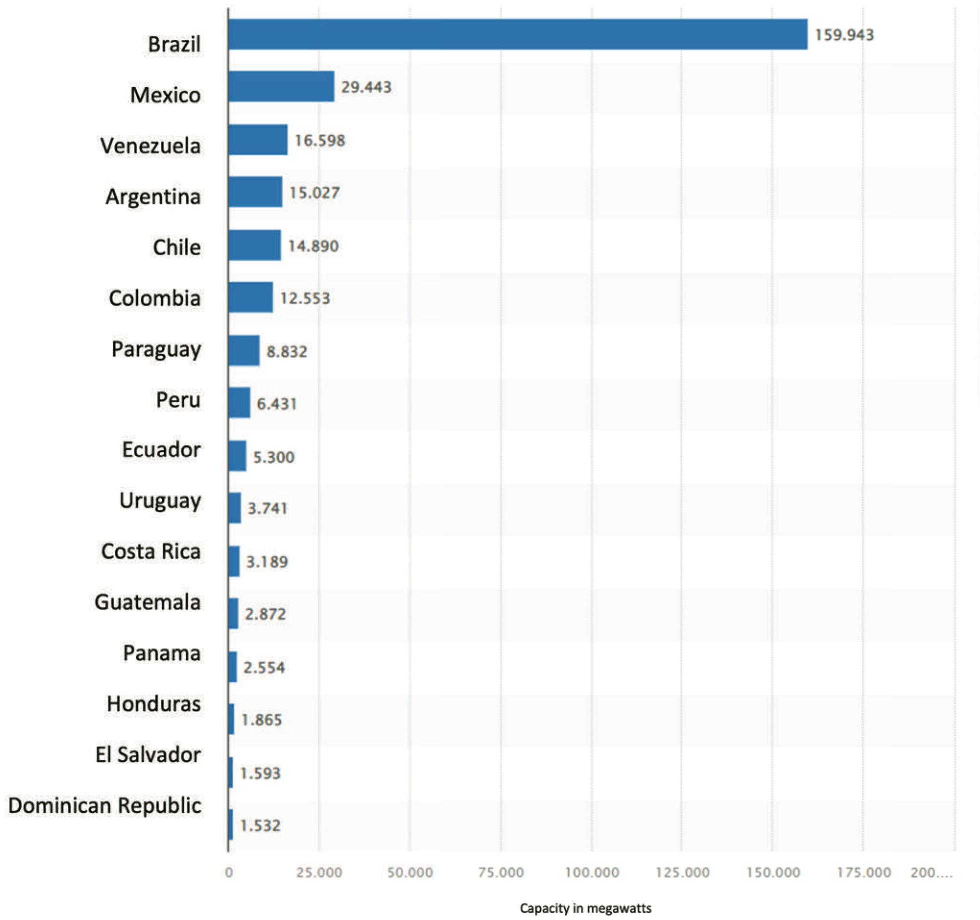
A percentage of compulsory recycling could also be applied, as was done by including a percentage of biofuel to cut emissions. As was mentioned, these measures far exceed the sector, yet the mining sector should support and promote them.

2. Action Plan for Energy Transitions

a) Energy & Powershoring

Sustainable, emission-free, clean, and competitive energy will be one of the differentiating factors when relocating energy-intensive industries. If a carbon tax system is put in place, industries in high-emission countries will suffer, as their products will be more hampered by this tax. On the other hand, countries with renewable electrical mixes shall have a great incentive to attract new industries.

However, this data without absolute values reflects only one aspect of our needs, so it is essential to understand how much energy this percentage represents and the margin available to include large users and considerable consumption. Therefore, it is critical to know the region's renewable energy value per country. Clearly, Brazil is leading by several lengths and followed by Mexico, with the top 5 being completed by Venezuela, Argentina, and Chile.



Graph 7 - Renewable Capacity Installed (including hydropower)

Lastly, we cross-referenced this table with the percentage of this renewable energy corresponding to hydropower, for although it is the renewable pillar upon which global mixes and, specifically, the LAC mix rest (with some exceptions in Central America), we should note that the climate events of the last decades have negatively affected hydropower technologies, changing water patterns and affecting the generation of electricity in several countries, risking the reliability of the electrical system.

China concentrates over 50% of the refining of the world's critical minerals and faces two significant challenges in the near future: reducing emissions from its plants and minimizing the risk of shortages for Europe and the USA, for they will double their efforts to avoid extreme dependence.

In this context, and given its clean energy and accessible prices, it becomes more likely for LAC to make steady progress in the productive chain across the region.

3. Action Plan for Updating the State

a) Modernizing the State

The matter of state regulations for the mining sector is broad and sensitive. This work does not intend to make a statement about the path countries must follow to improve the conditions necessary to develop this activity. Each country draws its action map in this area based on its convictions and on a case-by-case and mineral-by-mineral basis, where several of these minerals may be deemed indispensable for their development.
An example of this position is the case of the National Lithium Strategy in Chile, whose aim is to build wealth for the country by developing this key industry as a fundamental step to connect Chile's economic development to the shift towards a global green economy. This document does not seek to assess these strategies but to propose actions that, independent of public policies on mining activity, allow for optimizing this development.

Optimization in administration (one-stop-shop), promotion, oversight, and transparency are some of the essential pillars to attract investment and ensure responsible mining.

Dynamism in the state at all levels (national and regional) and in all stages allows for following up on investments and oversight commitments effectively, and, in addition, these new actions allow the state to build on trust across the territory. However, we must not fall into simplistic conclusions or magical solutions. Modernizing the State would help reduce deadlines for administrative procedures, integrate information, optimize oversight and revenue collection, and create an attractive investment environment. Yet more than this pillar alone will be needed to change the region's mining paradigm.

Especially with SMEs, the mining activity can be fostered by implementing development funds or creating a governing body that, apart from working together with the public sector and being present across the territory, can collaborate with the private sector to identify and establish productive connections, generating value at all stages of the mining process. The main goals are to provide training and education in the mining industry, use technical advice as an essential tool, strengthen business development, pursue sustained growth and financial inclusion in the sector, and provide the necessary financial support for their projects. Moreover, implementing a promotion scheme will substantially improve trade conditions and ensure the traceability of all legal transactions.

b) Resource Exploration

The geological understanding of the LAC subsoil still remains underdeveloped. Several geological services in the region aim to create a complete inventory of mineral resources available to understand their value and potential and plan a development strategy accordingly. By focusing this action on strategic minerals, we could prioritize the exploration and mapping of the following strategic minerals (H: High; M: Medium)

MEMBER	COPPER	LITHIUM	SILVER	MOLYBDENUM	NICKEL	GOLD	TIN	BAUXITE	ZINC	IRON	OTHERS
Argentina	H	H	M	M	H	M	M	M			
Barbados											
Belize											
Bolivia		H	H				H		H		
Brazil	H	M			M		H	H	H	M	RARE EARTHS
Chile	H	H	M	H	M				M	M	
Colombia	H		M		H	H					
Costa Rica						H		M			
Cuba	H				H						COBALT
Ecuador	H		H			H					
El Salvador	M		H			H					
Grenada											
Guatemala			H		H		M		M		
Guyana						H		H			
Haiti	M										
Honduras			H			H			H		
Jamaica								H			
Mexico	H		H						H	M	
Nicaragua	M		H			H					
Panama	M		M			H					
Paraguay										H	
Peru	H		H				H		H	M	
Dominican Rep.					H	H		H			
Suriname						H		H			
Trinidad and Tobago											
Uruguay										M	
Venezuela							M	H		H	

Table 15 - Exploration and Mapping of Strategic Minerals – Compiled by Author

4. Action Plan for Economic & Financial Recovery

a) Investments & Access to Financing

Focusing on large mining projects or larger mines is a strategy that seeks to maximize economic impact and efficiently leverage the resources available in the mining industry.

Given their scale and production, large mining projects have a more substantial economic impact than minor projects. These projects can significantly contribute to the GDP of the region's countries, generate jobs at a large scale, and provide substantial tax revenues through royalties and other tariffs. It is clear that large-scale mining projects can take advantage of economies of scale, which means that costs per unit of production tend to be lower. This translates into greater operational efficiency and, ultimately, the opportunity to attain more significant economic benefits.

When large-scale projects are implemented in the region, part of the resources are enforced in the project's impact area (depending on the rules of each country.) Large mining projects often require substantial investments in infrastructure, such as roads, railways, ports, and energy. These investments can drive the development of basic infrastructure in remote areas and benefit other industries and communities.

Investment is crucial to the development of the mining industry and is a constant priority, for it is the engine that drives the sector's economic growth and genuine employment generation.

5. Action Plan for Applied Technology

Research, development, innovation, and technology transfer in the mining industry are key factors in boosting its growth.

a) Research and Technology

Research, development, innovation, and technology transfer in the mining industry are key factors in boosting its growth. Another pillar to explore is the promotion of funds for piloting innovative solutions to reduce costs and integrate knowledge and value in the supply chain.

b) Polymetallic Mining

Polymetallic mining is mining that, rather than producing one mineral, taps into polymetallic deposits and is forced to exploit two or more minerals simultaneously to make the project profitable. In some cases, it also creates new opportunities to reuse tailings.

Given the constant growth in demand and rising prices, countries should consider the possibility of maximizing the extraction of by-products in polymetallic mining. Indium, a critical mineral in most lists, is primarily produced as a by-product of zinc mining. Silver is generally mined as a by-product of other metals, like gold or copper.

Main Mineral	By-product
Copper	Molybdenum
Zinc	Indium
Bauxite	Gallium
Nickel	Cobalt

Table 16 - Examples of By-Products in Mining

Polymetallic mining is more complex and has higher extraction and processing costs than regular mining. It also requires additional investments in specialized technology and equipment and can create a risk of cross-contamination. Finally, waste and waste management is more complex.

However, a mine with multiple minerals is more resilient to fluctuations in metal prices. Polymetallic mining generates more stable and diverse revenues, extracting several valuable minerals rather than relying exclusively on one. This helps mitigate the risks associated with metal price volatility. Extracting multiple minerals from one deposit also maximizes the efficient use of available geological resources. At a time when minerals represent one of the most critical points for the development of transition technologies, it offers the valuable possibility of optimizing deposits.

The following diagram developed by Nasar (2015) introduces the relationship between main minerals and their by-products, reinforcing the previously discussed point and the importance of diversifying and optimizing production and obtaining diverse minerals.

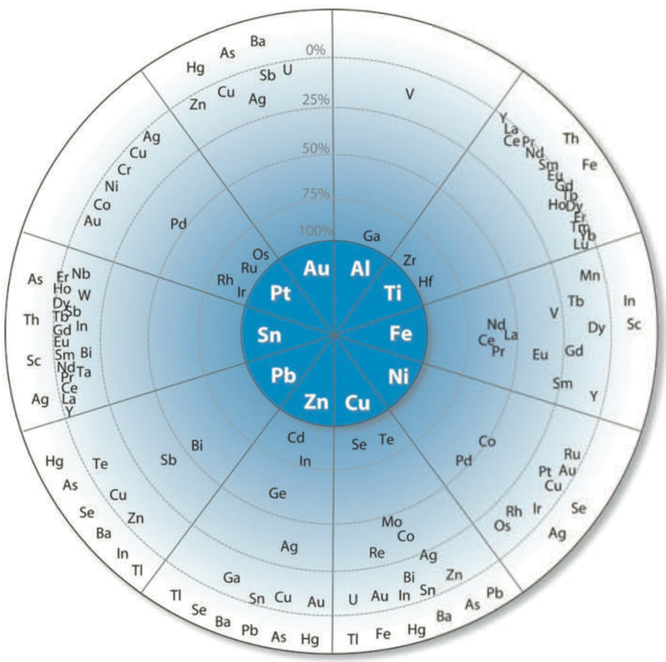


Figure 14 – Relationship between Minerals and By-Products

(Source: Nedal Nassar 2015 - By-product metals are technologically essential but have problematic supply)

The main minerals are shown in the inner circle. By-products appear in the outer circle at distances proportional to the percentage of their primary production. By-products in the white region of the outer circle are metals for which a production percentage has not been determined.

C. Next Steps

The first step is always to identify the problem, reach a diagnosis, and build a road map. Those are our first tools. Nevertheless, if they are not progressively and suitably implemented based on each country and context, they are but tools locked in a box.

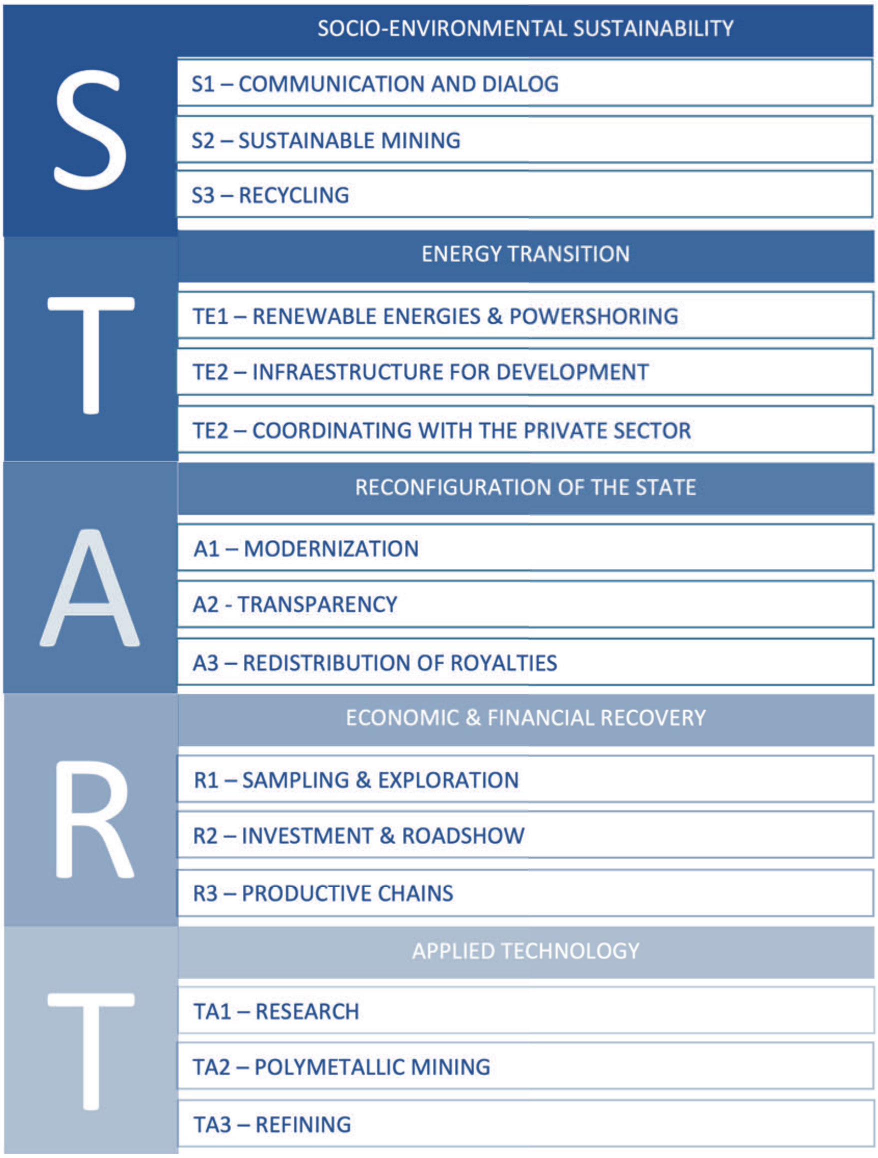


Figure 15 – Actions and Recommendations

It is pivotal to leverage the change the energy sector is undergoing as it evolves towards sustainability in almost every plan and experiences a growing demand for strategic minerals to be able to adapt to the proposals discussed in this document. This implementation would allow the region's countries to capitalize on this opportunity and launch a program that must be adjusted based on the context and resources of each country and the current situation the region and each member state is facing.

Finally, while no single, isolated extractive or industrial activity can solve all growth and development issues or all the structural problems LAC faces, such as poverty, social inclusion, or redistribution of wealth, mining can help achieve this goal. A solid case for this is that, as previously explained, mining has resources, reserves, a track record and tradition, a current solid production, and growth projections for green technologies that bode well for this activity and confirm that mining will continue to be one of the main drivers of LAC economies, with even more momentum over the next decade.

GLOSSARY

Al: Aluminum
Ag: Silver
AR: Argentina
Au: Gold
LAC: Latin America and the Caribbean
IDB: Inter-American Development Bank
WB: World Bank
BR: Brazil
BO: Bolivia
CAPEX: Capital expenditure
ECLAC: Economic Commission for Latin America
CH: Chile
Co: Copper
CODELCO:
COCHILCO: Chilean Copper Commission
ESMAP: Energy Sector Management Assistance Program
REE: Rare earth elements
Fe: Iron
NCSRE: Non-conventional sources of renewable energy
GEC: Global Energy and Climate Model
IRENA: International Renewable Energy Agency
HVL: High-voltage line (132KV or higher)
Li: Lithium
Mb: Molybdenum
ME: Mexico
WEM: Wholesale Energy Market
MWe: Megawatts electric
NDC: Nationally Determined Contribution
Ni: Nickel
OG: Multilateral organizations (IDF, CAF, WB, JICA, among others)
OLADE: Latin American Energy Organization
UN: United Nations Organization
OPEX: Operating expense
PPA: Power Purchase Agreement
PRODMELAC: Proposals for the Development of Strategic Minerals in Latin America and the Caribbean
NIS: Interconnected system
ES: Energy Secretariat
Sn: Tin
START: 5 work axes that frame the development of strategic minerals in LAC. (1) Social and Environmental Sustainability, (2) Just Energy Transitions, (3) State Update and Modernization, (4) Economic and Financial Reactivation, (5) Applied Technology
IRR: Internal rate of return
Zn: Zinc

FIGURES

GRAPHS

MAPS

TABLES

BIBLIOGRAPHY

Below are some of the most relevant studies carried out to date that were used in the drafting of this document:

#	Título	Organización	Año	Idioma
1	Critical Material for Energy Transition: Lithium	IRENA	2023	Inglés
2	Critical Minerals Market Review	IEA	2023	Inglés
3	Critical Minerals Outlooks Comparison	IEF	2023	Inglés
4	Critical Minerals Potencial of Brazil	MME Brasil	2023	Inglés
5	Geopolitics of the Energy Transition - Critical Minerals	IRENA	2023	Inglés
6	Inflation Reduction Act - Impact Minerals Report USA	SPGlobal	2023	Inglés
7	Material and Resource Requirements for the Energy Transition	ETC	2023	Inglés
8	Mercado Oro	SE Argentina	2023	Español
9	Mineral Commodity Summaries	USGS	2023	Inglés
10	Minerales Críticos para la Transición Energética - Nota Conceptual	CEPAL	2023	Español
11	Minerales Estratégicos	IEEE	2023	Español
12	Reporte estadístico de la producción chilena de cobre	COCHILCO	2023	Español
13	Precios de los principales Minerales	SE Argentina	2023	Español
14	Raw Materials Critical for the green transition	OECD	2023	Inglés
15	Study on Economic implications of the energy transition (…)	GIZ	2023	Inglés
16	Wolrd Silver Survey	Silver Institute	2023	Inglés
17	Anuario de la minería de Chile	MM Chile	2022	Español
18	Apalancando el crecimiento de la demanda en minerales (…)	IDB	2022	Español
19	Cambios en la demanda de minerales - Cobre y Litio	CEPAL	2022	Español
20	Metales y Minerales Críticos para la Transición Energética	SE Argentina	2022	Español
21	Panorama energético de América Latina y el Caribe	OLADE	2022	Español
22	Cambios en la demanda de minerales - Cobre y Litio	CEPAL	2021	Español
23	Critical Materials for Energy Transition	IRENA	2021	Inglés
24	Minerales y Metales Críticos y Estratégicos	SEGEMAR	2021	Español
25	The Role of Critical Minerals in Clean Energy Transition	IEA	2021	Inglés
26	Intensidad de materiales en la transición energética de ALC	CEPAL	2020	Español
27	Minerals for Climate Action: The Mineral Intensity of the C.E.T.	WB	2020	Inglés
28	Raw materials demand for wind and solar pv technologies	EU	2020	Inglés
29	Requirements for Minerals and Metals	Giurco et al	2019	Inglés
30	Materials critical to the energy industry	BP	2014	Inglés

The most comprehensive studies with disaggregated data that best translated the global needs for critical minerals to address the energy transitions worldwide over the next 30 years are those carried out by the IEA, The Role of Critical Minerals in Clean Energy Transition, and their corresponding updates.

The depth with which these documents model scenarios and discuss mining requirements turns them into instrumental reference documents.

APPENDIX

Table: Uses and applications of major critical minerals

2022	Chemical industry	Renewable generation Electrification	Sustainable Mobility	Metallurgy (steel and alloys)	Monetary (mint)	Jewelry	Welding Galvanization	Electronics	Multisectoral Construction	Others
Copper		30%	5%	5%				10%	24%	26%
Lithium			56%							44%
Silver	30%	20%			20%	15%		10%		5%
Molybdenum				80%						20%
Nickel			5%	80%			10%			5%
Aluminum									100%	
Gold					20%	54%		11%		15%
Tin	15%			6%			69%			10%
Zinc	6%			24%			50%			15%
Iron				100%						

Table 17 – Applications of Strategic Minerals

Methodological Assessment

1. Criticality

The first criterion for prioritizing critical minerals is the frequency with which these minerals are considered critical by the different markets, at least according to the existing lists. This list was drafted based on the study carried out by the IEF and the Paine Institute[17] and considering the 35 most required minerals (it should be noted that one of the items corresponds to the group of Rare Earth Elements (REE), so as not to list all 17 elements that make up the group.)

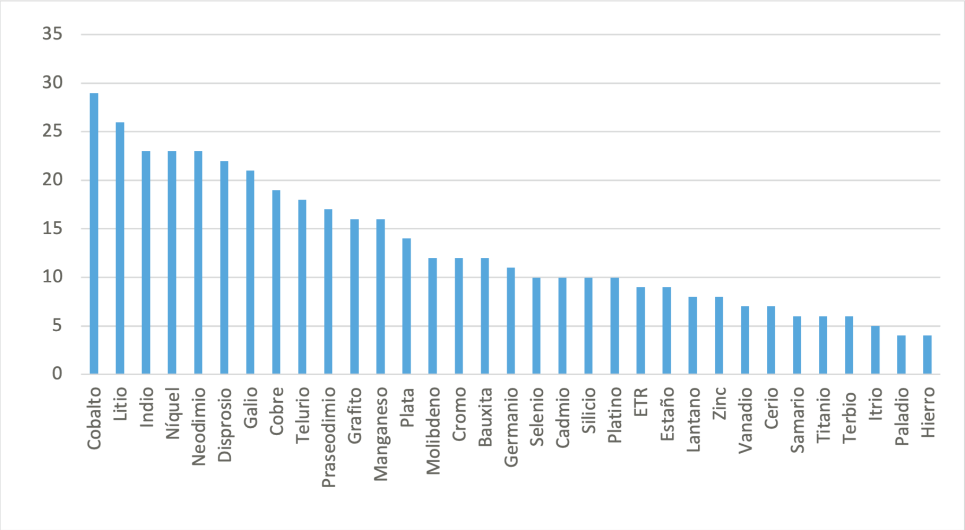


Table 18 - Minerals Listed as Critical

Taking a linear assessment criterion, minerals can be classified as follows based on their inclusion in lists:

ASSESSMENT	CRITERIA (Number of Lists)	SCORE
Very high	> 20	5
High	> 15	4
Medium	> 10	3
Low	> 5	2
Very low	< 5	1

This classification does not represent the need for these minerals but rather the difficulty in acquiring them, as was discussed in Chapter II. Thus, although central to the global metallurgical industry, iron and bauxite are only sometimes considered critical by most markets since their supply is not as critical as with REEs.

17.- Critical Minerals Outlook Comparison (IEF, Paine Institute – August 2023) https://www.ief.org/focus/ief-reports/critical-minerals-outlooks-comparison

Thus, this first criterion offers the following classification:

MINERAL	LISTS	ASSESSMENT	SCORE
COBALT	29	Very high	5
LITHIUM	26	Very high	5
INDIUM (REE)	23	Very high	5
NICKEL	23	Very high	5
NEODYMIUM (REE)	23	Very high	5
DYSPROSIUM (REE)	22	Very high	5
GALLIUM	21	Very high	5
COPPER	19	High	4
TELLURIUM	18	High	4
PRASEODYMIUM (REE)	17	High	4
GRAPHITE	16	High	4
MANGANESE	16	High	4
SILVER	14	Medium	3
MOLYBDENUM	12	Medium	3
CHROMIUM	12	Medium	3
BAUXITE	12	Medium	3
GERMANIUM	11	Medium	3
SELENIUM	10	Medium	3
CADMIUM	10	Medium	3
SILICON	10	Medium	3
PLATINUM	10	Medium	3
REE	9	Low	2
TIN	9	Low	2
LANTHANUM (REE)	8	Low	2
ZINC	8	Low	2
VANADIUM	7	Low	2
CERIUM (REE)	7	Low	2
SAMARIUM (REE)	6	Low	2
TITANIUM	6	Low	2
TERBIUM (REE)	6	Low	2
YTTRIUM (REE)	5	Very low	1
PALLADIUM	4	Very low	1
IRON	4	Very low	1
GOLD	3	Very low	1
LEAD	3	Very low	1

2. Production Assessment

Second, it measures the production of minerals produced by LAC and their corresponding share in the global mining market. In this case, the absolute extraction value is less relevant than its global relevance.

LAC produces 6% of global GDP[18], so mining production can be measured against that share to assess its impact on national economies, considering that today, the region is a producer and exporter of raw materials. The proposed linear criterion is as follows:

ASSESSMENT	CRITERIA (LAC v. World)	SCORE
Very high	> 25%	5
High	> 20%	4
Medium	> 10%	3
Low	> 5%	2
Very low	< 5%	1

Based on this criterion, and together with the production data obtained from the national reports and the British and North American geological services (BGS and USGS, respectively), the following table was prepared:

MINERAL	LAC PRODUCTION (thousands of tons)	WORLD PRODUCTION (thousands of tons)	LAC PARTICIPATION	ASSESSMENT	SCORE
Silver	12	25	47%	Very high	5
Copper	8,984	20,546	44%	Very high	5
Molybdenum	96	250	38%	Very high	5
Manganese	6,300	20,000	32%	Very high	5
Lithium	29	108	27%	Very high	5
Zinc	2,676	11,500	23%	High	4
Tin	62	278	22%	High	4
Iron	517,169	3,018,000	17%	Medium	3
Gold	1	3	17%	Medium	3
Lead	610	4,500	14%	Medium	3
Bauxite	41,031	368,000	11%	Medium	3
Nickel	254	2,510	10%	Medium	3
Graphite	96	1,000	10%	Medium	3
Indium	0.06	0.9	6%	Low	2
Cobalt	4	190	2%	Very low	1
Chromium	7	41,000	< 1%	Very low	1
REE	< 0.1	< 1	< 1%	Very low	1

NOTE: The following sources were used for these reports:

- Mineral Commodity Summaries – USGS 2023
- Anuario de la minería de Chile 2022 – SERNAGEOMIN 2023
- Metales y minerales críticos para la transición energética – SE Argentina 2022

18.- IMF 2023

3. Assessment of reserves

When assessing existing mining reserves in LAC, the same criterion applies to production since participation is considered more important than the absolute value of such reserves.

ASSESSMENT	CRITERIA (LAC v. World)	SCORE
Very high	> 25%	5
High	> 20%	4
Medium	> 10%	3
Low	> 5%	2
Very low	< 5%	1

Although assessments may be similar, results show slight differences, as shown in the table below:

MINERAL	LAC RESERVES (thousands of tons)	WORLD RESERVES (thousands of tons)	LAC PARTICIPATION	ASSESSMENT	SCORE
Lithium	10	17	61%	Very high	5
Copper	399,420	890,000	45%	Very high	5
Molybdenum	4,240	11,144	38%	Very high	5
Silver	190	550	34%	Very high	5
Gold	14	53	27%	Very high	5
Graphite	77,138	323,138	24%	High	4
Lead	12,500	54,100	23%	High	5
Tin	970	4,600	21%	High	6
Iron	16,200,000	85,000,000	19%	Medium	3
Manganese	275,440	1,490,440	18%	Medium	3
Nickel	16,010	87,680	18%	Medium	3
Zinc	36,000	210,000	17%	Medium	3
Bauxite	4,700,000	31,000,000	15%	Medium	3
Cobalt	5	7,000	< 1%	Very low	1
Chromium	1	560,000	< 1%	Very low	1
REE	N/A	N/A	< 1%	Very low	1
Indium	N/A	Not specified	< 1%	Very low	1

4. Market Assessment

Finally, having a criterion encompassing the turnover for each mineral was fundamental to understanding the weight of each mineral for metalliferous mining, where copper, iron, and gold together make up for over two-thirds of all metalliferous mining.

This document calculated market price values for ounces or tons (as appropriate) to estimate these values and multiplied the value by traded volume. Some publications show slightly different values, but the most critical aspect of this criterion was the order of magnitude, as it allows for comparing different market sizes.

MARKET (M$)	ASSESSMENT	Score
>100,000	Very high	5
>20,000	High	4
>10,000	Medium	3
>5,000	Low	2
<5,000	Very low	1

The regional market for critical minerals is around US$180 billion, which represents 25% of the global market[19]. The main minerals include copper (US$70 billion), iron ore (US$50 billion), gold (US$30 billion), and silver (US$10 billion). The assessment table was compiled using the main minerals produced by LAC and according to the following classification table.

MINERAL	MARKET (million US$)	ASSESSMENT	SCORE
Copper	180,802	Very important	5
Iron	181,080	Very important	5
Gold	162,032	Very important	5
Nickel	37,650	Important	4
Manganese	30,000	Important	4
Zinc	26,450	Important	4
Bauxite	22,080	Important	4
Silver	21,660	Important	4
Chromium	14,350	Medium	3
Lead	12,100	Medium	3
Cobalt	11,400	Medium	3
Lithium	11,000	Medium	3
Tin	6,950	Small	2
REE	6,000	Small	2
Molybdenum	5,960	Small	2
Graphite	5,000	Small	2
Indium	450	Very small	1
TOTAL	**734.964**		

19.- Estimating the production of Latin America and the Caribbean (ALC) for each mineral and using the percentage to calculate market share.

RISKS & CHALLENGES

In our region, mining faces multiple risks and challenges.
The following table was a brainstorming tool that helped build on the risks and challenges mentioned in this document.

IDENTIFIED RISKS	CHALLENGES
DISPLACED COMMUNITIES	Ensure that mining is naturally integrated into the territories without displacing communities, ecosystems or endangered species.
ACCESS TO FINANCING	Difficulty in accessing financing without surcharges in the region. Often, the issue is a need for more knowledge on the side of local banks. This also happens with SMEs.
CONTEXT AND DELAYS IN PROJECT LAUNCHS	Unfavorable context without access to energy in mining areas, where diesel driven by truck is used. Minimize the use of fossil fuels with a higher cost and more emissions, fostering the development of renewable energies that integrate sustainable electric energy. Connect mining areas with the main export corridors to facilitate the integration of mining. Develop accesses and routes.
	Develop mining areas with services and infrastructure to generate short- and long-term opportunities. Reduce administrative delays for environmental clearances and permits.
FISCAL RISK	Prevent variations in mineral markets from having a fiscal impact on budgets.
INVESTMENT RISK	Improve mining revenues to generate a chain effect and encourage exploration. Diversify mining to increase the types of minerals produced and mitigate risk.
ENVIRONMENTAL DETERIORATION RESOURCE CONTAMINATION	Prevent mining from generating adverse impacts on biodiversity and implement the highest environmental standards in mining. Care for natural resources such as drinking water and reduce water volumes in operations. Minimize waste from the extraction and refining activity.
POVERTY AND EXCLUSION UNEMPLOYMENT	Prevent new mining projects from disproportionately increasing the cost of living, thus leading to exclusion, poverty, and migration.
CORRUPTION	Reduce corruption levels in countries with large reserves.
UNCONTROLLED MIGRATION	Guarantee that mining exploitation does not generate internal migrations with negative impacts on the local population, such as child labor, forced labor, prostitution, violence, or harassment against women.
ACTIVITY SHUTDOWN	Prevent conflicts in the territory from shutting down the development of projects.
OCCUPATIONAL SAFETY	Improve the safety of workers who often face poor working conditions and risks in mines (accidents, exposure to toxic chemicals, unstable mines.)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