Lithium extraction and industrialization

Opportunities and challenges for Latin America and the Caribbean

June 2023

Introduction[1]

- Lithium is one of the key elements in the energy transition. Until now it has been an essential input in the production of lithium-ion batteries —a key technology for the decarbonization of transport and the storage of energy generated from renewable sources. Lithium is also considered a strategic resource by countries that have abundant lithium deposits. In Latin America, Argentina, Chile and the Plurinational State of Bolivia stand out for their deposits, forming the "lithium triangle", while Brazil, Mexico and Peru, with smaller deposits, also have the potential to produce significant amounts.
- The strategic nature of lithium stems from its potential to contribute to the countries' economic development. This resource can have a positive impact based on new value creation, in the form of increased output, exports, employment and tax revenues. However, various actors in the aforementioned countries have considered that its greatest potential lies in opportunities to develop productive and technological capacities associated with lithium, thus contributing to the process of structural change in resource-rich economies. From the perspective of governments, this requires policies and regulations that are conducive to the creation of public goods, the development of soft and hard capacities and infrastructures, and the mobilization and steering of the necessary resources.

[1] The cut-off date for the information used to prepare this report is 20 April 2023, unless otherwise indicated.

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This raises the need for a productive development agenda[2] centred on lithium, to promote its extraction for use in economic activities that are either directly or indirectly related to it.

- Nonetheless, these opportunities also pose challenges for the lithium mining activity itself, owing to the risks involved in demand projections and the launch of projects for its supply, and potential substitutes for the mineral or the technologies that use it in their components. They also raise problems for industrial activity, because of gaps in capacities for exploration and (upstream) production or (downstream) consumption to integrate into lithium value chains. Governments also face challenges related to the scope for improvement, both in the capture of economic rents from mineral exploitation and in the distribution and use of these finite rents for investment in other forms of capital. Above all, however, they face challenges in the supervision, monitoring and control of extractive activities, owing to their potential impacts on the environment and communities. As is the case with any extractive activity, lithium mining also exerts environmental and social pressure on the territories of extraction, affecting the sustainability of the ecosystems that exist there. In the case of lithium brine, this is manifested mainly in terms of water stress and the effects on biodiversity and traditional economic activities carried out by social groups living near the salt flats.
- This report provides a synthetic analysis of some of the key dimensions involved in analysing the opportunities and challenges posed for the region's lithium-rich countries. Chapter I, which follows this introduction, analyses the dynamics of the electromobility and lithium-ion battery industries. It describes some of the initiatives adopted by countries, in which lithium has become a critical input; and it shows how resource-rich countries in the region have responded by declaring lithium a strategic resource. Chapter II analyses the role of lithium-rich Latin American and Caribbean countries in the lithium-ion battery value chain. Chapter III examines several key dimensions of the lithium governance regimes in Argentina, Chile and the Plurinational State of Bolivia: the legal regimes that regulate lithium-related activity, the public agendas or policies for productive development to promote value-added, the regulations aimed at promoting environmental and social sustainability, and the tax systems applicable to mining activity. Lastly, chapter IV sets forth public policy guidelines to contribute to structural change based on the industrialization of strategic minerals (for the energy transition and electromobility), taking the analysis of lithium into account.

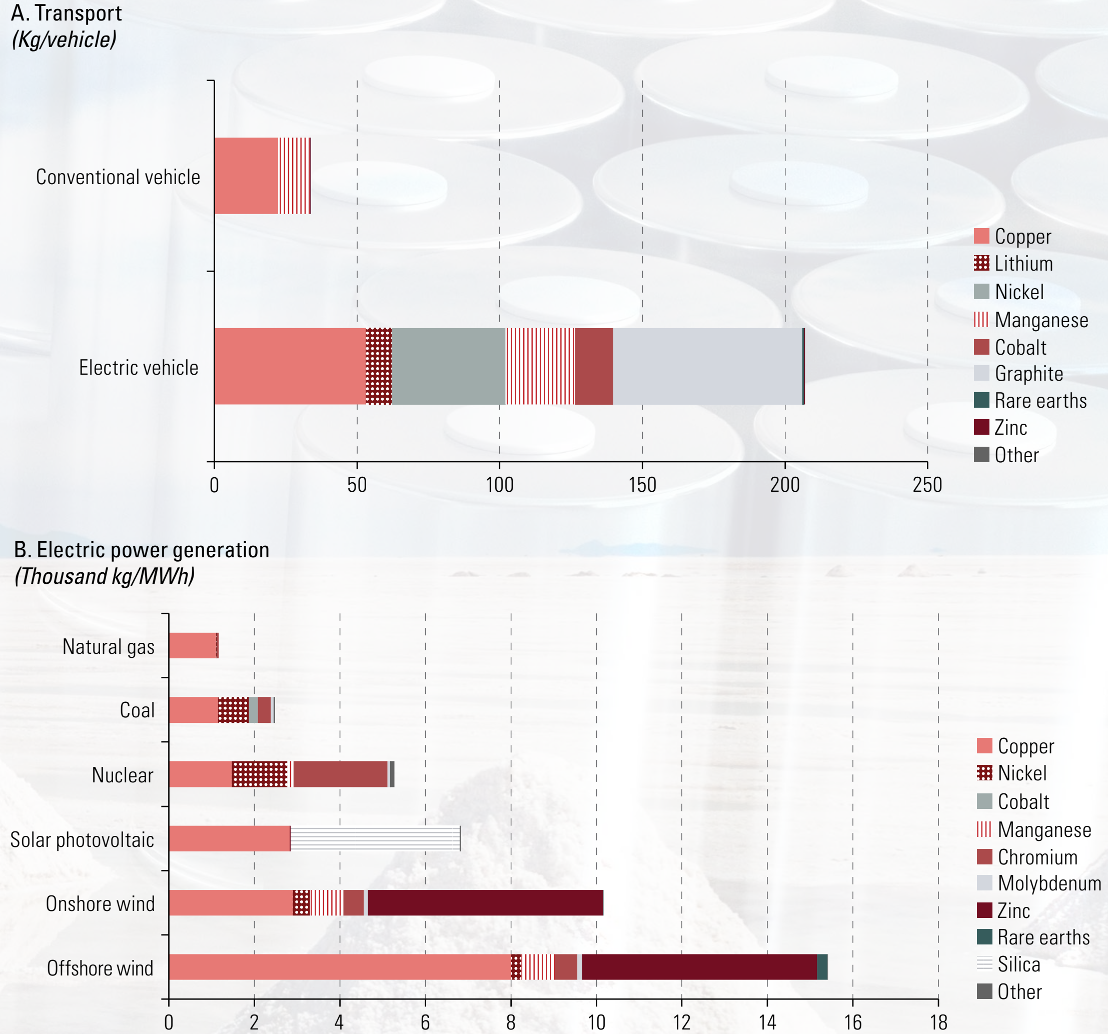
I. The global market for lithium batteries is expanding rapidly

A. Energy transition and climate change commitments

- The exponential growth in the global demand for lithium is explained mainly by the transformations triggered by the energy transition that is currently unfolding across the world. The commitments undertaken to limit global warming include substantially reducing the use of fossil fuels, expanding electrification, improving energy efficiency and using alternative fuels (IPCC, 2022).
- As part of this process, the electrification of transportation, in combination with increased use of low-emission energy sources, implies a transition to a mineral-intensive paradigm (IEA, 2021). Many of the minerals concerned, including lithium, copper, nickel, cobalt and rare earths, have become critically important (IEA, 2021). Figure I.1 compares the mineral demand for various traditional technologies and for some of those introduced as part of the decarbonization process. For example, an electric automobile needs six times more minerals than a conventional car, while an offshore wind plant needs nine times more minerals than a gas-fired plant of the same capacity. Furthermore, not only a larger quantity but also a wider diversity of minerals is required.

[2] The productive development agenda, also called "industrial policy", refers to public-sector support for productive development, in other words the dimension of economic development that focuses on the process of expanding production-related capabilities (Correa, Dini and Letelier, 2022). The Economic Commission for Latin America and the Caribbean (ECLAC) proposes that this agenda or policy should seek a structural, sustainable and inclusive transformation.

Figure I.1 Quantity of minerals used in selected clean-energy technologies



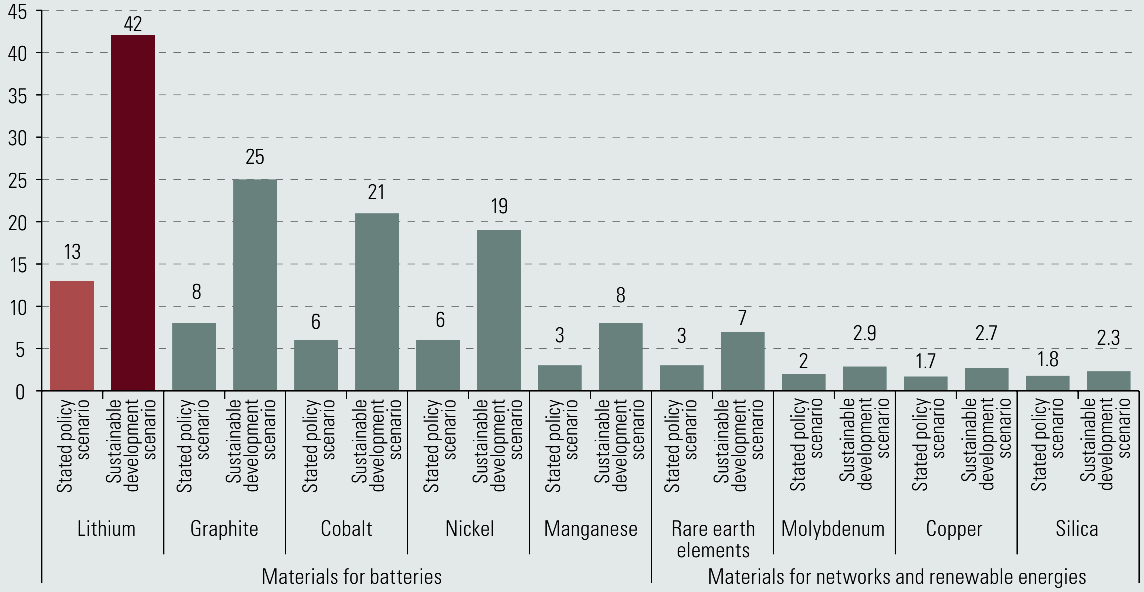
Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of International Energy Agency (IEA), *The Role of Critical Minerals in Clean Energy Transitions,* Paris, 2021.

- The International Energy Agency (IEA) envisages total global demand for minerals potentially doubling in the stated policy scenario (STEPS) and even quadrupling in the sustainable development scenario (SDS) between 2020 and 2040 (see figure I.2).[3] This projection sees lithium as the metal with the strongest growth in demand, with increases of 13 and up to 42 times, depending on the scenario.[4]

[3] The stated policy scenario (STEPS) indicates the future course of the energy system, based on a sector-by-sector analysis of current policies and policy announcements. The sustainable development scenario (SDS) indicates what would be required on a path consistent with meeting the Goals of the Paris Agreement.

[4] Nonetheless, the relative increase in demand for lithium is due largely to a much smaller basis of comparison than for other minerals, because the current size of its market is smaller. Lithium demand in 2020 was roughly 300,000 tons of lithium carbonate equivalent (LCE)), whereas the demand for refined copper was 75 times greater at 22,550,000 tons, according to the United States Geological Survey (USGS).

Figure I.2 Relative growth of demand for selected minerals used in clean energy, projections to 2040
(Multiples of estimated 2020 demand)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of International Energy Agency (IEA), *The Role of Critical Minerals in Clean Energy Transitions,* Paris, 2021.

Box I.1 The current energy situation could hasten the transition process

- The conflict between the Russian Federation and Ukraine has disrupted global geopolitics and trade flows, resulting in a considerable increase in international fossil fuel prices. This has been passed on to the energy sectors, other productive sectors and consumers, affecting households, firms, industries and entire economies. Although the conflict and its impact on energy prices are more direct and serious on the European continent, where most countries import fuels from the Russian Federation, it has also affected the rest of the world and, in particular, developing countries, which are unable to respond with their own resources. Some of the immediate shortfalls in fuel imports from the Russian Federation, particularly natural gas, need to be filled by production from elsewhere; and new liquefied natural gas (LNG) infrastructure will be needed to facilitate the diversification of supply, drawing on other markets outside the Russian Federation. While oil and gas investment increased by 10% relative to 2021, it remains well below 2019 levels. High fossil fuel prices cause problems for many economies, but also produce unprecedented windfall profits for oil and gas producers. Income in the global oil and gas sector is expected to rise to US$ 4 trillion by 2022, more than double the five-year average, with most of these revenues going to major oil- and gas-exporting countries (IEA, 2022a).
- The Executive Director of the International Energy Agency (IEA) has argued that the energy crisis and the climate crisis are not mutually conflicting; but there is currently an opportunity to address both problems at once. In July 2022, he noted that a "massive surge in investment to accelerate clean energy transitions is the only lasting solution. This kind of investment is rising, but we need a much faster increase to ease the pressure on consumers from high fossil fuel prices, make our energy systems more secure and get the world on track to reach our climate goals".
- In general, the conflict slows down globalization as currently conceived, by accentuating the trends towards regionalization and the relocation of production chains and trade that were already occurring with the trade dispute between the United States and Europe, on the one hand, and China, on the other (ECLAC, 2022). In this fragmented scenario, geopolitical considerations will likely gain greater weight in economic policy decisions in the near future. Regional integration will become more important and various efforts will be made to secure supply chains, mainly between allied countries (a number of examples related to lithium are discussed in section I.E).

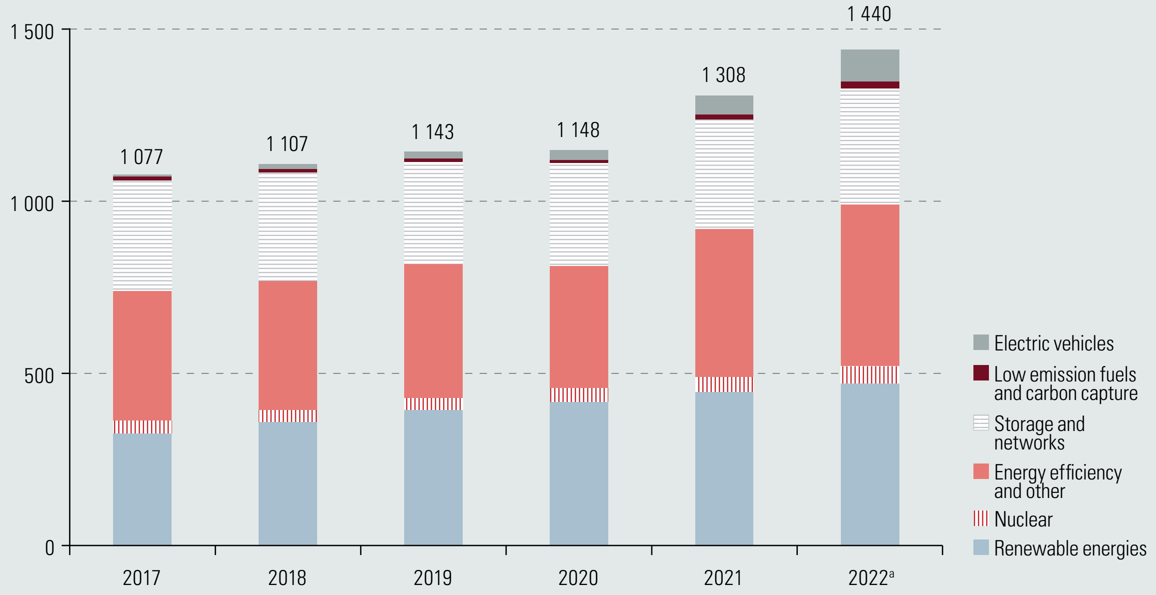
Source: Economic Commission for Latin America and the Caribbean (ECLAC), *Repercussions in Latin America and the Caribbean of the war in Ukraine: how should the region face this new crisis?,* Santiago, 6 June 2022 [online] https://repositorio.cepal.org/bitstream/handle/11362/47913/S2200418_en.pdf.; International Energy Agency (IEA), *World Investment Energy 2022,* Paris, 2022; J. Myers, "This is the technology driving the world's renewables revolution", Geneva, World Economic Forum (WEF), 12 July [online] https://www.weforum.org/agenda/2022/07/renewable-energy-technology-iea-investment/.

B. Investment in clean energy and the growth of electromobility and lithium-ion batteries

On the supply side, the spread of electromobility has fuelled a substantial increase in investment in the automotive and lithium-ion battery production industries. On the demand side, electric vehicle penetration rates are increasing in the higher-income economies, supported by specific regulations and tax benefits. This process is at an incipient stage in Latin America and the Caribbean, where electric vehicle penetration is increasing, albeit at very low levels.

The energy transition requires a high level of investment. In the five years following the signing of the Paris Agreement in 2015, clean energy investment grew by an average of just over 2% per year; but since 2020, the rate has risen to 12%. Nonetheless, it is still below what is needed to meet international climate targets (IEA, 2022a). In 2021, the highest levels of clean energy investment were recorded in China (US$ 380 billion), followed by the European Union (US$ 260 billion) and the United States (US$ 215 billion). Investment in electric vehicles amounted to US$ 93 billion, representing 6.5% of total investment (see figure I.3).

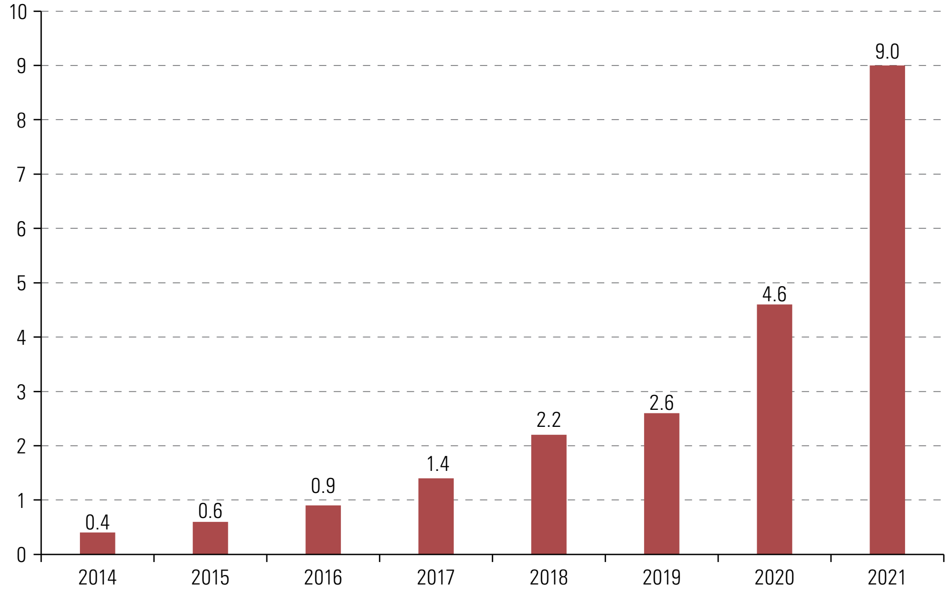
Figure I.3 Global investment in clean energy, 2017–2022
(Billions of dollars)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of International Energy Agency (IEA), *World Investment Energy 2022,* Paris, 2022.
[a] The figures for 2022 are estimates.

- In 2021, electric vehicle sales were more than double the previous year's total, and their strong growth continued in 2022. Electric vehicle penetration in the automotive market increased by 650% between 2014 and 2019 (see figure I.4) and is estimated to account for 4.6% of total vehicle sales in 2020 and 9% in 2021, nearly quadrupling the 2019 figure (IEA, 2022b). The robust growth of electromobility explains the expansion of demand for lithium-ion batteries over the past few years, which is forecast to remain around 25% per year until 2030 (World Economic Forum, 2019). This rate of growth raises questions about the ability of automakers to keep pace with production and deliveries. The main constraints stem from the raw material supply chain and the global shortage of semiconductors.

Figure I.4 Electric vehicle penetration rate, 2014–2021
(Percentages of total vehicle sales)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of M. Obaya and M. Céspedes, "Análisis de las redes globales de producción de baterías de ion de litio: implicaciones para los países del triángulo del litio", *Project Documents* (LC/TS.2021/58), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC), 2021; International Energy Agency (IEA), Global EV Outlook 2022, Paris, 2022; and McKinsey & Company data.

Note: The 2020 and 2021 light passenger electric vehicle penetration rates are estimates provided by the International Energy Agency (IEA, 2022b).

- As part of efforts to combat climate change worldwide, an increasing number of governments have introduced incentives for the production and consumption of electric vehicles, which have contributed to the adoption of this form of mobility (IEA, 2020; LaRocca, 2020). Public expenditure on subsidies and incentives for electric vehicles nearly doubled in 2021 to around US$ 30 billion. Moreover, a growing number of countries have committed to phasing out internal combustion engines in the coming decades and have set ambitious vehicle electrification targets.[5] In the framework of the Clean Energy Ministerial Forum, 16 countries, including Chile, created the Electric Vehicle Initiative, a multi-governmental policy forum dedicated to speeding up the introduction and adoption of electric vehicles worldwide. In addition, many manufacturers have already responded to these commitments and incentives by announcing decisions to electrify their vehicle fleets.[6]

- In the region, Brazil has the largest market, followed by Mexico and Colombia. Forecasts indicate strong growth in countries such as Colombia, Costa Rica and Uruguay (see figure I.5). However, average penetration rates in the region remain below 1%.[7]

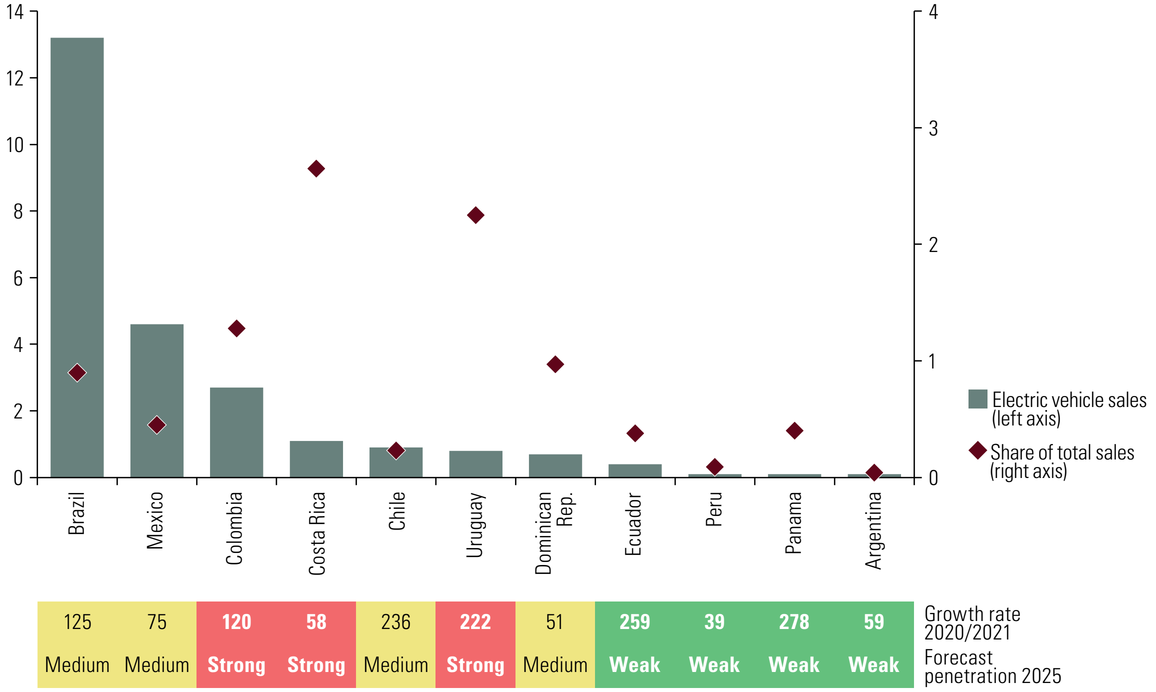
[5] In 2021, the twenty-sixth session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP 26) set an unofficial target for all new cars sold globally to be zero-emission vehicles by 2040. For a list of electric vehicle fleet commitments by country, see IEA (2022c). Norway has made a commitment (unofficial target) that 100% of new light-duty passenger vehicles sold should be zero-emission vehicles by 2025. In February 2023, the European Union passed a law banning the sale of new gasoline and diesel cars as from 2035.

[6] For example, Mercedes-Benz announced that all new vehicles launched will be fully electric as from 2025; and Volvo made a commitment to become an all-electric car manufacturer by 2030. Meanwhile, in China, Dongfeng Motor Corporation plans to electrify 100% of its new models of major passenger car brands by 2024, and BYD announced that it would only produce electric vehicles as from April 2022 (IEA, 2022b).

[7] There have also been commitments in the region on electric vehicle fleets. Chile, the Dominican Republic, El Salvador, Mexico and Paraguay are signatories to the unofficial target of the twenty-sixth session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP 26) that all new car sales will be zero emission vehicles by 2040. Outside of this unofficial COP 26 target, Brazil, Chile, Costa Rica, Ecuador, Panama and Uruguay have set different commitments (mostly unofficial targets) for electric vehicle sales and fleets for specific years (see IEA (2022c) for a complete list).

Figure I.5 Latin American electric vehicle market, 2021

(Thousands of units and percentages)

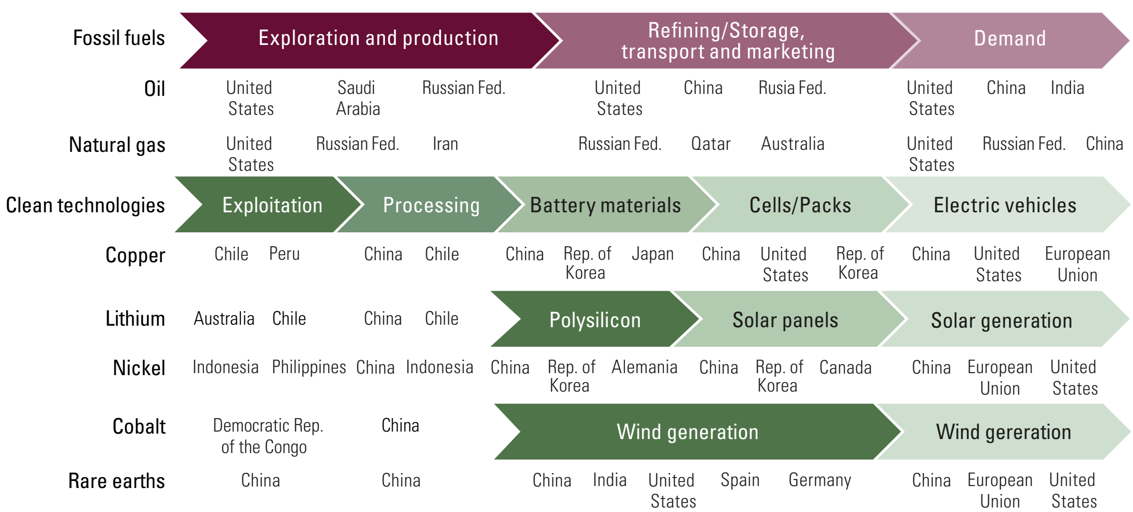


Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of BloombergNEF.

C. The geography of mineral resources

- The location of both the reserves and the production of many minerals that are critical to the energy transition is geographically more concentrated than in the case of fossil fuels (see diagram I.1). For example, in the case of lithium, which is essential for the production of lithium-ion batteries, the three leading producer countries account for more than three quarters of global production. In the case of other minerals, such as cobalt, a single country produces about half of the world total.

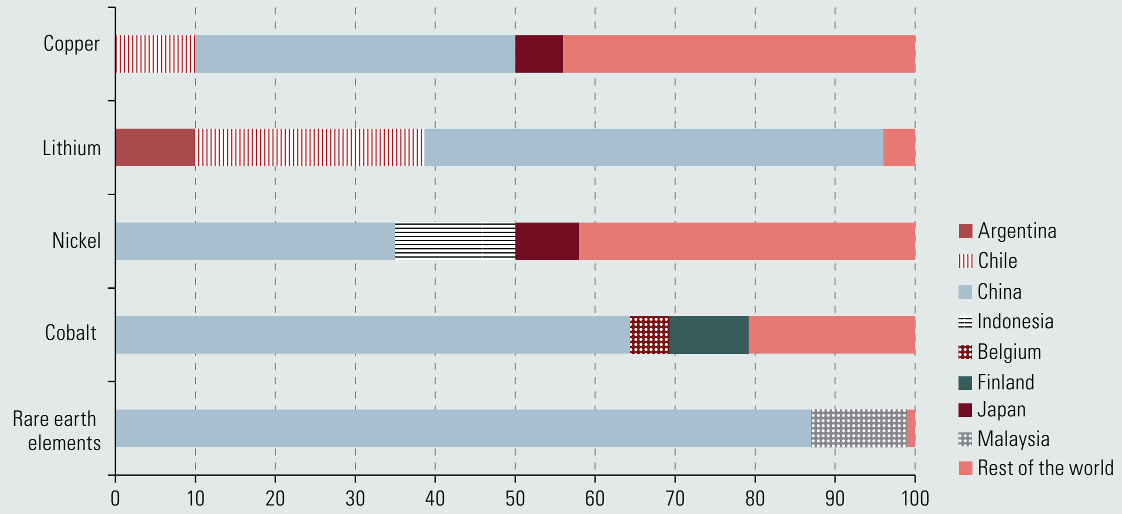
Diagram I.1 Country shares in selected natural resource value chain activities



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of International Energy Agency (IEA), *The Role of Critical Minerals in Clean Energy Transitions,* Paris, 2021.

- There are also high levels of concentration in the mineral processing and refining chain, in which China is a dominant player. In refining activities, China accounts for approximately 35% in the case of nickel, between 50% and 70% in the cases of lithium and cobalt, and nearly 90% in the case of rare earths (see figure I.6). Chinese firms have also invested heavily in assets located in countries such as Argentina, Australia, Chile, the Democratic Republic of the Congo, Indonesia and Mexico, enabling them to achieve a high degree of vertical integration.

Figure I.6 Share of processing, selected minerals, 2019
(Percentages)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of International Energy Agency (IEA), *The Role of Critical Minerals in Clean Energy Transitions,* Paris, 2021.
Note: The data shown for copper refer to refining capacity.

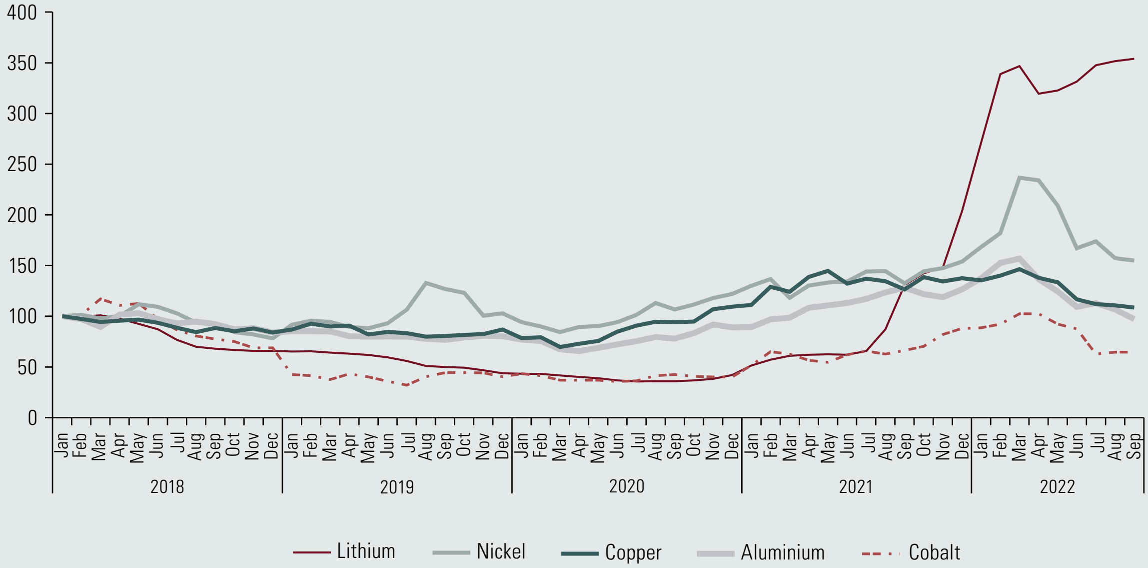
D. The price of lithium continues to rise steadily in the wake of the energy transition

- The prices of many minerals (both metals and rare earths) that are essential for the energy transition have risen steeply owing to a combination of factors, such as a sharp increase in demand, the disruption of supply chains, and expectations of shortages and supply bottlenecks (IEA, 2022b). In this context, lithium has posted the steepest price increase of all metals, even resisting the decline experienced since April 2022. This has a considerable impact on the cost of producing the lithium-ion battery cells needed to expand electromobility.
- Between July 2020 and September 2022, copper, nickel, cobalt and aluminium prices rose by between 20% and 80% (see figure I.7). Having peaked in March and April 2022, they then started to fall back as countries emerged from the worst of the coronavirus disease (COVID-19) pandemic and the outbreak of the conflict between the Russian Federation and Ukraine. While there are specific factors that explain the situation of each metal, all have been affected by negative expectations for trends in the industrialized economies and China, against the backdrop of a global economy subject to tight monetary policies and inflation.
- In the case of lithium, not only has the price risen almost ninefold, but, unlike other minerals, there has been no significant reduction. This is explained by the substantial growth of electric vehicle sales in 2021 and early 2022,[8] combined with expectations for supply, which in the past has proven unable to respond with capacity increases on a timely basis. In the longer term, the prospect of a further fracturing of the global economy, with potential for major disruption in supply chains, could put additional pressure on prices.

[8] Various sources indicate a further increase in electric vehicle sales in 2022 compared to 2021.

Figure I.7 Price variation among selected minerals

(Index: 31 January 2018=100)



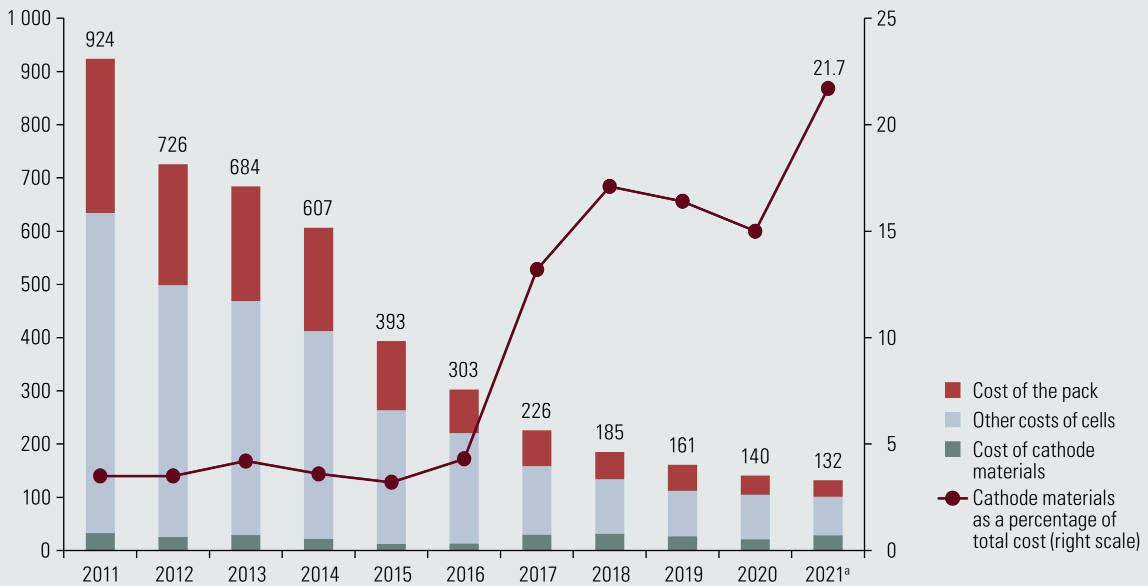
Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of Bloomberg.

Note: Price indices for the selected metals are calculated using the market closing price on the last business day of the month. The price index for lithium (carbonate, battery grade, 99.5%) is calculated from the average between the prices in the United States and China, while the price indices for aluminium, cobalt, copper and nickel are calculated from the spot prices of these metals on the London Metal Exchange (LME).

- Raw material costs could have a major impact on financing needs for the energy transition, as their share in the total cost of the technologies is increasing. For example, cathode materials for lithium-ion batteries (which can combine lithium, nickel, cobalt and manganese in varying proportions) accounted for less than 5% of battery pack costs in the mid-2010s. Following the increase in the price of lithium and other battery metals that occurred in early 2022, this figure is now around 20% (see figure I.8).

Figure I.8 Trend of the cost of lithium-ion batteries and share of parts in the total cost, 2011–2021

(Dollars per kilowatt-hour and percentages)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of International Energy Agency (IEA), *Global EV Outlook 2022,* Paris, 2022.

[a] The figures for 2022 are estimates.

E. Lithium: a critical resource for countries leading the transition to electromobility

- In the economies that are leading the energy transition process, increasing raw material needs have given rise to policy strategies aimed at securing their stable supply. In recent years, with the rise of China as an economic power, with its manufacturing industry and its increasing participation in international trade, greater focus has been placed on controlling the raw materials extraction process, which is considered strategic for this purpose. Each country has defined different criteria for assessing the criticality of raw materials. These include the degree of diversification of raw material sources, the level of resource endowment and reserves, and the type of bilateral relationship that exists with the main producing countries (Lèbre and others, 2019). The key initiatives of the leading regions and countries in electromobility worldwide are described below.

1. European Union

- Since 2011, the European Commission has been publishing a list of key raw materials, which in its first edition included 14 items. The list is updated every three years, and the number of minerals increasing steadily: 20 in 2014, 27 in 2017, and 30 in the latest edition in 2020, in which lithium was included for the first time. The European Union pursues a model of open strategic autonomy, which involves integrating into the global economic governance system and forging win-win bilateral relations. European countries are aware of their reliance on other economies for the supply of these raw materials; and they realize that achieving autonomy or self-sufficiency is impossible in the short or medium terms.
- In keeping with its intention to develop a regional electric vehicle industry, in 2017 the European Union launched the European Battery Alliance.[9] This initiative, which is particularly significant for lithium, aims to support the creation of a lithium-ion battery value chain in Europe, premised on sustainability and competitiveness. In 2020, inspired in the model of the aforementioned Alliance, the European Commission announced the creation of a European Raw Materials Alliance (ERMA),[10] which seeks to increase investment in the supply of critical minerals and the circular economy of raw materials in Europe. In addition, in September 2022 the President of the European Commission announced a new legislative initiative, the European Critical Raw Materials Act (Breton, 2020), which seeks to ensure the resilience of the supply chain for minerals such as lithium and rare earths by becoming less dependent on China (for example, by diversifying trading partners, supporting production and refining initiatives in other countries, and setting recycling targets in the European Community).

2. United States

- In the United States, a list of critical minerals was first drawn up in 2018. It was then updated in 2022 under the directive of the Energy Act of 2020, which called for the Department of the Interior to update the listing every three years. The updated list includes 50 minerals in addition to lithium, 15 more than the 2018 version. The criticality of materials is assessed using scientific methods that seek to identify vulnerabilities and potential disruptions in the chain.[11] The Energy Act defined a “critical mineral” as any non-fuel mineral, element, substance, or material that is essential to the economy or national security and has a high risk of supply chain disruption. It also notes that the minerals in question are critical inputs for the production of industrial products.
- Re-shoring initiatives[12] have gained momentum since the passage of the Energy Act. In February 2022, the Biden Administration signed an executive order (Government of the United States, 2022) to secure the value chains. Incentives totalling US$ 3 billion are available for the supply of raw

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9 See [online] https://www.eba250.com/.

10 See [online] https://erma.eu/.

11 See the methodology and frequently asked questions in United States Geological Survey (USGS), “2022 list of critical minerals FAQs” [online]https://d9-wret.s3.us-west-2.amazonaws.com/assets/palladium/production/s3fs-public/media/files/Final%20FAQs.pdf.[online] https://d9-wret.s3.us-west-2.amazonaws.com/assets/palladium/production/s3fs-public/media/files/Final%20FAQs.pdf.

12 The process of re-shoring (also known as on-shoring or in-shoring) entails transferring a firm’s operations back to its country of origin or close to market demand, and is the opposite of off-shoring, which occurs when the relocation is to another country. The latter practice has been associated with globalization. A new concept associated with de-globalization is that of near-shoring, which occurs when a firm moves its operations to a country close to the country of origin, often with a shared border. Meanwhile, relocation to countries that are allied or perceived as politically and economically safe or low-risk (friend-shoring or ally-shoring) is intended to avoid disruption of supply chains. See Ellerbeck (2023).

materials needed for lithium-ion batteries, which has reinvigorated mining exploration and the progress of projects in United States territory. In addition, the Inflation Reduction Act of August 2022 (United States Senate, 2022) highlights the development of an electric vehicle market. The policy in question includes tax benefits for domestic production and a US$ 7,500 tax credit for purchasers of new electric vehicles that satisfy certain requirements, one of which is that the vehicle battery must have a minimum percentage of critical minerals mined or processed in the United States, or in a country with which the United States has a free trade agreement (the requirement is 40% of the minerals used in the battery in 2023, rising incrementally to 80% in 2026).

3. Japan

- In 2020, Japan's Ministry of Economy, Trade and Industry expressed concern about the supply of raw materials, particularly rare earths, a sector in which it depends heavily on China (METI, 2020). In the case of lithium-ion batteries, Japan has seen its market share shrink sharply from 40% in 2015 to 20% in 2020 (METI, 2020). Difficulty in accessing raw materials could increase the vulnerability of the Japanese battery industry.
- The Japan Organization for Metals and Energy Security[13] has been supporting projects worldwide for the development of mineral resources. In recent years, it has augmented its strategy by including Japanese firms involved in business models for the construction of smelting and refining works, with the aim of promoting a relocation of these activities. An example of this is the lithium hydroxide plant in Naraha belonging to the joint venture between Allkem and Toyota Tsusho, which have lithium compound production operations in Argentina.

Minerals Security Partnership

- In June 2022, an initiative sponsored by the United States to strengthen critical minerals supply chains —the Minerals Security Partnership (IEA, 2022d)— was launched at the Prospectors and Developers Association of Canada trade show[14] held in Canada. Participants in the Minerals Security Partnership include: Australia, Canada, Finland, France, Germany, Japan, the Republic of Korea, Sweden, the United Kingdom, the United States and the European Commission. The partnership includes countries that are net suppliers of minerals, such as Australia and Canada, and others that could join them in the future, such as Finland and Sweden. The Minerals Security Partnership will help catalyse government and private sector investment in strategic opportunities throughout the value chain, adhering to the highest environmental, social and governance standards.

4. China

- China has developed strong vertical integration in the lithium-ion battery value chain, as reflected in its growing presence in all links of the chain. China's share in refining is around 35% for nickel[15] and between 50% and 70% for lithium and cobalt (IEA, 2021). China is also the third largest producer of lithium, based on its own ore or brine deposits; it ranks first in refining, and it processes most of the output of spodumene concentrates from Australia (Obaya and Céspedes, 2021).
- The criticality and security of supply has been high on the government's agenda and has given rise to practical initiatives. The "Made in China 2025" plan, for example, promoted a continuation and deepening of the expansion of the "Opening up" or "Go out" strategy, with global resources and markets, strengthening international cooperation with the aim of improving domestic manufacturing. The Belt and Road Initiative, launched in 2013, is also encompassed by these actions and has boosted much of China's foreign direct investment (FDI), with the aim of expanding markets and, at the same time, securing the supply of inputs for the country's economy and industry.

[13] This is a Japanese government agency that was created in Tokyo in 2004, on the basis of the Act on Japan Oil, Gas and Metals National Corporation of 2002. Its activities focus on the supply of oil and natural gas, metals and minerals, and coal, and on the financing of these activities in Japan and elsewhere.
[14] The annual convention of the Prospectors and Developers Association of Canada (PDAC), the world's largest mining event.
[15] The figure increases when the participation by Chinese firms in Indonesian operations is included.

F. The strategic nature of lithium for Latin American and Caribbean countries

- In keeping with the critical status it has assumed for countries leading the transition to electromobility, lithium has also become strategic for other countries with abundant resources and is considered a potential platform to promote economic development (Barandiarán, 2019). The countries in the region that are in this group have recognized this strategic nature of lithium in their regulatory frameworks.
- However, as shown in table I.1, the justifications and practical scope of this criterion vary greatly from one country to another. In Argentina, the decision has been confined to the province of Jujuy, which created a public enterprise with a shareholding in operations carried out in its territory. In the Plurinational State of Bolivia, lithium has been declared strategic for essentially economic reasons, and the government controls and promotes the entire lithium-ion battery value chain. In Chile, in contrast, this decision was made several decades ago, justified by the nuclear interest of lithium. This has not had significant implications in terms of direct control of the activities to exploit the resource or of the lithium-ion battery value chain; but the National Lithium Strategy announced in April 2023 could change this situation. A few months earlier, Mexico declared the mineral a public utility and created the State Lithium Company for Mexico.

Table I.1 Latin America (4 countries): strategic nature of lithium in legal regimes

Country	Regulations	Reason and objectives
Argentina (in two provinces only)[a]	Confined to the provinces of Jujuy, Provincial Act No. 5674 of 2011, and La Rioja, Provincial Act No. 10.608 of 2023	The Provincial Act of Jujuy declares lithium a strategic natural resource, since it is considered a "generator of the province's socioeconomic development". The Provincial Act of La Rioja declares lithium a strategic natural resource "for its contributions to the energy transition and to the province's socioeconomic development".
Bolivia (Plurinational State of)	Supreme Decree No. 29.496 of 2008	Declares "the industrialization of the Salar de Uyuni to be a national priority for the productive, economic and social development of the Department of Potosi".
	Political Constitution of the State (Article No. 369)	Declares the non-metallic natural resources existing in the salt flats, brines, evaporites, sulphurs and other forms to be "strategic for the country".
Chile	Decree Law No. 2886 of 1979	Gives exclusive ownership of lithium to the State, "as required by the national interest", and provides that the mineral is subject only to the legal acts of the Chilean Nuclear Energy Commission, except in the case of ownership claims already constituted or in the process of being constituted.
	National Lithium Commission (2014)	Reaffirms the "strategic nature of lithium", extending it to other industries, especially the energy industry.
	Ministry of Mining before the Senate Mining and Energy Commission (2022); National Lithium Strategy (2023)	Presents a public policy for the development of lithium, including the creation of a National Lithium Company (ENL); asserts that lithium is a strategic material for the energy transition and that the country needs to have control of the resource through a State enterprise that participates in both the exploration and exploitation of lithium as well as its industrialization. The enterprise would be formed as a public-private partnership in which the State would be the majority shareholder. This policy led to the launch of the National Lithium Strategy in April 2023.[b]
Mexico	Mining Law Reform (2022)	Declares lithium to be of public utility, for which reason no concessions, licenses, contracts, permits or authorizations will be granted. Also states that lithium is strategic and that its exploration, exploitation, benefit and use will be in the hands of the decentralized agency specified by the Federal Government. In August 2022, Lithium for Mexico (LitioMx) was created to explore, exploit, benefit and take advantage of lithium located in Mexico, and to manage and control the economic value chains associated with this mineral.

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of official data.

[a] In early 2023, the province of La Rioja passed Act No. 10.608, which in its first article declares lithium and its derivatives to be "strategic natural resources owing to their contributions to the energy transition and to the socioeconomic development of the province". The text also declares this mineral to be of "provincial public interest" and suspends exploration permits and concessions for 120 days. In addition, the regulation enables the detection of "areas of interest" where mining permits expire and clarifies that in the development of lithium "State-owned firms will have a fundamental preponderance".

[b] See National Lithium Strategy [online] https://www.gob.cl/litioporchile/.

II. Latin America is a major global player in the lithium sector, with a high degree of specialization in the extraction of the resource and the production of lithium compounds

A. Lithium resources, reserves and production

- Given its abundant lithium resources, the region of Latin America and the Caribbean has great potential to become a key player in the global lithium industry. However, its current performance is far from this potential, as reflected in the relatively small volume of production of lithium raw materials and compounds and the heavy geographic concentration of such production in Chile and Argentina. The region's difficulties in keeping pace with the burgeoning demand for the mineral can be explained by a combination of factors, the most important of which are technical. In the case of resources in salt flats (*salares*), projects must be adapted to the chemical characteristics of the brine and the environment of the territory in which they are located. In the case of other types of lithium resources, such as Mexican clays, production processes are still in the development stage and have not yet attained industrial scale.

- Economic deposits of lithium are of three main types:[16] (i) brine deposits in salt flats; (ii) pegmatite deposits, including the lithium-cesium-tantalum (LCT) family of granitic pegmatites and associated metasomatic rocks; and (iii) volcanic clay deposits. Latin America has lithium deposits of all three types, although the most important, in terms of the volume of resources identified, are brine in salt flats.

- The area spanning the southwest of the Plurinational State of Bolivia and northern Argentina and Chile (the central Andes of South America) displays a geography characterized by numerous endorheic basins developed in an environment that has an average altitude of about 4,000 metres above sea level. This region is commonly referred to as the "lithium triangle".[17] Deposits in pegmatites can be found in Argentina, Brazil, Mexico and Peru, but they are currently being exploited only in Brazil; while in Argentina there is a history of exploitation in the last century. In the case of the third type —lithium-enriched clays— there are deposits in advanced stages of exploration in Mexico and Peru, but there are no projects yet in production.

- The countries of the lithium triangle account for 56% of the world's total identified resources (see figure II.1). When the other Latin American countries mentioned above are included, the region accounts for nearly 60% of total lithium resources.

- When considering mineral reserves, that is the portion of identified resources that can be extracted economically with the available technology, the picture changes considerably for some countries in the region. This is explained by the fact that the calculation of reserves considers many aspects related to economic factors, market conditions and financing, as well as the engineering and extraction method to be used, and the prevailing legal, environmental and social conditions. In other words, factors that condition the feasibility of exploiting the resource are taken into consideration, beyond the geological knowledge of the deposit.

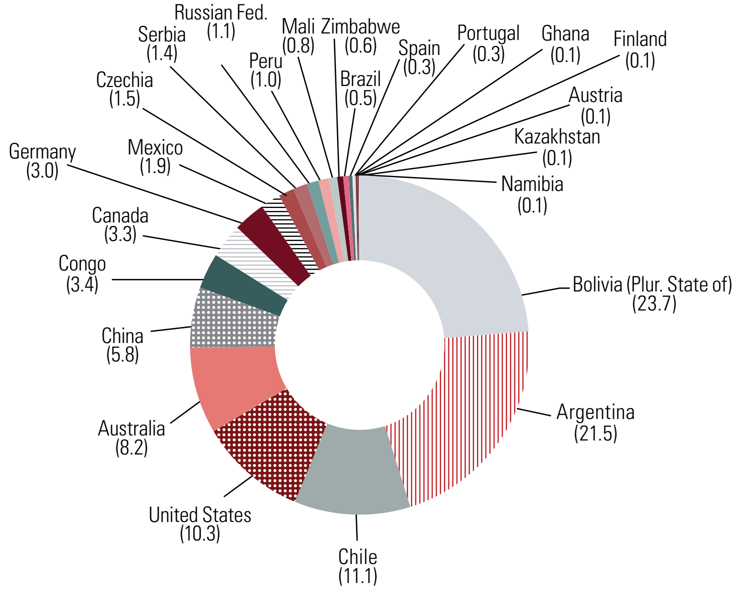
- In this context, the region maintains a 52% share of world reserves (see figure II.2). Nonetheless, there is a significant imbalance between countries, with Chile alone accounting for 41% of world reserves, and Argentina almost 10%. The remaining countries with resource estimates, such as Mexico, Peru and the Plurinational State of Bolivia, do not have reserve estimates.[18]

[16] To a lesser extent, lithium is found in wastewater from oil wells, in geothermal fields and in deposits of jadarite, a recently discovered lithium boron silicate belonging to the zeolite group.

[17] These lithium-rich brine systems are characterized by an arid climate, with low rainfall and very high evaporation rate, the existence of a closed basin containing a salt lake or salt flat in the central area that forms the local base level for groundwater and surface water, the existence of one or more aquifers suitable for storing brine, and sufficient time to concentrate the brine, among other features (Bradley and others, 2016).

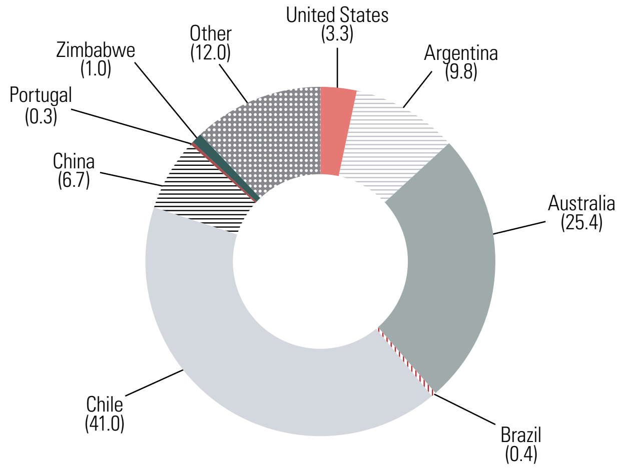
[18] The case of the Plurinational State of Bolivia can be explained by the fact that the government's strategy to exploit the resource has been based on autonomous financing granted by the Central Bank of Bolivia. This has meant that the country has thus far not needed another source of financing; but, at the same time, it has also reduced the possibility of moving forward more decisively with the investments needed to explore and exploit the salt flat (Obaya and Pascuini, 2020). This step could be accelerated following the agreement signed recently between the State-owned Yacimientos de Litio Bolivianos (YLB) and the Chinese consortium CBC, to produce lithium through two plants using direct lithium extraction technology (for further details, see chapter III).

Figure II.1 Global share of lithium resources by country, 2021
(Percentages)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of United States Geological Survey (USGS).

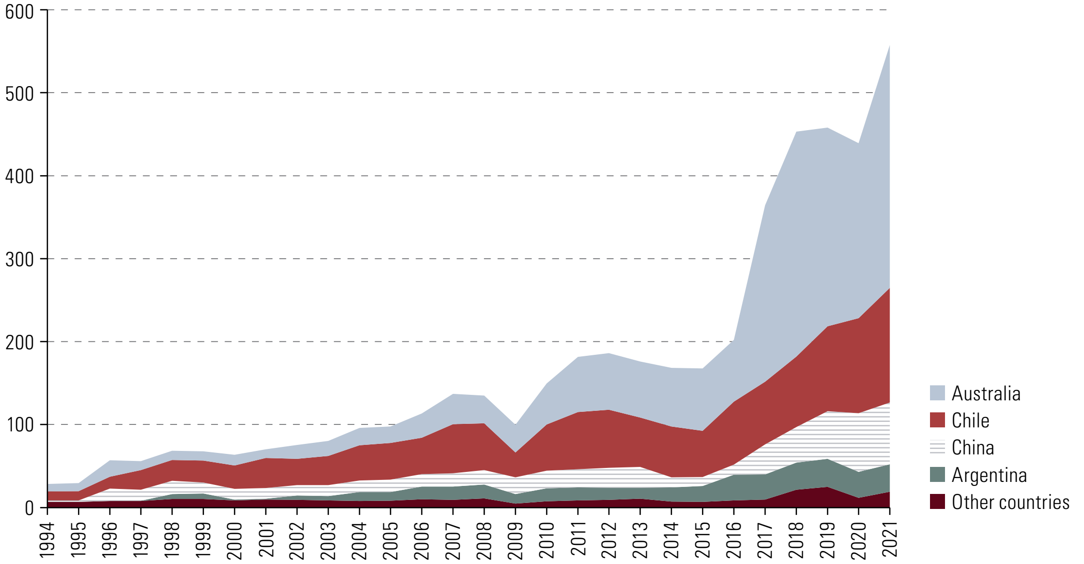
Figure II.2 Global share of lithium reserves, by country, 2021
(Percentages)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of United States Geological Survey (USGS), *Mineral Commodity Summaries 2021,* Reston, 2022.

- In 2021, four countries —Australia, Chile, China and Argentina— jointly accounted for more than 96% of global production of lithium (see figure II.3). Australia generates over 52% of mined production. The high geographic concentration of lithium production is one of the reasons why the main lithium-ion battery producing countries have included this input in a list of critical materials.
- The relative share of each country has changed over the years. In the decade of 2000, Chile had an average share of 40% of world production, while Australia accounted for about 23%. In that decade, China and Argentina emerged in the market, with shares averaging around 15% and 9%, respectively. In the subsequent decade, the leadership changed hands, and Chile's share dropped to 31%, while Australia's rose to 44%. Between 2015 and 2021, when there was a marked increase in demand —and, consequently, in prices— began to be discerned, the gap between the two countries widened; and in 2018 the peak shares were 60.2% for Australia and 19% for Chile.

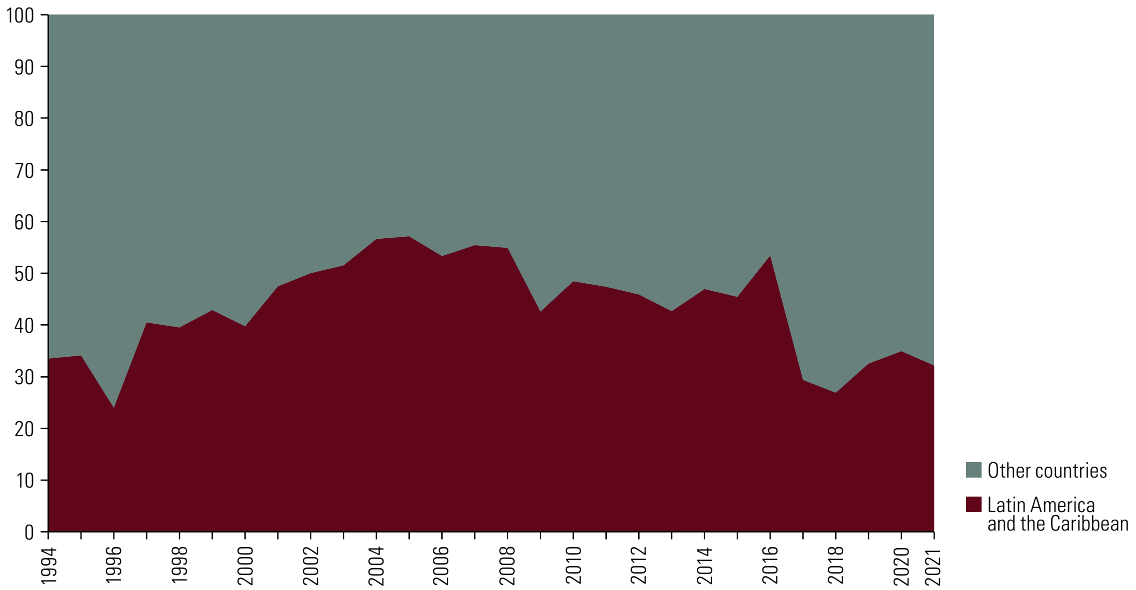
Figure II.3 Trend of world lithium production, 1994–2021
(Thousands of tons of lithium carbonate equivalent (LCE))



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of United States Geological Survey (USGS).

- In the region, the trend has been marked by the performances of Argentina and Chile. Between 2000 and 2008, the region generated over 50% of global lithium production, with a peak of 57% in 2005 (see figure II.4). In 2016, Latin America and the Caribbean again contributed more than half of global production, supported partly by the increase in Argentina following the start-up of Salar de Olaroz, the second operation in the country. However, this situation did not last, since the largest increase in capacity in 2017 occurred in Australia.

Figure II.4 Latin America and the Caribbean: change in share of world lithium production, 1994–2021
(Percentages)

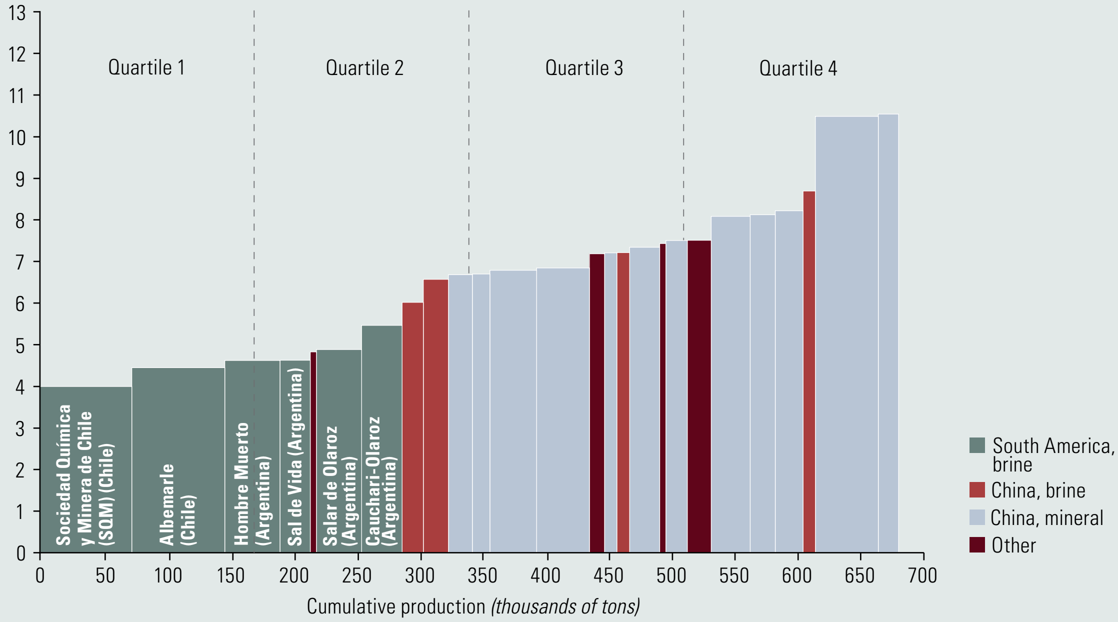


Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of United States Geological Survey (USGS).

- The difficulties that South American countries with brine deposits have had in responding quickly to the increased demand for lithium are explained largely by the complexity of the chemical composition of the salt flats. Operations in salt flats take longer to develop than operations in rock ore. Each of the salt flats is different in terms of lithium concentrations and impurities —that is all the other elements and compounds that are dissolved in the brine and that make the salt flat systems more complex.[19] Consequently, the extraction processes have to be designed and adjusted specifically for each of the different salt flats.

- There are also various parameters that affect the economic viability of using brines. Some are related to natural factors, such as the evaporation rate in the salt flat zone, climatic conditions, the hydrogeology of the basins and the permeability of the different subsoil layers; while others are linked to external factors, such as the availability of infrastructure and access to it (electricity, gas and fresh water for industrial use). The salt flats that tend to be more competitive —that is, with lower operating costs— have high lithium concentration and evaporation rates, while containing low levels of lithium-magnesium and lithium-sulphate. This is more prevalent in the projects under way in Chile and several in Argentina (see figure II.5).

Figure II.5 Lithium carbonate cost curve, projection to 2025
(Thousands of dollars per ton of lithium carbonate equivalent at 2020 prices)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of B. Jones, F. Acuña and V. Rodríguez, "Cambios en la demanda de minerales: análisis de los mercados del cobre y el litio, y sus implicaciones para los países de la región andina", *Project Documents* (LC/TS.2021/89), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC), 2021.

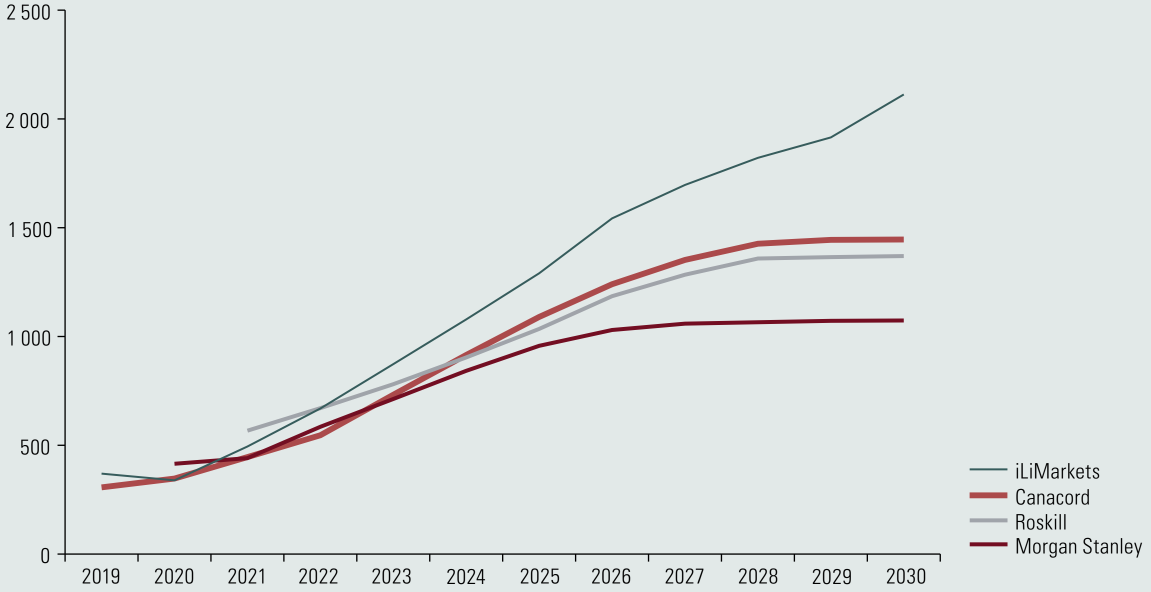
B. Global lithium production: operations and projects

- In 2021, global lithium supply reached levels of around 500,000 tons of lithium carbonate equivalent (LCE). Forecasts of market trends in the coming years vary widely (see figure II.6). However, based on project portfolios and recent announcements, there is consensus that the four main producer countries —Australia, Chile, China and Argentina— will achieve absolute increases in their production capacity in the coming years. In relative terms, however, their importance is likely to decline. This is explained by the increasing contribution of countries that currently do not produce large volumes of lithium, such as Canada, the United States and Zimbabwe, which can be expected to raise their production substantially above current levels.

[19] The most important impurities (elements or chemical compounds other than lithium) are magnesium, sulphate, calcium, sodium and potassium.

Figure II.6 World lithium supply, projections, 2019–2030

(Thousands of tons of lithium carbonate equivalent)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of D. Jiménez and M. Sáez, "Agregación de valor en la producción de compuestos de litio en la región del triángulo del litio", *Project Documents* (LC/TS.2022/87), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC), 2022.

- Although prospects for Latin America and the Caribbean are promising in terms of projects, the region's share could fall in relative terms. While 37% of the lithium consumed worldwide was sourced from Latin America in 2021, this figure is expected to drop to 32% by 2030.
- The realization of projects currently under development would result in a significant increase in the region's production capacity. However, the progress and status of each of these projects varies widely (see annex 1) Argentina is the country with the most projects under development, as explained in chapter III, because its regulatory framework is open to international private investment. Its neighbours in the lithium triangle, and also Mexico, have laws that accord lithium a strategic status and impose restrictions on private investment. In the case of Chile, the contribution to this panorama is reflected in the expansions of the two projects in operation in the Atacama salt flats, since the exploitation of other deposits is subject to administrative or special operating contracts that the State has not yet used.
- In Argentina, projects currently under way include the expansion of two operations already on stream (Minera del Altiplano and Sales de Jujuy), the construction of six new projects, two projects that have passed the feasibility analysis phase, three in pre-feasibility stage, five with preliminary economic assessments (PEA) and 20 in an advanced exploration phase (Mining Secretariat, 2021). A specific feature in this country in recent years is the large number of mergers and acquisitions, which brought new players into the lithium industry.[20]
- In the Plurinational State of Bolivia, the most advanced project to produce lithium compounds is led by the State-owned Yacimientos de Litio Bolivianos (YLB), in Salar de Uyuni. This project has a pilot plant, while the construction of an industrial plant with a production capacity of 15,000 tons of LCE per year is also under way. In 2021, YLB launched an international tender for direct lithium extraction for the Uyuni, Coipasa and Pastos Grandes salt flats.
- In Chile, there are two large-scale operations in the Salar de Atacama with the Salar del Carmen (operated by Sociedad Química y Minera de Chile (SQM)) and La Negra (operated by Albemarle) plants. With the planned expansions, they would jointly double their production as from 2025. The government has established a National Lithium Company (ENL) as part of its lithium mining development policy. This seeks to lead the exploration and exploitation of lithium projects with private participation, but under State control; and in the near future it could expand the portfolio of projects in operation and production in Chile.

[20] For example, the French enterprise, Eramet, reached an agreement with the Chinese steelmaker Tsingshan, to finance the construction of the Centenario-Ratones project in exchange for a 49.9% stake. The merger of the Australian Orocobre Ltd. and Galaxy Resources Ltd., two firms with experience in primary production, gave rise to Allkem Ltd., which became the fifth largest lithium chemicals company in the world. In addition, the Chinese multinational Zijin Mining Group Ltd. acquired the Canadian firm, Neo Lithium, from the Tres Quebradas project and announced the start of construction.

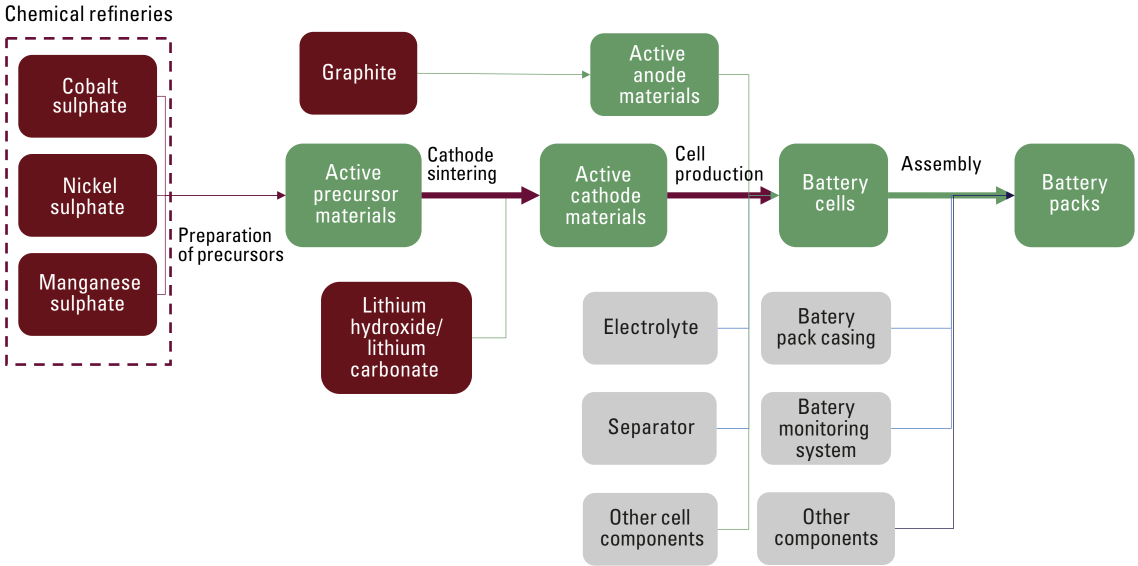
- Brazil has the Mibra operation (run by AMG Lithium), with a production capacity of approximately 5,000 tons of LCE, and an expansion currently under way to reach 13,500 tons of LCE. In addition, the Grota do Cirilo project (Sigma Lithium), which would have a capacity of more than 25,000 tons of LCE, is expected to come on stream by the mid-2020s. With these two operations and other relatively minor projects, Brazil will become a large-scale lithium producer in the coming years.
- Mexico has the Sonora project (currently owned by Ganfeng Lithium of China), based on a lithium deposit in enriched clays, located in the eponymous state. It is currently under construction and is projected to contribute around 35,000 tons of battery-grade lithium per year by the middle of the decade.[21] In addition, the Mexican government recently created Lithium for Mexico (LitioMx), a State-owned enterprise whose purpose is the exploration, exploitation, benefit and use of lithium located in Mexico, as well as the administration and control of this mineral's economic value chains.
- Outside of Latin America and the Caribbean, a large number of projects are identified as under development (see annex 2). Australia, the world's largest producer, has only one project at an advanced stage for which a feasibility study has already been completed. In the other cases, the initiatives are more heterogeneous, in relation to both the type of deposit and the degree of progress. Since these are mainly projects based on "non-traditional" resources, the uncertainty surrounding their economic feasibility increases significantly. In such cases, lithium is found at lower concentration levels, and sometimes it is necessary to develop new technological productive processes, as in the case of clays, jadarite or hydrocarbon brines.

C. The lithium-ion battery value chain

- The division of labour in the lithium-ion battery value chain is bipolar. A relatively small group of countries, including those in Latin America and the Caribbean, specializes in the production of raw materials; while another group, led by China, is engaged mostly in downstream activities in the value chain. Production in the lithium-ion battery cell manufacturing segment is in a phase of rapid expansion, dominated by a small group of firms. Just seven firms of Asian origin account for an estimated three quarters of the current production capacity.
- The lithium-ion battery value chain can be broken down into five main parts: (i) lithium extraction and processing; (ii) precursor preparation; (iii) cathode sintering process; (iv) cell manufacturing; and (v) battery pack assembly (Jones, Acuña and Rodríguez, 2021a) (see diagram II.1). In general, the division of labour in the chain is clearly differentiated: on the one hand, there is a group of countries that produce lithium and its compounds (including Argentina and Chile); on the other, there is a group of countries, located mainly in Asia, that have specialized in the production of lithium-ion precursors, cells and batteries. China is the only country with a leading position throughout the value chain in the different segments, except for lithium production, where it is the world's third largest producer and is unable to supply its own domestic demand.
- The South American countries specialize in lithium mining and processing activities for the production of compounds. In Chile, Albemarle produces technical-grade and battery-grade lithium carbonate and lithium chloride, while SQM produces technical-grade and battery-grade lithium carbonate and lithium hydroxide. In Argentina, Livent produces mainly technical-grade lithium carbonate and lithium chloride. Allkem Ltd. produces both technical-grade and battery-grade lithium carbonate. In Brazil, AMG Lithium produces spodumene concentrate. In Australia, which focuses only on the extraction and production of spodumene concentrate (which is subsequently refined in China), high purity lithium hydroxide was produced for the first time at the Kwinana plant, linked to the Greenbushes operation, which is the source of the spodumene used (IGO Limited, 2021).
- The preparation of precursors prior to electrode manufacture and cell assembly is a very important step, because battery materials need a high degree of purity. China has developed a leading position in this sector —which extends to nickel and cobalt ores— despite having a relatively small geological endowment.

[21] The extraction of lithium in clay deposits requires technological-productive innovations that are globally incipient. In addition to Mexico, there are also similar deposits in the United States (Nevada) that are not operating on an industrial scale, but are under construction: the Tonopah Lithium Claims project of American Lithiums and the Tracker Pass project of Lithium Americas, whose main shareholders are the automobile company General Motors and the Chinese company Ganfeng Lithium.

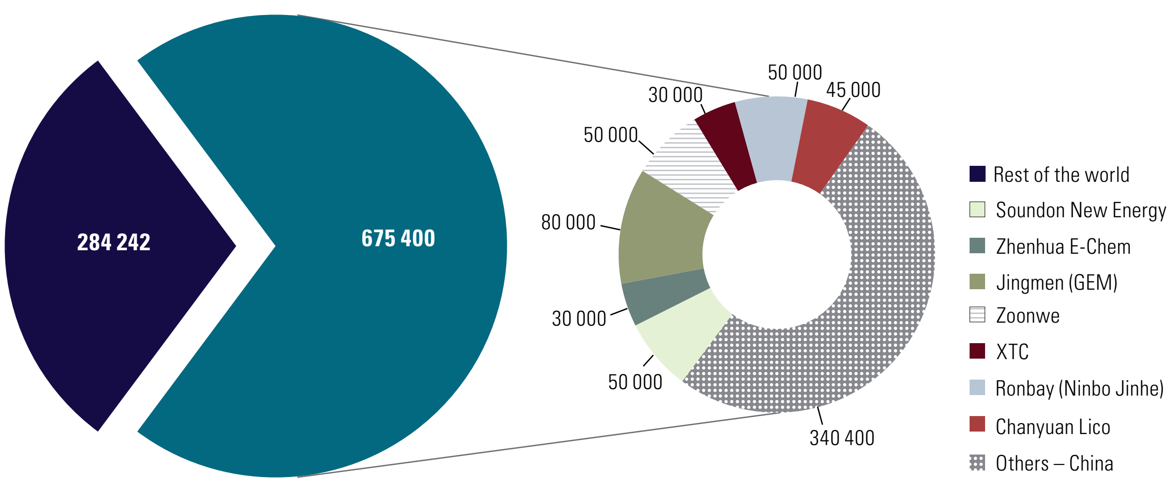
Diagram II.1 The lithium-ion battery value chain



Source: B. Jones, F. Acuña and V. Rodríguez, "Cadena de valor del litio: análisis de la cadena global de valor de las baterías de iones de litio para vehículos eléctricos", *Project Documents* (LC/TS.2021/86), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC), 2021.

- Total cathode production in 2019 was 960,000 tons (Jones, Acuña and Rodríguez, 2021a). China has the largest operators and accounts for 70.4% of world production (see figure II.7). Only Sumitomo Metal Mining (SMM), which is based in Tokyo and produces mainly nickel-metal hydride (NiMH) batteries, is among the largest producers outside China. China is also an extremely large market, containing 37 of the 57 plants operating worldwide.

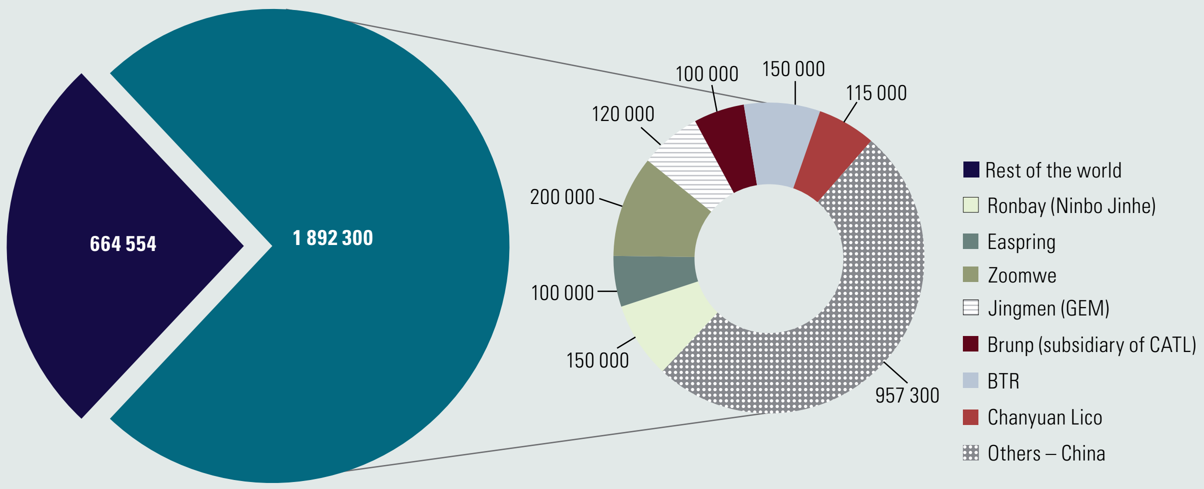
Figure II.7 China: market share of cathode production compared to the rest of the world, 2019
(Tons)



Source: B. Jones, F. Acuña and V. Rodríguez, "Cadena de valor del litio: análisis de la cadena global de valor de las baterías de iones de litio para vehículos eléctricos", *Project Documents* (LC/TS.2021/86), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC), 2021.

- In a projection to 2025, Jones, Acuña and Rodríguez (2021a) estimate that the concentration could be even greater, with China potentially accounting for 74% of global capacity (see figure II.8).

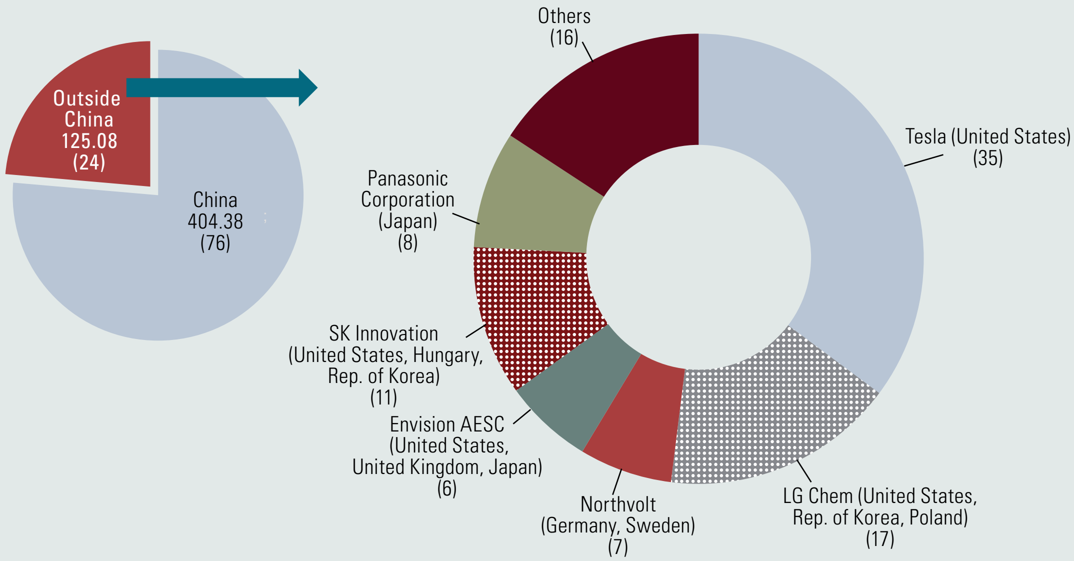
Figure II.8 China: market share of cathode production compared to rest of the world, 2025
(Tons)



Source: B. Jones, F. Acuña and V. Rodríguez, "Cadena de valor del litio: análisis de la cadena global de valor de las baterías de iones de litio para vehículos eléctricos", *Project Documents* (LC/TS.2021/86), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC), 2021.

- Cell manufacturing capacity has grown significantly in response to increased demand from the electric vehicle sector, in terms of both investment and gigafactory size. In 2015, Jones, Acuña, and Rodríguez (2021a) identified 33 factories in the CRU Consulting gigafactory database, with an average size of 1.8 GWh; in 2020, the number had risen to 77 active facilities with an average capacity of 6 GWh. By 2026, these figures are expected to grow to 107 GWh and 13.8 GWh, respectively. Thus far, cell manufacturing capacity remains dominated by China, which had 76% of global capacity in 2020, estimated at 529 GWh (see figure II.9). Total capacity outside China is 125 GWh, dominated by a small number of cell manufacturers in Japan and the Republic of Korea, as well as Tesla of the United States (Jones, Acuña and Rodríguez, 2021a).

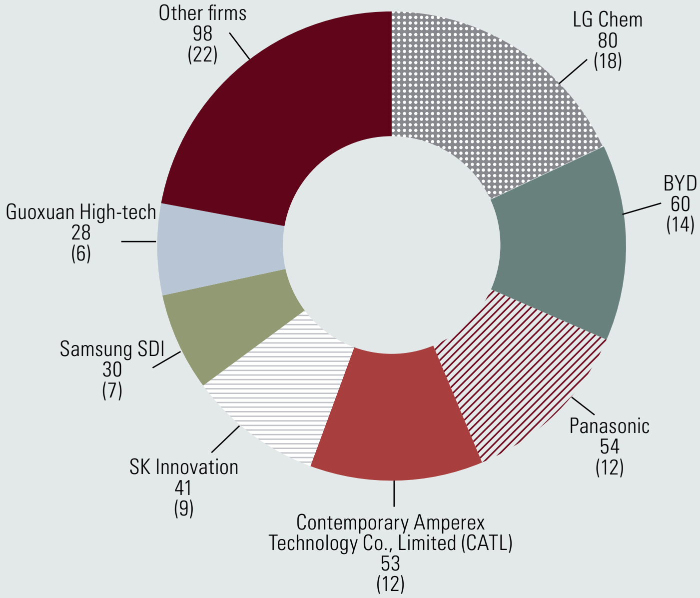
Figure II.9 Breakdown of gigafactory capacity globally and outside of China, 2020
(GWh and percentages)



Source: B. Jones, F. Acuña and V. Rodríguez, "Cadena de valor del litio: análisis de la cadena global de valor de las baterías de iones de litio para vehículos eléctricos", *Project Documents* (LC/TS.2021/86), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC), 2021.

- According to an analysis by CIC EnergiGUNE (Gisbert and Careaga, 2021), based on information from global technology leader ABB, in 2020 seven large firms accounted for over 75% of total battery cell production capacity (see figure II.10). The origins of the capital of these seven firms are distributed between the Republic of Korea (LG Chem, Samsung SDI and SK Innovation), China (BYD, Contemporary Amperex Technology Co., Limited (CATL), Guoxuan High-tech) and Japan (Panasonic). These enterprises are leaders in the development of the cell industry owing to their technological, innovation and capital capacity, while at the same time driving an ecosystem of related firms that supply inputs and technology in their respective countries.

Figure II.10 Concentration of the cell market by firm, 2020
(Gigawatt hours and percentages)

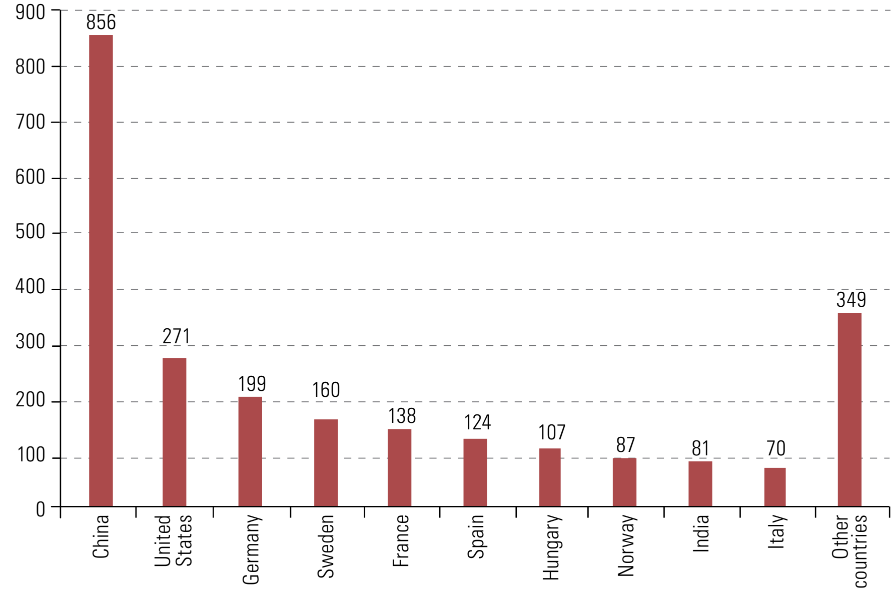


Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of N. Gisbert and I. Careaga, "Who are the big players in the gigafactories race?", Alava, CIC EnergiGUNE, 2021 [online] https://cicenergigune.com/en/blog/big-players-gigafactories-race.

- At the same time, the aforementioned enterprises are making agreements to supply the electric vehicle market. For example, LG Chem has set cell supply targets for producers such as General Motors and Volkswagen. Tesla has a strategic alliance with Panasonic, its main supplier, but has also forged alliances with LG Chem and Samsung, from the Republic of Korea, and with China's Contemporary Amperex Technology Co., Limited (CATL) to develop the Shanghai gigafactory. The BYD group of Chinese technology firms —which encompasses businesses spanning passenger and road freight vehicles, batteries, renewable energies, electronics and rail transport— has an alliance with the automaker Toyota and is one of its main suppliers.
- Various press sources and recent announcements of new plant installations indicate that global cell production capacity is set to grow exponentially. According to a dynamic survey conducted by CIC EnergiGUNE, based on the various announcements and published originally in October 2021, China accounted for more than 34% of the announced capacity, followed by the United States with 11% and Germany with 8% (see figure II.11) (CIC EnergiGUNE, 2021).

Figure II.11 Cumulative announced capacity by country, 2021

(Gigawatt hours)

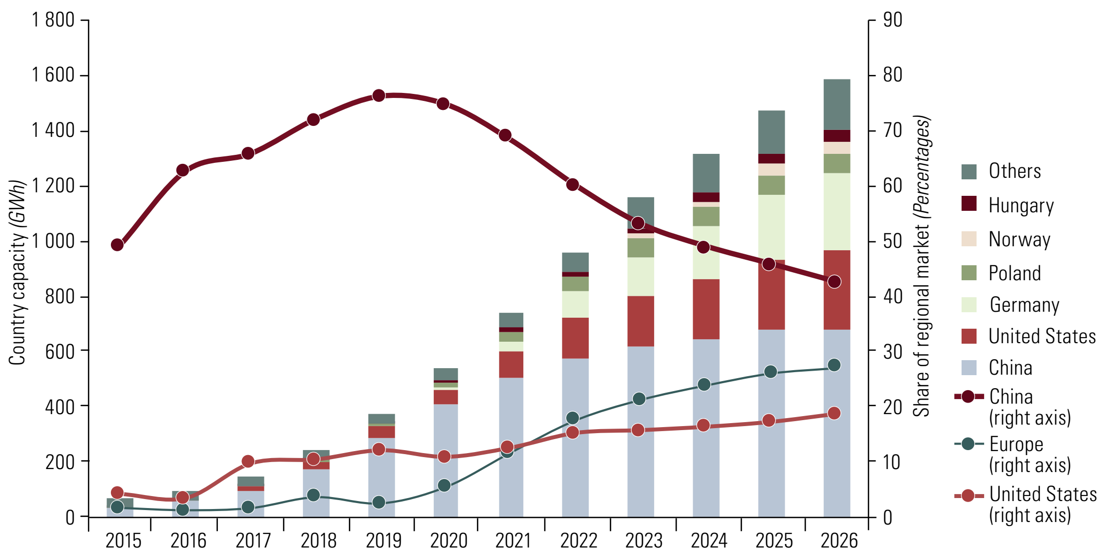


Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of CIC EnergiGUNE, "World map of gigafactories", Alava, 2021 [online] https://cicenergigune.com/en/blog/world-map-gigafactories.

- It should be noted that the date on which the investments will actually be made is highly uncertain, depending largely on the financial capacity to do so. Moreover, an analysis of the announcements shows that not all of the firms have a track record in the market; so the current leading firms will likely account for most of the investments in capacity expansions. Even with the prospect of production plants in Europe, a projection to 2026 by Jones, Acuña and Rodríguez (2021a) shows that almost 50% of the capacity is likely to remain in China (see figure II.12).

Figure II.12 Battery cell manufacturing capacity by country and regional market share, 2015–2026

(Gigawatt hours and percentages)



Source: B. Jones, F. Acuña and V. Rodríguez, "Cadena de valor del litio: análisis de la cadena global de valor de las baterías de iones de litio para vehículos eléctricos", *Project Documents* (LC/TS.2021/86), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC), 2021.

D. Opportunities and challenges for Latin American and Caribbean countries in lithium exploitation and value-added

- The energy transition and, in particular, the expansion of electromobility and renewable energies present both opportunities and challenges for lithium-abundant countries. The opportunities stem mainly from burgeoning demand, which, as noted above, is expected to multiply several times over in the coming decades. The most immediate possibilities are those arising from lithium extraction and refining activities: export growth, job creation, increased tax revenues and the forging of productive links. There are also possibilities related to the creation of knowledge-intensive capacities that can be generated from the use of the resource and foster a structural change process.
- The greatest challenges relate to initiatives seeking to process lithium locally for the production of lithium-ion battery cells or their components. Production activities in the downstream segments of the value chain face entry barriers, stemming mainly from the need for high levels of financing, difficulties in accessing other critical materials and complex requirements in terms of technological know-how. Moreover, the installation of a lithium-ion battery cell industry is closely related to the prospects for the development of a large-scale electromobility industry in a nearby geographic region. There are also challenges of a different type, linked to the growing demands of social and environmental sustainability in lithium mining, which is giving rise to ever-more demanding standards from raw material consumption markets.

1. Opportunities for lithium-rich countries: production volume and technological and productive capacities

- The expansion of lithium mining is reflected in export growth, increased job creation, and opportunities to grow tax revenues and create productive linkages through the establishment of a supply chain. However, the potential benefits offered by lithium mining are commonly viewed as a “window of opportunity” that is likely to close within a few years. This time constraint could be explained by several factors. Firstly, alternative battery technologies are being developed that are less lithium-intensive or do not use lithium at all (for example, sodium-sulphur batteries or hydrogen fuel cells). Secondly, owing to the growing demand for lithium, several countries that were previously outside the industry have either intensified their exploration projects, started to develop new types of deposits, or are endeavouring to increase the volume of small-scale operations (Obaya and Céspedes, 2021). A third factor is the increased use of lithium recovered from battery recycling as a source of input for the manufacture of lithium-ion batteries (Jiménez and Sáez, 2022).
- Although these factors are certainly present in the development of the industry, it is not easy to put a deadline on this “window of opportunity”, as they are subject to a high degree of technological uncertainty. Moreover, even if the threats in question were to materialize, the demand for lithium produced in Latin America and the Caribbean would not disappear. The region would also remain among the lowest-cost sources of production, given the competitive advantages of salt flats over deposits of other types.
- Beyond the direct effects generated by lithium mining, there are also indirect opportunities, related to the creation of new, more technologically complex, capacities that can be generated from the use of the resource. References for processes of this type, are countries that have been successful in establishing sustained development processes over time, leveraged on natural-resource-based productive activities, including Australia, Canada, Norway, Sweden or even the United States (Ramos, 1998; Blomström and Kokko, 2007; Smith, 2007; Wright, 2015; Andersen, Marín and Simensen, 2018). These capacities would remain available for use in other activities of the production system, even if lithium mining activity declines. From this perspective, capacity building centred on lithium-related activity, in both the industrial and the service sectors, would contribute to a process of structural change, towards an economy based on more knowledge-intensive activities.
- However, taking advantage of these opportunities requires State participation, as demonstrated by the experiences of countries that have successfully generated sustained development founded on natural-resource-based production activities. This implies implementing a productive development agenda or a policy centred on lithium and other strategic minerals, to generate promotional actions and facilitate the provision of certain public goods that contribute to the creation or strengthening of capacities. For example, soft infrastructure, such as human resource

training, is needed in areas related to both extraction and refining in lithium mining, as well as its use as an input in different industrial production activities (such as the production of active materials or nuclear energy). This process also requires the creation of hard infrastructure, such as laboratories or pilot plants for the creation and dissemination of scientific knowledge.

2. Challenges for lithium-rich countries: progressing in the value chain and sustainability

- Latin American and Caribbean countries with lithium resources have implemented (or are in the process of implementing) a variety of policies aimed at advancing downstream in value chains that use lithium as an input. As noted above, because of its size and dynamism, the value chain for lithium-ion batteries used in electromobility is a key leading example. Scaling-up in this value chain, however, presents major challenges that need to be taken into account when investing public funds to promote it. These include the large volume of financing required to install cell factories; the need to access other critical minerals (such as cobalt, graphite and nickel), the supply of which is subject to strong international competition; and the complex technological capabilities and investment in research and development (R&D) required to enter this value chain, in which technological change is rapid.
- Furthermore, the development of a large-scale lithium-ion battery cell industry with capacity to process a substantial portion of the lithium produced by the region, requires the development of an electric vehicle industry that generates demand for these batteries. As the experiences of Asia, Europe and the United States show, automotive firms prioritize strategies of geographic co-location with the battery firms,[22] to enhance their competitiveness. Accordingly, when designing a strategy of productive linkage with downstream segments in any value chain that uses lithium as an input, the capacities and conditions needed to do so must be evaluated.
- Last but not least, the expansion of lithium mining, whether or not on an industrialized basis, faces environmental and social challenges. As with any activity involving the exploitation of natural resources and, in particular, activities of an extractive nature, lithium mining entails risks in both dimensions. Civil society organizations, local communities living near the salt flats and the scientific community are among those who have raised alarm and called for stricter regulations and standards to ensure the sustainability of the activity (see chapter III).
- More recently, countries and firms that obtain lithium resources have joined this group in demanding higher social and environmental standards. They have started to demand that its extraction and processing fulfil conditions that respect the environment and uphold human rights, and that due diligence criteria be met in the mineral supply chain. This is in response to growing pressure from consumers and the implementation of new legislation (regulatory and supervisory frameworks) in more industrialized countries. Examples include the 2021 German law on due diligence in supply chains, which entered into force on January 1, 2023,[23] or the proposed European Union regulation on batteries and their waste products which the European Commission is set to adopt in the next few months.[24]
- Firms operating downstream in the value chain are gradually starting to adopt the standard of the Responsible Mining Assurance Initiative,[25] which offers third-party certification at the mine level. In the electromobility chain, firms such as BMW, Ford, General Motors, Volkswagen and Tesla are among this group. The Initiative for Responsible Mining Assurance (IRMA) involves multiple stakeholders, including the private sector, local communities, civil society and workers. Thus far, members include SQM and Albemarle, in Chile, and Livent, in Argentina; while Lithium Americas, which has operations in Argentina, is in the process of gaining admission.

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[22] Co-location refers to the strategy of locating the activities in a firm's value chain close to each other. Examples include production and innovation (for example research and development or development, design and testing), or else firms that provide innovation services to multinationals in the pursuit of benefits, such as those related to coordination, integration and travel and transportation costs, among others. This strategy may also be motivated by re-shoring (Belderbos and others, 2016).

[23] This law requires firms with 1,000 or more employees to perform due diligence in their supply chains in terms of respect for internationally recognized human rights and certain environmental standards. The law refers to the United Nations Guiding Principles on Business and Human Rights. See Germanwatch and others, "Initiative Lieferkettengesetz" [online] https://lieferkettengesetz.de/en/.

[24] The draft regulation states that the economic operator placing a battery on the European Union market must establish a supply chain due diligence policy, which, given the risk, must be based on internationally recognized due diligence principles, such as the 10 principles of the United Nations Global Compact, the United Nations Environment Programme (UNEP) Guidelines for Product Social Life Cycle Assessment, the International Labour Organization (ILO) Tripartite Declaration of Principles Concerning Multinational Enterprises and Social Policy and the OECD Due Diligence Guidance for Responsible Business Conduct. For further information, see European Commission (2020).

[25] Further information is available [online] at https://responsiblemining.net/.

III. Governance models

- The countries of the lithium triangle have adopted various approaches to address the opportunities and challenges offered by the mineral. This is reflected in the instruments deployed and the use of public funds. In other words, the countries of the region have different models of lithium "governance".
- Governance is a multi-meaning concept which refers to the collective capacity to govern. In addition to the different levels of government, which are the actors with formal responsibilities, there are private and social actors of different types that participate in the decision-making process. In the case of non-renewable natural resources, governance "entails regulating ownership, the forms of appropriation and the distribution of the profits reaped from natural resources, so that society as a whole can benefit from their exploitation" (Bárcena, 2016). Thus, natural resource governance is defined analytically as the governance of the processes of interaction and decision-making among various governmental and non-governmental actors involved in a collective problem related to the management of natural resources (ownership, access, extraction, use, conservation, appropriation and distribution of rents). In a given context, this leads to the creation, reinforcement, reproduction or change of institutional rules, both formal and informal, to resolve conflicts of interest over these resources between the actors involved (León and Muñoz, 2019).
- This chapter analyses specific aspects of governance: the regulatory framework governing lithium mining, initiatives for adding value to and industrializing lithium, environmental and social legislation and, lastly, the tax regime applicable to the activity.

A. Regulatory framework

- Table III.1 summarizes the key characteristics of the regulations governing lithium mining in each of the lithium-triangle countries. Argentina has a federal regime that is open to private capital and foreign investment, in which the provinces retain original ownership of the resource. At the other extreme, the Plurinational State of Bolivia has a unitary regime, in which lithium has been declared a strategic resource and its use has been reserved exclusively to the national State. The Chilean regulatory framework shares some of the characteristics of both neighbouring countries. It also declares lithium to be of national interest (although for its potential nuclear use rather than for economic reasons). Consequently, lithium is defined as a non-concessionable resource, with its use reserved to the government or its enterprises, or by means of (not judicial) administrative concessions or special operating contracts with non-State third parties. These are subject to the requirements and conditions that the President of the Republic establishes on a case-by case basis, through a supreme decree. Nonetheless, lithium has always been exploited by private firms, since the activity is carried out on land that had been assigned by law to the Production Development Corporation (CORFO) before non-concessionability was declared.

Table III.1 Argentina, Chile and the Plurinational State of Bolivia: analysis of the regulatory framework governing lithium

Dimension	Argentina	Bolivia (Plurinational State of)	Chile
Type of regulation	General mining regulations (with specific legislation at the provincial level)	Lithium declared a strategic resource Specific regulations	Lithium declared of national interest (or "strategic resource") Specific regulations
Lithium governance regime	Federal	Centralized	Centralized
Coverage of the regulations	Activities related to the exploitation of the resource	Activities related to the exploitation and industrialization of the resource	Activities related to the exploitation of the resource, with a quota reserved for industrialization through the Corporación de Fomento de la Producción (CORFO)
Resource exploitation modalities	Concessions to private firms Jujuy: shareholding in a provincial State-owned enterprise (Jujuy Energía y Minería Sociedad del Estado (JEMSE))	Public Company (Yacimientos de Litio Bolivianos (YLB))	Agreement between CORFO and private actors (lease contracts) Possible modalities, but not currently applied: the State or its enterprises, or through administrative concessions or special operating contracts with third parties

Source: Economic Commission for Latin America and the Caribbean (ECLAC).

- The following paragraphs provide a brief description of each regulatory framework, with some of their features discussed in greater depth further below.

1. Argentina

- The Argentine regulatory framework gives rise to a federal governance system that is open to private investment. In this system, the provinces and the national State have several joint responsibilities and some exclusive ones (see table III.2). The regulatory framework of the State is founded on three pillars: the National Constitution, the Mining Code and the Mining Investments Act. Article 124 of the 1994 Constitution establishes that natural resources originally belong to the provinces. The Mining Code provides that individuals or legal entities may acquire ownership of lithium mines through concessions granted by the competent authority.

Table III.2 Argentina: functions of the federal government and provinces with respect to lithium

Subject matter or legislation	National government	Provincial government
Control of natural resources		Constitution of 1994
Rights, obligations, and procedures relating to the acquisition, exploitation, and use of mineral substances	Mining Code	Provincial codes of mining procedures and mining authority regulations
Investment promotion regime	Mining Investments Act, No. 24.196 of 1993	Provincial adherence to the national regime Local promotion laws
Standards on the environment and on participation by citizens, including indigenous peoples	General Environment Act (No. 25,675) Mining Code Amendment Act (No. 24.585) Act Approving the Escazú Agreement (No. 27.566) Act on Free Access to Public Environmental Information (No. 25.831) Act approving Convention 169 of the International Labour Organization concerning Indigenous and Tribal Peoples in Independent Countries (No. 24.071)	Provincial codes of mining procedure sand mining authority regulations that specify compliance with national regulations Provincial laws (on Environmental Impact Assessments (EIA))
Tax regime	Act No. 27.541 of 2019 and regulatory decrees on export duties. Income Tax Act (Decree No. 620 of 2021) Act No. 27.111 of 2014 (updates the mining royalty)	Provincial tax laws and codes (royalties) Fiduciary agreements between provincial governments and firms

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of C. Freytes, M. Obaya and V. Delbuono, *Federalismo y desarrollo de capacidades productivas y tecnológicas en torno al litio*, Buenos Aires, Fundar, 2022.

- Lastly, the Mining Investments Act offers a number of incentives to private investment. Essentially, it provides tax stability for a 30-year period and incentives aimed at reducing the cost of investment, especially during the initial years of activity: deduction of prospecting and exploration expenses, accelerated amortization of investments, and tax exemptions on imported capital goods, equipment and specific inputs. The law places a 3% cap on provincial royalties, calculated on the pithead value.

- The provinces' functions in the management of mining properties include administering permits, regulating the exploitation of the salt flats, implementing consultation and social participation processes, and monitoring operations, among others. Each of the provinces has specific organizational structures and procedures, which results in a heterogeneous mosaic.

- The firm YPF Lithium was recently created as a publicly traded subsidiary of YPF S.A., in which the Argentine State has majority control— to enable the national State to participate indirectly in lithium exploitation projects in the provinces.

2. Plurinational State of Bolivia

- The Bolivian regulatory framework considers lithium a strategic resource and provides the government with wide-ranging regulatory and production powers to manage the country's evaporite resources. Article 351 of the Political Constitution of the State gives the national government authority over all fiscal reserves and "control and direction over the exploration, exploitation, industrialization, transport and commercialization of strategic natural resources" (Government of the Plurinational State of Bolivia, 2009).
- In this context, as discussed in greater detail below, in 2010 the government launched the National Strategy for the Industrialization of Evaporite Resources, to be financed by the Central Bank of Bolivia. This programme encompasses the entire value chain and defines a series of milestones, such as the production of lithium carbonate and the installation of research centres and production plants for cathode materials and lithium-ion batteries (GNRE, 2011; Borja, 2018).
- In 2017, through Act No. 928, the government created the strategic public enterprise Yacimientos de Litio Bolivianos (YLB), which has built pilot lithium carbonate, cathode material and battery assembly plants. It has also built a potassium chloride industrial plant which has already come on stream, and it has begun construction of a lithium carbonate plant (Montenegro, 2018).

3. Chile

- Decree Law No. 2886 of 1979 made lithium the exclusive preserve of the Chilean State, because it was considered a material of nuclear interest. The law also established that private parties could not obtain exploration and exploitation concessions that would allow them to appropriate lithium once it had been extracted. The exploration, exploitation and benefit of substances classified as not subject to mining concessions, as in the case of lithium, can be conducted directly by the State or by its enterprises, or else through administrative concessions or special operating contracts granted to private parties (Poveda, 2020).[26]
- Exemptions from this rule were granted to ownership claims established (or in the process of being established) before the regulation entered into force in 1979. These included CORFO land in the Salar de Atacama, which are currently operating under the control of SQM and Albemarle (Poveda, 2020). The lease agreements with these firms were renegotiated between 2016 and 2018. In addition to the possibility of increasing the production volume, the new contracts represent a paradigm shift in the relationship with the firms. Since their signing, the State's capacity to capture the economic rent from the resource has increased significantly. A royalty was established which is applied on a marginal basis according to the price of the product and rises progressively from 6.8% to 40%. Part of the income captured is earmarked for specific purposes, linked to the creation of productive and technological linkages or the relationship with the communities.

B. Lithium value-added and industrialization initiatives

- In the three countries of the lithium triangle, public policies have been implemented to promote the development of productive and technological capacities linked to this mineral. These can be grouped into a productive development agenda or policy centred on lithium. The set of instruments available (or that can be used) depends largely on the characteristics of each country's legal regime, as discussed in the previous section. Consequently, the approaches adopted, the activities prioritized, and the tools used to promote them vary widely across the region.
- Table III.3 summarizes the main elements reviewed in the section. In Argentina, actions have focused mainly on financing the science and technology system, based on a relatively large number of small-scale projects (compared to the other countries). In the Plurinational State of Bolivia, initiatives led by the strategic public enterprise, YLB, have been promoted to develop the entire value chain, from brine extraction and lithium carbonate production to battery production. In Chile, a strategy has been adopted since 2019, based on international bidding for quotas of lithium compounds at a preferential price, for firms interested in industrializing the resource in

[26] This is established in the Political Constitution of the Republic of Chile of 1980 (article 19 (10) subparagraph 24) and in the Mining Code (article 8).

their territory. Research and development centres have also been created on topics related to the circular economy, electromobility and the development of clean technologies, financed with contributions from the firms operating in the salt flats. Recently, an intention to create a public lithium enterprise has been expressed, which would operate in partnership with private capital.

Table III.3 Argentina, Chile and the Plurinational State of Bolivia: main instruments used to promote productive and technological capacities related to lithium

	Argentina	Bolivia (Plurinational State of)	Chile
Appropriation of the product	Free for the operating firms	Controlled by Yacimientos de Litio Bolivianos (YLB)	Free for the operating firms and, through the Production Development Corporation (CORFO), with a 25% quota reserved at a preferential price for industrialization projects
Instruments for lithium processing in downstream activities	Possibility of using a share of Jujuy Energía y Minería Sociedad del Estado (JEMSE) for industrialization in the province of Jujuy	Possibility of partnership with private firms	Share tenders at preferential prices for industrialization projects, through CORFO
Science, technology and innovation	Public funding from the National Research,Technological Development and Innovation Promotion Agency (Agencia I+D+i) Public financing for researchers and scholarship holders of the National Council of Scientific and Technical Research (CONICET) UniLiB Project (YPF Tecnología (Y-TEC) and academic community)	Pilot plants Centre for Research in Science and Technology of Materials and Evaporite Resources of Bolivia (CICYT-MAT-REB), Centre for Research, Development and Pilot Projects (CIDYP)	Bidding for research and development centres, financed with funds generated from the agreements, through CORFO

Source: Economic Commission for Latin America and the Caribbean (ECLAC).

- Given that these initiatives are relatively recent, especially in the cases of Argentina and Chile, no consideration has been given to measuring their impact on lithium value-added and industrialization activities.

1. Argentina

- The nature of the Argentine federal system makes it necessary to identify the initiatives implemented by the different levels of government. In the case of the national government, these include the financing of science, technology and innovation activities. The participants in this system have been highly active with respect to lithium. According to Freytes, Obaya and Delbuono (2022), 236 researchers and doctoral and postdoctoral fellows of the National Council of Scientific and Technical Research (CONICET) worked on lithium-related topics between 2011 and 2021. Of these, 52% focused their research on topics related to batteries and their compounds.
- Another important financing channel is provided by Agencia I+D+i, in particular the Scientific and Technological Research Projects (PICT) and the Argentine Technological Fund (FONTAR). Also in this case, 49% of the funding was allocated to batteries and their compounds. The PICT initiative finances projects oriented mainly towards academic activities. Between 2011 and 2021, 26 lithium-related projects were funded, each receiving an average of US$ 58,651. In the case of FONTAR, in which the private sector participates, 12 projects were defined that, on average, received US$ 195,692 (Freytes, Obaya and Delbuono, 2022).
- The firm YPF Tecnología (Y-TEC), owned by YPF S.A. and CONICET, along with the Instituto de Investigaciones Fisicoquímicas Teóricas y Aplicadas (INIFTA), a CONICET centre, and the National University of La Plata (UNLP) are promoting another initiative in the area of science and technology, titled UniLiB. This was launched in 2021, with the aim of building a plant to manufacture lithium-ion cells and batteries, with a production capacity of 13 MWh per year. The project is aimed mainly at dismantling the technological package for the design and manufacture of lithium-ion cells and batteries and the training of skilled human resources at each stage of the value chain.

- There are also other initiatives that involve cooperation between the national government, through the National Institute of Industrial Technology (INTI), an autonomous entity that operates within the Ministry of Productive Development, and the ministries of production of the provinces involved, together with several key business chambers. One such project aims to develop the lithium mining value chain by providing services to microenterprises and small firms. The aim of this instrument is to enable these firms, which do not have a track record, to upgrade to the safety and quality standards required by this activity. The INTI strategic area of technological development and research is also planning projects on energy storage and the circularity of lithium-ion batteries.
- Another interjurisdictional initiative, which is also being developed in the province of Jujuy, is the Centre for Research and Development in Advanced Materials and Energy Storage of Jujuy (CIDMEJU). This is a tripartite interjurisdictional unit, which has been operating since 2015 and depends on CONICET, the National University of Jujuy (UNJU) and the government of the Province of Jujuy (represented by the province's Science and Technology Secretariat). Its activities include research projects covering both the extraction and processing stages, along with the development of by-products and research and development (R&D) on batteries and their components (Obaya, López and Pascuini, 2021).
- In provinces that have lithium resources, productive development actions have focused on "buy local" legislation (local content policies). This mechanism, which has been formalized in Salta (Provincial Act No. 8164) and Catamarca (Ministry of Mining Resolution No. 498 of 2014) sets the minimum participation requirements for local suppliers and labour at 60%–70%.
- In the case of the province of Jujuy, lithium was declared a resource of strategic interest through Decree-Agreement No. 7592 of 2011, and considered as a "generator of socioeconomic development" of the province. In this context, the public enterprise Jujuy Energía y Minería Sociedad del Estado (JEMSE) was created in 2015, holding an 8.5% interest in the two firms operating in the province: Sales de Jujuy and Minera Exar. In addition, JEMSE has preferential right to sell a 5% share of the lithium carbonate produced by the firms in which it participates. The purpose of this share is to attract firms to the province to process the resource through manufacturing activities. Thus far, no use has been made of this right.

2. Plurinational State of Bolivia

- The main actions aimed at developing productive and technological capabilities in the Plurinational State of Bolivia are framed by the National Strategy for the Industrialization of Evaporite Resources, which was presented in 2010. Its key milestones are summarized in table III.4.

Table III.4 Plurinational State of Bolivia: phases of the lithium industrialization strategy

Phase	Description	Government investment *(Millions of dollars)*	Financing	Estimated production year	Technology
I	**Research and pilot plants** Research and development of the technological process of exploitation of the salt flat. Construction and start-up of pilot plants producing potassium salts (potassium chloride and potassium sulphate) and lithium carbonate.	19	100% by the Bolivian State	2012	Bolivian
II	**Industrial plants** Construction and start-up of industrial plants producing lithium carbonate (30,000 tons per year) and potassium salts (700,000 tons per year).	485[a]		2016	
III	**Industrialization of lithium** Production of cathode materials, electrolytes and lithium-ion batteries.	400		2014	Technology transfer partners

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of M. Obaya, "Estudio de caso sobre la gobernanza del litio en el Estado Plurinacional de Bolivia", *Project Documents* (LC/TS.2019/49), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC), 2019; National Office of Evaporite Resources (GNRE), *Memoria Institucional 2011,* La Paz, Bolivian Mining Corporation (COMIBOL), 2011; *Memoria Institucional 2010*, La Paz, Bolivian Mining Corporation (COMIBOL), 2010; Yacimientos de Litio Bolivianos (YLB) [online] https://www.ylb.gob.bo/.

[a] According to GNRE (2010), the investment will be distributed as follows: US$ 255 million for the potassium chloride plant, US$ 174 million for the lithium carbonate plant and US$ 56 million for infrastructure works.

- In accordance with the legal regime described in the previous section, the Bolivian approach has two key features. First, the strategy covers the entire value chain: from the production of lithium carbonate and other salts from resources present in the salt flat, through to battery production. Secondly, this strategy is controlled by the national government. Private firms can only enter the battery production phase, with the main objective of transferring technology, always in partnership with the State and as a minority shareholder.
- Although the deadlines set originally in the strategy were not met, progress was made on initiatives that made it possible to increase the infrastructure necessary to carry out productive, scientific and technological activities. The key achievements in the initial phases include the inauguration of a potassium chloride plant in 2018 (albeit with a lower-than-projected capacity of 350,000 tons per year), the construction of a lithium carbonate pilot plant, inaugurated in 2013, and the start of construction of an industrial-scale plant. In the resource processing segments, the Research, Development and Pilot Plant Centre (CIDYP) was created to supervise, manage and coordinate projects related to lithium batteries, active materials for cathodes, lithium electrolytes and other advanced products. This centre comprises two pilot plants, one for batteries and the other for cathode materials, and a Centre for Research in Materials Science and Technology and Evaporite Resources of Bolivia (CICYT-MAT-REB) (Obaya, 2019).
- In 2017, YLB was created. After a selection process, YLB chose the German firm ACI Systems to produce lithium hydroxide from the residual brines that would be generated by YLB's production of lithium carbonate. In December 2018, the YLB-ACISA joint venture was created and it was agreed to set up another firm specialized in the production of cathode material and batteries. However, then-President Evo Morales dissolved this partnership in November 2019, following a period of intense protests in the Potosí region, led by the Potosinista Civic Committee (COMCIPO).
- The government of Luis Arce launched a process to select firms interested in developing direct extraction methods in Bolivian salt flats. In 2021, YLB issued an international call for interested firms to conduct pilot tests.[27] The aim of the process is to evaluate firms with experience and technology capable of adapting to the characteristics of the brines of these salt flats, by applying new technologies for direct lithium extraction. Proposals were received from 20 firms, six of which were pre-selected. The analysis of the results of the pilot tests of the proposals indicates that all the technologies evaluated would be applicable to the Uyuni, Coipasa and Pastos Grandes brines, attaining lithium recovery rates of above 80% and even 90% (YLB, 2022a and 2022b). On 20 January 2023, YLB published the results of the bidding process and signed an agreement with the Chinese consortium CBC, formed by Contemporary Amperex Technology Co., Limited (CATL), Guangdong Brunp Recycling Technology and CMOC Group Limited for the installation of two lithium industrial complexes in the Coipasa (Oruro) and Uyuni (Potosí) salt flats using direct lithium extraction technology.[28]

3. Chile

- The contracts negotiated by CORFO with the firms Albemarle and SQM set a quota of up to 25% of the production capacity which the firms would have to supply at a preferential price for the local processing of lithium compounds. Between 2019 and 2020, two tenders were held to allocate the quota among interested firms.[29] Only one firm agreed to participate.[30] This was a small Chilean enterprise, Nanotec, which was developing a process to manufacture lithium nanoparticles as an input for battery manufacture. Given the characteristics of the product developed and the incipient state of the market for the product developed by Nanotec, the volume of resources used by the firm will probably be well below the 25% available in the quota, at least during the first few years.

[27] See Yacimientos de Litio Bolivianos (YLB), "Convocatoria Internacional Extracción Directa de Litio (EDL)" [online] https://www.ylb.gob.bo/archivos/notas_archivos/convylb.pdf.

[28] Based on news from YLB, the agreement envisages an investment of more than US$ 1 billion and a production capacity of 25,000 tons of battery-grade lithium carbonate per year, at 99.5% purity, for each complex. In addition, it involves semi-industrialization processes, under the sovereign model, in which the Bolivian State controls the entire production chain (YLB, 2022a and 2022b).

[29] In August 2022, CORFO announced a new call for proposals, which will be launched on August 31 and will remain open for one year (CORFO, 2022).

[30] The other selected firms —Sichuan Fulin Industrial Group (China), Samsung SDI, POSCO (Republic of Korea) and Molymet (Chile)— withdrew their projects. For further details of the process, see Obaya and Céspedes (2021).

- The new contracts also establish contributions for the creation of research and development centres. In the case of Albemarle, an amount was set that rises progressively from US$ 6 million to US$ 12.4 million per year, while for SQM the equivalent figure rises from US$ 10.7 million to US$ 18.9 million per year. This totals more than US$ 510 million by 2043. CORFO has already concluded the three processes planned for the creation of the centres (see table III.5).[31]

Table III.5 Chile: research and development centres created with contributions from contracts with the Production Development Corporation (CORFO)

Year of award	Name of centre	Leader and concession-holders (consortium)	Financing	Objectives
2019	Technological Centre for Circular Economy (CTEC)	Centre for Innovation and Circular Economy (CIEC) of Iquique Members: Arturo Prat University, University of Antofagasta, University of Atacama, Catholic University of the North, University of Chile, University of Santiago, University of Tarapacá, Pontifical Catholic University of Chile, APTA Hub and Know Hub.	US$ 21.5 million for a 10-year period, with funds coming from the contract with Albemarle (US$ 10 million), the regional government of Tarapacá US$ 4.9 million), the private sector, universities and study centres (US$ 6.6 million).	To create an institution that facilitates innovation and scales up to commercialization of circular-economy-oriented enterprises and ventures. Targets: solar energy, lithium salts, lithium batteries and energy storage, and metallic and non-metallic mining.
2020	Centre for Sustainable Acceleration of Electromobility (CASE)	University of Chile Members: Energy Sustainability Agency, Mario Molina Centre, University of Santiago, Metropolitan University of Technology, Austral University of Chile, and Ernst & Young (EY).	US$ 7 million for a five-year period, with funds from the Albemarle contract (but capped at 80% of the total cost of the proposal), and with contributions from the winning bidder (up to 20%). It is supported by the Ministry of Energy and the Ministry of Transportation and Telecommunications.	To create and scale-up technology providers and users of electromobility-related services. Increase electric load distribution systems, more sustainable electric power self-generation and the development of technical and professional capacities; and contribute to the increase in national demand for technologies that use copper and lithium.
2023	Institute of Clean Technologies (ITL)	Association for the Development of the Technological Institute (ASDIT) Members: Alta Ley Corporation, Association of Industrialists of Antofagasta (AIA), Northern Catholic University (UCN), Antofagasta University (UA), Pontifical Catholic University of Chile (PUC), Pontifical Catholic University of Valparaíso (PUCV), University of Chile (UCH), University of Concepción (UDEC), University of Santiago (USACH), University of Talca (UTALCA), University of Tarapacá (UTA), Federico Santa María Technical University (USM), Adolfo Ibáñez University (UAI) and eight research and R&D centres.	US$ 209 million by 2030, with funds from the contract with SQM (60%), and direct contributions from the successful bidder (40%). Based on information from ASDIT, these direct contributions do not take into account the reinvestment of profits from the provision of technological service by ASDIT, estimated at US$ 64 million.	To promote solar energy, sustainable mining, advanced materials from lithium and other minerals, and green hydrogen. The initiative will be implemented in the Antofagasta region.

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of Production Promotion Corporation (CORFO).

[31] The award of the Clean Technologies Institute (ITL) to the consortium Association for the Development of the Technological Institute (ASDIT) was finally decided by CORFO in April 2023, after the Supreme Court annulled in July 2022 the first award to the Associated Universities Inc. (AUI), published in January 2021, which ruled in favour of the appeal for protection filed by rectors of Chilean universities.

C. Environmental sustainability and social participation

- As is the case with other activities that use natural resources intensively, such as agriculture or hydrocarbon extraction, mining is one of the activities that have the greatest impact on the environment. In the case of lithium, the growing demand fuelled by the energy transition process generates socioenvironmental tensions that pose major challenges to governance regimes.
- In the countries of the lithium triangle, regulatory frameworks have been developed that establish mechanisms for environmental assessment and social participation. In all cases these include the commitment to conduct the free, prior and informed consultation established in the Indigenous and Tribal Peoples Convention, 1989 (No. 169) of the International Labour Organization (ILO) (see table III.6). However, it is undeniable that the quality of their implementation and their effectiveness in addressing the challenges mentioned varies, not only between countries, but also within each one, depending on the different communities, mining operation cycles and specific geographic characteristics.

Table III.6 Argentina, Chile and the Plurinational State of Bolivia: arrangements for environmental regulation and social participation

Regulatory framework	Citizen participation and indigenous consultation
Argentina	
The national government issues the norms that contain the minimum protection budgets, while the provinces issue those needed to complement them (Constitution of the Argentine Nation, art. 41). Minimum budgets are rules that grant uniform or common environmental oversight for the whole national territory and impose the conditions needed to ensure environmental protection (General Environment Act No. 25,675). The environmental impact assessment (EIA) is the process that makes it possible to determine, predict, evaluate and mitigate the potential negative effects that a project, work or activity may cause to the environment, in the short, medium and long terms, before deciding to execute it. The implementation and regulation of the procedure is the responsibility of the provincial authorities.	To authorize activities that may have significant negative effects on the environment, the authorities must institutionalize mandatory consultation procedures or public hearings. Citizen participation should be ensured mainly in environmental impact assessment (EIA) procedures and in environmental land management plans and programmes, particularly in the planning and performance evaluation stages. Since the implementation and regulation of the procedure is the responsibility of the provincial authorities, each province will regulate and evaluate the impact of the projects in its territory. The Indigenous and Tribal Peoples Convention, 1989 (No. 169) of the International Labour Organization (ILO), which establishes the obligation of free, prior and informed consultation, is current law. However, the implementation of such consultation is not yet regulated.
Bolivia (Plurinational State of)	
The Plurinational State of Bolivia has a normative and institutional framework for the environmental regulation of activities, works and projects carried out within its territory. This is aimed at prevention, monitoring and environmental control of economic and productive activities. There are general environmental regulations, defined by the Environment Act, and sectoral regulations such as those governing the mining sector (which includes lithium mining). The Environmental Impact Statement (EIS) and the Certificate of Waiver (CD) are the environmental permits that allow mining operations to begin. In addition to the Environmental Impact Assessment Study, which endorses the granting of environmental permits, since 2014 the Environmental Monitoring Report has been prepared, which provides evidence of compliance and the adequacy of mitigation measures.	The Bolivian regulatory framework that guarantees social participation includes the obligations and rights stipulated in the Political Constitution of the State, the Environment Act, the Framework Act of Mother Earth and Comprehensive Development for Living Well and the Mining and Metallurgy Act. In 1991, the Plurinational State of Bolivia ratified the Indigenous and Tribal Peoples Convention, 1989 (No. 169) of the International Labour Organization (ILO), which establishes free, prior and informed consultation. The consultation process is preventive in nature. A dialogue is established between stakeholders, reconciling interests to reduce the risk of conflict, particularly in relation to aspects of the mining operation that could violate certain collective rights.
Chile	
Lithium mining projects are subject to the Environmental Impact Assessment System (SEIA), established by Act No. 19.300 and regulated by Supreme Decree No. 40 of 2012 of the Ministry of the Environment. The environmental impact assessment (EIA) is the procedure used to determine whether the environmental impact of a project or activity complies with current legislation. The procedure administered the Environmental Evaluation Service (Act No. 19.300, the Basic Act on the Environment). The Environmental Superintendency oversees and monitors compliance with the conditions set forth in the environmental qualification resolutions.	Citizen participation is required in the SEIA, and in prevention and decontamination plans, environmental quality standards, emission standards and the Strategic Environmental Assessment (SEA). The EIA must include a mandatory citizen participation mechanism (Act No. 19.300, article 29). Chilean law also provides for the participation of indigenous peoples who may be directly affected by a project. The mandatory indigenous consultation procedure complies with the Indigenous and Tribal Peoples Convention, 1989 (No. 169) of the International Labour Organization (ILO).

Source: Economic Commission for Latin America and the Caribbean (ECLAC).

- Faced with the possibility of having their living conditions and livelihoods affected, different communities living in the areas of influence of mining operations have staged protests and filed lawsuits, supported by social organizations and actors from the science and technology system. These mobilizations have raised the profile of environmental issues in the public debate, facilitated by the expansion of environmental rights that has occurred in recent decades. In the countries of the lithium triangle, many of these processes have constitutional status.
- This makes it necessary to strengthen the environmental and social governance of the extractive activities. In particular, it is important to have adequate ex ante and ex post mechanisms for social and environmental licensing, and participatory and transparent decision-making processes for the management of these activities. To this end, the public must have guaranteed access to timely and quality information, in a transparent and appropriate manner, which makes it possible to gauge the impact of the extractive activities (Pinheiro and others, 2020). This type of information includes the freshwater and brine extraction rates in mining projects and other activities (tourism, agriculture, livestock, among others) through the comprehensive monitoring of salt flats.[32] It is also necessary to establish compensation mechanisms for biodiversity loss and ecosystem degradation. The right to these mechanisms is recognized particularly in the case of indigenous peoples, as reflected in both national and international regulations.
- International standards or certifications to promote more sustainable mining probably do not cover all the issues and aspects to be considered in terms of the potential impacts and socioenvironmental problems arising from the activity. However, they can complement the environmental and social rules and regulations of the countries and serve as a benchmark for improving them and enhancing the transparency of the different actors involved in the activity. These international initiatives include the IRMA Standard for Responsible Mining, which, as noted in the previous section, was adopted by three lithium mining firms in the countries analysed: SQM and Albemarle in Chile, and Livent in Argentina. The self-assessments of these firms are undergoing independent audits.

D. The taxation of lithium mining

1. Criteria for the design of the tax regime

- A characteristic that is traditionally sought when designing tax systems is neutrality, in the sense that taxes should not discriminate on the basis of the economic activities undertaken by the taxpayers. However, the particular characteristics of the extractive industries mean that they are often subject to special taxes, such as royalties and taxes on economic income (Jorratt, 2022). Some of these characteristics are summarized in table III.7.
- In addition to the aforementioned neutrality, mining taxation should be evaluated in terms the desirable attributes of any tax system, which are summarized in table III.8.

[32] This would make it possible to evaluate and monitor the carrying capacity of the environment, with a view to generating alerts and regulating extraction rates to ensure the sustainability of economic activities and communities in the territories concerned.

Table III.7 Special characteristics of the mining sector justifying the application of extraordinary or special taxes

1. Ownership of mineral resources	Generally, mineral resources belong to the State or its citizens, so it is logical for the owner to demand a reasonable payment for transferring the right to exploit the resources to a third party.
2. Prospects for high economic income	Generally, a resource in fixed supply can generate a higher than normal return on investment, after deducting production costs, including exploration costs, and the opportunity cost of capital, so it is reasonable for the government to be able to capture part of this rent.
3. High sunk costs and long production periods	The complete life cycle of a mining project involves exploration, development, operation and mine closure activities. All of this involves high costs, but above all, a large initial investment and lengthy execution period, which can span decades. The initial investment is an irrecoverable cost, which is not recovered if it is decided to abandon the project. This leads to a problem of time consistency between the investor, with these disincentives to investment, and the government with incentives to create or increase taxes, so it is feasible to consider tax benefits during the investment stage and special taxes.
4. Significant contribution to tax revenues	With appropriate taxes designed to capture economic rents, the government's fiscal position can be strengthened by the sector's significant contribution (absolute and relative), which makes it possible to reduce debt, increase expenditures or reduce other distortionary taxes.
5. Uncertainty	Mining activity is subject to uncertainty at all stages, but unlike other activities, the geology, the volatility of prices and the projects' long time horizons aggravate the risks. This is compounded by political, regulatory and fiscal uncertainty, among other aspects.
6. International considerations	Mining investments are often made by firms that are non-resident in the host country. Consequently, the effective tax rate of a mining project will also depend on the taxes paid by the investors in the country of residence. Moreover, the international nature of the operations opens up opportunities for tax avoidance by transferring income to low tax countries (such as through transfer pricing with related firms).
7. Information asymmetries	Governments have less information than private investors about the geological, technical and commercial characteristics of mining projects. On the other hand, private investors are unaware of the tax policies that governments plan to adopt in the future. This situation results in incentives for investors not to disclose and share key information about projects.
8. Market power	Some countries or firms control a large portion of the mineral reserves, so that they can exercise considerable control over the flows of the resulting products. The ability to influence such flows has implications for the effects of taxation, both for resource-producing and resource-importing countries.
9. Exhaustible resources	As the planet's mineral resource reserves are limited, they will eventually run out. Although technological progress and the discovery of new deposits may change these reserves, it is undeniable that the extraction of a given mineral in the present reduces potential extraction in the future, especially when considering specific geographic regions.
10. Impact on communities and the environment	Taxes on mining activity must also compensate for the costs imposed by its impact on local communities and the environment. This involves not only to fines or penalties but also contributions or investments that can then be deducted from the tax on profits.

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of M. Jorratt, "Renta económica, régimen tributario y transparencia fiscal en la minería del litio en Argentina, Bolivia (Estado Plurinacional de) y Chile", *Project Documents* (LC/TS.2022/14), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC), 2022.

Table III.8 Desirable attributes of mining sector tax regimes

Collection	The instruments must enable the government to appropriate a reasonable share of the economic rents over time.
Economic efficiency	Taxes should be as neutral as possible to affect investment decisions as little as possible.
Simplicity	Administration and compliance costs must be minimized to limit the risks of tax avoidance and evasion.
Equity	The taxes levied should be related to the ability to pay, and the distribution of the proceeds should be balanced between current and future generations and between jurisdictions.
Flexibility	The instruments must be able to adapt to changing market conditions.
Progressivity	Taxes should achieve a proportionally higher State share of rents generated in cycles of price booms or cost reductions.
Distribution of risk	The instruments must reduce the risk assumed by the investor, relative to that of the government in its role as silent partner.
Stability	The tax regime must be stable and investors must believe it is stable.

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of M. Jorratt, "Renta económica, régimen tributario y transparencia fiscal en la minería del litio en Argentina, Bolivia (Estado Plurinacional de) y Chile", *Project Documents* (LC/TS.2022/14), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC), 2022.

2. Estimation of economic rents in the lithium-triangle countries

- In his study, Jorratt (2022) evaluates the capacity of Argentina, Chile and the Plurinational State of Bolivia to capture the economic rent from lithium mining. Given the difficulties in determining a reference price for this product, the author makes two estimates: the first is based on prices reported by the mining companies, and the second on average prices in the United States. The difference between the two prices is around 20%. The results would be in a range between both estimates.
- The measurement of costs also poses difficulties. In particular, the author highlights the issue of thin capitalization, which consists of a portion of the investment being made through capital contributions in the form of loans between related firms, with the aim of exploiting the tax advantage of interest relative to dividend payments. To avoid income being underestimated as a result of debt, the flows before the deduction of interest are considered. For this purpose, Jorratt (2022) determines the weighted average cost of capital (WACC), which is applied on the annual balance of assets to determine the capital cost.
- In the three countries of the lithium triangle, a profit tax (ISU) is levied at a rate of 35% in Argentina, 25% in the Plurinational State of Bolivia and 27% in Chile. Given the lack of a specific tax regime for lithium, these rates are the same as applied to economic activities generally. Argentina and Chile have highly accelerated depreciation systems, with a useful life for tax purposes of up to three years in Argentina and six years in Chile for most assets. All three countries allow immediate deduction of exploration expenditures. Argentina and the Plurinational State of Bolivia allow tax losses to be carried forward for up to five years, while Chile allows unlimited carry-forwards. In addition to ISU, the tax system is completed with other taxes and royalties in each country (see table III.9).

Table III.9 Argentina, Chile and the Plurinational State of Bolivia: main fees and royalties applied to lithium projects

Argentina	Provincial royalty of 3% on the pithead value, equivalent to 1.6% of sales revenue.
	Export duties, which since 2021 have been equivalent to 4.5% of the free-on-board (FOB) value of exports.
	Current account debits and credits taxed at a rate of 0.6% of the ITF.
	Refunds equal to 1.5% of the FOB value of exports.
	Dividends distributed to investors taxed at a rate of 7%.
Bolivia (Plurinational State of)	Additional tax rate of 25%, after deduction of 33% of cumulative investments and 45% of net income, and a 12.5% surtax (not yet defined for lithium).
	Mining royalty of 3% of the value of exports.
	ITF of 0.3% on current account debits and credits.
Chile	Royalty to the Production Development Corporation (CORFO) established in the lease agreements between this entity and the mining company, which consists of a progressive quota based on the price of lithium carbonate (6.8%–40%).
	IEAM, whose rate varies between 4.8% and 12.3%, depending on the operating margin recorded each year.
	Contribution for regional development of 1% of the investment for the first five years.

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of M. Jorratt, "Renta económica, régimen tributario y transparencia fiscal en la minería del litio en Argentina, Bolivia (Estado Plurinacional de) y Chile", *Project Documents* (LC/TS.2022/14), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC), 2022.
Note: ITF = Financial transactions tax; IEAM = Specific tax on mining activities.

- Jorratt (2022) estimates the tax burden of lithium mining in the three countries using a hypothetical investment project starting in 2021.[33] The model is used to calculate the effective tax rate, considering direct taxation of both the firm and investors. The following is the analysis for an effective tax rate calculated as the quotient between the present value of taxes paid by the project and the net present value of the project without taxes.[34] The assumptions of the simulation model are set out in table III.10.

[33] The project involves a total investment of US$ 635.8 million, with an annual production of 40,000 tons of lithium carbonate, for a period of 40 years.
[34] In his report, the author performs a simulation considering two other tax rates, calculated as follows: (i) the quotient between the present value of taxes and the present value of financial profits; (ii) the percentage reduction that taxes produce in the project's internal rate of return (IRR).

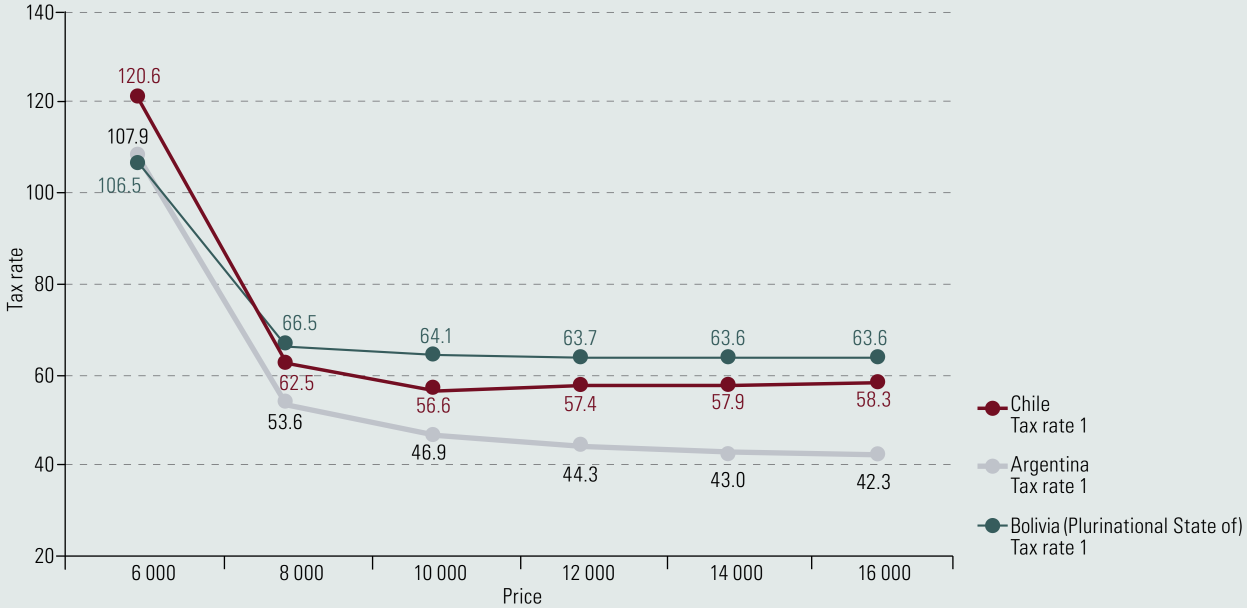
Table III.10 Assumptions of the simulation model of a lithium exploitation project in a salt flat

1	Initial year of investment	2021
2	Investment period *(years)*	5
3	Useful life of mine *(years)*	40
4	Last year of operation	2065
5	Discount rate *(percentages)*	8
6	Initial investment *(millions of dollars)*	555.3
7	Maintenance investment *(millions of dollars per year)*	6.9
8	Last year of maintenance investment	2064
9	Working capital *(millions of dollars)*	55.5
10	Exploration and prospecting expenses *(millions of dollars)*	25
11	Mine closure costs *(millions of dollars over three years)*	32.5
12	Annual production *(thousands of tons of lithium carbonate)*	40
13	Price *(dollars per ton)*	12 000
14	Unit operating cost before depreciation *(dollars per ton)*	3 579
15	Earnings are reinvested at the discount rate and withdrawn in the last year	

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of M. Jorratt, "Renta económica, régimen tributario y transparencia fiscal en la minería del litio en Argentina, Bolivia (Estado Plurinacional de) y Chile", *Project Documents* (LC/TS.2022/14), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC), 2022.

- In the case of Argentina, the base scenario yields a present value of taxes of US$ 983.3 million and a net present value (NPV) of the project of US$ 1,235 million. By far the most important tax in terms of present value of collection is the profits tax (ISU), which accounts for 77.3% of the total. This is followed by export duties (18.4%), provincial royalty (6.5%), financial transaction tax (FTT) (2.1%) and dividend tax (1.8%). Lastly, rebates reduced revenues by 6.1%.
- In the Plurinational State of Bolivia, considering the base scenario, the present value of taxes is higher than in Argentina, at US$ 1,413.7 million, and the NPV of the project is US$ 804.5 million. The most important tax, in terms of present value of revenue collected, is corporate income tax (IUE), which represents 41.4% of the total. It is followed by the additional 25% tax (28.2%), the 12.5% surtax (20.7%), the mining royalty (8.5%) and, lastly, the financial transactions tax, which represents 1.1% of the total taxes of the investment project.
- In the case of Chile, when considering the base scenario, the present value of taxes is higher than that of Argentina, but lower than in the Plurinational State of Bolivia, at US$ 1,273.1 million, and a NPV of the project of US$ 945.1 million. The most important tax, in terms of present value of collection, is the CORFO royalty, which represents 57.1% of total taxes. This is followed by the first category tax (33.2%), the specific tax on mining activity (IEAM) (7.7%), the tax on dividends (1.8%) and, lastly, the future contribution to regional development, which represents just 0.3% of the total taxes of the investment project.
- A sensitivity analysis of the effective tax rate relative to the price of lithium carbonate (which varies between US$ 6,000 and US$ 16,000 per ton) shows that when the price is US$ 6,000 per ton, the rate is above 100% in the three countries. This means that the government collects taxes, even when there is no economic rent (see figure III.1). This result is partially explained by taxes.
- Based on a price of around US$ 10,000 per ton, the trajectory of the effective rate varies from one country to another. While in Argentina it continues to fall as the price rises, in Chile it tends to increase slightly and in the Plurinational State of Bolivia it remains almost constant. This result is explained by the design of the taxes levied in each country. Argentina combines a flat rate first category tax with flat rate ad valorem taxes. These taxes make the system regressive, by collecting a smaller percentage of the economic income as this increases with the price. In Chile, on the other hand, CORFO negotiated a progressive ad valorem royalty with the firms, so that the rate rises rapidly as prices increase. In addition, the IEAM also has a progressive structure (Jorratt, 2022).

Figure III.1 Argentina, Chile and the Plurinational State of Bolivia: effective tax rate based on the price of lithium carbonate
(Percentages and dollars per ton)



Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of M. Jorratt, "Renta económica, régimen tributario y transparencia fiscal en la minería del litio en Argentina, Bolivia (Estado Plurinacional de) y Chile", *Project Documents* (LC/TS.2022/14), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC), 2022.

- Given a future scenario of rising prices (see chapter I), it is important to adapt and strengthen control and inspection mechanisms to combat tax evasion. The current market is still not very transparent because the purchase and sale of lithium compounds are based mainly on contracts between private parties. Prices are estimated by consulting firms, drawing largely on key informants. The difficulties in obtaining reference prices are increasing for two reasons. Firstly, the technical specifications of the salts produced vary. Secondly, firms operating in the countries of the region have parent firms, subsidiaries or strategic partners abroad, where lithium carbonate undergoes further processing. Consequently, a substantial part of exports corresponds to intra-company trade, at transfer prices that may be undervalued (Obaya and Céspedes, 2021).
- Jorratt (2022) notes that the market prices of lithium carbonate differ from the prices implied by the free-on-board (FOB) value of exports, by 58% in Argentina and by 21% in Chile. In estimating the potential of the lithium triangle countries to capture the economic rent of the resource, the author argues that for every 20 points of difference in the market price of lithium carbonate the appropriation of the total economic rent of production can decrease from 44.3% to 30.4% in Argentina, from 63.7% to 41% in the Plurinational State of Bolivia and from 57.4% to 47.8% in Chile. In other words, the price difference observed translates into an average direct transfer of 15.4 percentage points of income from the States to the firms.
- The same author notes that, at the international level, progress made by tax authorities to prevent tax leakage resulting from transfer pricing practices remains slow in both developed and developing economies. While input-output transfer pricing mechanisms are well known, the capacity of governments to address these practices remains weak and poses a major challenge that distorts potential revenue collection.

IV. Concluding remarks: guidelines for a productive development agenda around lithium

- Lithium has become established as one of the critical minerals of the energy transition, in particular because it is an input for the production of lithium-ion batteries used for electromobility. Latin America and the Caribbean, especially the lithium-triangle region, has an abundance of this mineral. Consequently, its member countries have come to view it as a strategic resource with the potential to promote their economic development. This expectation is based on the possibility not only of boosting value creation and the capture of the economic rent generated by the use of the resource, but also of creating of knowledge-intensive productive and technological capabilities that contribute to a process of structural change.
- The resource governance regimes adopted in each of the region's countries differ profoundly. This means that the management of lithium and its uses is governed by different types of rules, within which the government, the market and social actors have different functions, resources and instruments. Despite this heterogeneity, it is possible to formulate a non-exhaustive set of policy guidelines aimed at improving the region's potential to take advantage of the opportunities offered by lithium and to have better tools to face the challenges presented by its exploitation.
- In light of the analysis of the previous sections and following the life cycle of a mining project, the following guidelines are highlighted:

Environmental and social sustainability

- Existing regulations and standards need to be adapted, and the rules must respond to a twin demand. First, local social actors need mechanisms to ensure their participation in the regulation, supervision, oversight and management of socioenvironmental impacts and conflicts throughout the life of extractive projects. Secondly, environmental and social governance must be adapted to the increased demands of countries and consumers of end products containing lithium, such as lithium-ion batteries or, considering other strategic minerals, electric vehicles. Among other issues, this adaptation process should consider the evaluation and improvement of spaces and mechanisms for multi-stakeholder and multilevel participation and coordination, transparency and access to public information, and the capacities of States to supervise and oversee regulations and standards and to address and resolve disputes or conflicts. With respect to the latter, given the water stress involved in lithium mining, practices and technologies need to be incorporated or developed to improve efficiency in the use of water and energy, conduct comprehensive monitoring of salt flats, establish sustainable extraction rates, and provide compensation mechanisms for biodiversity loss or ecosystem degradation, among others.

Tax revenues and public and private investment

- The tax arrangements applied to extractive activities enable a larger portion of economic rents to be captured more transparently. However, this process must be based on the criteria of progressivity, efficiency and equity of taxation, while maintaining competitiveness between countries. To this end, governmental supervision and control capacity needs to be increased, particularly with a view to reducing tax evasion and avoidance in international trade.
- Closely related to the previous point, the distribution and use made of economic rents obtained from lithium also need to be improved. One of the priority uses of these resources should be to support a process of structural change in the countries of the region, in favour of more knowledge- and technology-intensive activities. This process should promote the creation of techno-productive capabilities and infrastructures for adding value, the generation of productive linkages and scaling up in global value chains. However, this requires appropriate incentives to mobilize resources and attract foreign investment and new forms of partnership between public and private actors to ensure the transfer of knowledge and technology. This line of action should also form part of the promotion of the circular economy to make commercial use of waste from extractive activities. This would involve developing the capacity to recycle batteries and, considering other strategic minerals, components and parts of mineral-intensive technologies, such as electric vehicles or solar panels. Natural capital would thus be transformed into other forms of capital.

Regional cooperation, coordination and integration

- The guidelines discussed for environmental and social sustainability and tax revenues and investment provide fertile ground for intraregional cooperation and coordination. The exchange of knowledge and experiences can contribute to better standards, designs and practices in each country. It would also offer the possibility of agreeing on common contents at the regional level, and thereby strengthen the region's position relative to the demands of the industrialized countries, in the framework of the design of global governance while also helping to avoid a race to the bottom.
- Cooperation, coordination and regional integration are important tools for strengthening the opportunities provided by the industrialization of strategic minerals and the development of regional value chains. This is especially true of technologies for energy transition and electromobility in the global geopolitical context, where the risk of supply and value chains breaking down is latent. A regional productive development agenda centred on lithium or strategic minerals can serve this purpose, to pool efforts, complement capacities and seek synergies. In the particular case of lithium-ion batteries there are strategies of geographic co-location, or the re-shoring of production and manufacturing which are giving rise to large industrial clusters, both inside and outside Asia. This is a necessary condition for growing a large electromobility and renewable energy market that contributes to the development of regional industrial capacities to produce batteries and their inputs. For example, collaboration with the automotive industry in the region, especially among countries with installed capacity, such as Argentina, Brazil, Colombia and Mexico, can hasten development of the electromobility market or some of its segments, such as the electrification of public passenger transport for the large Latin American and Caribbean cities.

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Annex 1

Table A1 Latin America and the Caribbean: lithium mining projects

Project	Company	Origin of the firm	Planned [Current] capacity *(Tons of lithium carbonate equivalent)*	Investment *(millions of dollars)*	Status
		Argentina			
Expansion of the Salar del Hombre Muerto (Fénix) (Catamarca)	Livent	United States	67 839 [initial phase 25 839]	640	Construction
Olaroz Salt Flat Expansion (Jujuy)	Allkem Ltd.	Australia	42 500 [initial phase 25 000]	450	Construction
	Toyota	Japan			
	Jujuy Energía y Minería Sociedad del Estado (JEMSE)	Argentina			
Cauchari-Olaroz	Ganfeng Lithium	China	40 000	741	Construction
	Lithium Americas	Canada			
Centenario-Ratones (Salta)	Eramet	France	24 000	595	Construction
	Tsingshan	China			
Sal de Oro (Salta)	POSCO	Republic of Korea	25 000	831	Construction
Tres Quebradas (Catamarca)	Zijin Mining	China	20 000	380	Construction
Mariana (Salta)	Ganfeng Lithium	China	10 000	243	Construction
Salt of Life (Catamarca)	Allkem Ltd.	Australia	45 000	795	Construction
Pastos Grandes (Salta)	Lithium Americas	Canada	24 000	448	Feasibility Pilot plant
Rincón Salt Flat (Salta)	Rio Tinto	United Kingdom	25 000	770	Feasibility Demonstration plant
Cauchari (Jujuy)	Lake Resources	Australia	N/A	N/A	Pre-feasibility
Cauchari Salt Flat (Jujuy)	Allkem Ltd.	Australia	25 000	446	Pre-feasibility
Kachi (Catamarca)	Lake Resources	Australia	50 000	544	Pre-feasibility
Rincon Lithium Project (Salta)	Argosy Minerals Ltd. (77.5%) and private firms	Australia	10 000	141	Preliminary economic evaluation Pilot plant

Project	Company	Origin of the firm	Planned [Current] capacity *(Tons of lithium carbonate equivalent)*	Investment *(millions of dollars)*	Status
Candelas (Catamarca)	Galan Lithium Ltd.	Australia	14 000	408	Preliminary economic evaluation
Hombre Muerto Norte (Salta)	Lithium South Development Corp. NRG Metals Inc.)	Canada	5 000	93	Preliminary economic evaluation
Hombre Muerto Oeste (Catamarca)	Galan Lithium Ltd.	Australia	20 000	439	Preliminary economic evaluation
Pozuelos (Salta)	Ganfeng Lithium	China	25 000	338	Preliminary economic evaluation
		Bolivia (Plurinational State of)			
Uyuni Salt Flat	Yacimientos de Litio Bolivianos (YLB)	Bolivia (Plurinational State of)	15 000	N/A	Construction
		Chile			
Expansion of La Negra Chemical Plant	Albemarle	United States	42 500 (additional)	N/A	Construction
Salar del Carmen (enlargement)	Chilean Chemical and Mining Company (SQM)	Chile	40 000 (additional)	N/A	Environmental approval granted
Lithium carbonate plant (expansion)	Chilean Chemical and Mining Company (SQM)	Chile	110 000 (additional)	N/A	In development
Maricunga Salt Flat	Lithium Power International	Australia	15 000	N/A	Environmental approval granted
		Brazil			
Mibra	AMG Lithium	Germany	13 500	50	Expansion
Cirilo Grotto	Sigma Lithium (from Sigma Mineração S.A.)	Canada	36 700	131.6 (Phase 1)	Construction
		Mexico			
Sonora Lithium	Ganfeng Lithium (through Bacanora Lithium and Sonora Lithium)	China	17 500	419.6 (Phase 1)	Construction
		Peru			
Falchani Lithium	Plateau Energy Metals	Canada	23 000	586.9 (Phase 1)	Preliminary economic evaluation

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of Chilean Copper Commission (COCHILCO), "El mercado de litio: desarrollo reciente y proyecciones al 2030", Santiago, 2021; Mining Secretariat, *Informe litio: octubre 2021,* Buenos Aires, 2021; Yacimientos de Litio Bolivianos (YLB) and official information from the respective firms.

Annex 2

Table A2 Selected lithium mining projects outside Latin America and the Caribbean

Project	Company	Planned capacity *(Tons of lithium equivalent)*	Capital expenditures *(millions of dollars)*	Status
		Australia		
Mt Holland	Wesfarmers (Australia) Sociedad Química y Minera de Chile (SQM) (Chile)	45 000	Not available	Construction
		United States		
Clayton Valley	Century Lithium Corp. (formerly Cypress Development Corp.)	27 400	493	Pre-feasibility
Thacker Pass	Lithium Americas	30 000	581 (Phase 1)	Pre-feasibility
Clayton Valley Lithium Project	Pure Energy Minerals	10 000	297	Preliminary economic evaluation
Lanxess Project	Standard Lithium	20 900	437	Preliminary economic evaluation
		Canada		
Leduc Reservoir	E3 Lithium Limited (formerly E3 Metals Corp.)	Not available	Not available	Advanced exploration
Authier	Sayona Mining Limited	13 000	91	Feasibility

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of public information from the respective firms.

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