OECD Rural Studies

Mining Regions and Cities in the Region of Antofagasta, Chile

TOWARDS A REGIONAL MINING STRATEGY

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BETTER POLICIES FOR BETTER LIVES

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Foreword

This report provides the building blocks for a new mining strategy in the region of Antofagasta, Chile, which prioritises well-being standards and opportunities for local communities. This medium- and long-term strategy aims to create a new pact amongst different societal stakeholders to build trust and unite efforts for more inclusive and sustainable growth in the region.

Mining regions play an essential role in supplying mineral raw materials to meet global climate goals and sustain growth objectives. Access to a reliable and environmentally sustainable supply of mineral raw materials has become a political priority in many countries, for example in the European Green Deal and the United States Inflation Reduction Act. International investment strategies and consumers are progressively focusing on the social and environmental sustainability of the mineral supply, increasing scrutiny of the mining process and encouraging mining companies to invest in low-carbon mining practices.

Against this backdrop, mining regions must ensure that local businesses, citizens and Indigenous peoples also benefit from the green and digital transition in mining. For instance, deploying renewable energy projects to power mining operations or investments in circular economy approaches in mining can provide new opportunities to local economies and reduce environmental impacts. Without the right planning, local communities may miss out on the benefits of these developments and, instead, risk being left with adverse effects, for example, environmental and land use impacts.

Antofagasta, a world leader in copper and lithium production, is undergoing several transitions that can reshape its regional development model. First, the region expects large flows of investments to modernise existing mining operations, mainly copper, and to expand the production of non-traditional minerals, such as lithium. Second, mining companies are adapting to the green and digital transitions, with projects to increase the use of renewable energy sources, desalinated water and automation in mining operations. Finally, Chile's ongoing decentralisation process has also strengthened institutional capacities for regional development, including through the new position of a democratically elected regional governor. These transitions represent an opportunity to shape a new development model that delivers higher well-being standards in Antofagasta.

This report is part of the elaboration process of the regional mining strategy led by the regional government of Antofagasta in collaboration with the Catholic University of the North, Chile. Building on more than 80 in-person meetings, focus groups and assemblies with regional stakeholders, this study helped gather regional priorities and agreed-on common objectives and strategic projects for this strategy.

This report is the fifth study of the OECD Mining Regions and Cities Initiative, which supports countries in implementing better regional development policies in a mining and extractive context. Previous studies in this series include Outokumpu and North Karelia (Finland), Norrbotten and Västerbotten (Sweden), Andalusia (Spain) and the Pilbara (Australia). The report was approved by the Working Party on Urban Policy [CFE/RDPC(2023)12] via written procedure in September 2023.

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The OECD team responsible for the report includes Andres Sanabria, project co-ordinator, working under the guidance of Jose Enrique Garcilazo, Head of the Regional and Rural Policy Unit in the Regional Development and Multi-level Governance Division, led by Dorothée Allain-Dupré. Chapter 2 was drafted by Fernando Riaza (CFE), Chapter 3 by Juan Biset, former Vice-minister of Mining of Argentina, and Chapter 4 by Andres Sanabria (CFE). The review benefitted from comments from Nadim Ahmad, Lisanne Raderschall and Isidora Zapata (all CFE). Evangelina Thanasi (CFE) co-ordinated the organisation of meetings and Pilar Phillip (CFE) led the publication process. The report was copy-edited and formatted by Eleonore Morena.

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Abbreviations and acronyms

ADI	Indigenous Development Area
AIA	Antofagasta Industrial Association
COCHILCO	Chilean Copper Commission
CODELCO	National Copper Corporation of Chile
CONADI	National Corporation for Indigenous Development
CORE	Regional Council
CORFO	Production Development Corporation
COSOC	Constitution and operation of the Regional Civil Society Council
CSR	Corporate Social Responsibility
DBA	Desert-based agriculture
EMRA	Antofagasta's Regional Mining Strategy
ENAMI	National Mining Company of Ecuador
ESG	Environmental, social and corporate governance
GDP	Gross domestic product
GHG	Greenhouse gas
GVA	Gross value added
GVC	Global value chain
HDI	Human Development Index
ICMM	International Council on Mining and Metals
ILO	International Labour Organization
IPP	Institute of Public Policy
LCE	Lithium carbonate equivalent
METS	Mining equipment, technology and services
PPP	Purchasing power parity
R&D	Research and development
RDS	Regional Development Strategy
SERC	Solar Energy Research Center
SEREMI	Regional Ministerial Secretary
SMA	Superintendence of the Environment
SMART	Specific, measurable, action-oriented, realistic and time-bound
SMEs	Small and medium-sized enterprises
TL2	Territorial Level 2 – Large regions
TL3	Territorial Level 3 – Small regions
UNDRIP	United Nations Declaration on the Rights of Indigenous Peoples

Executive summary

This study presents the diagnosis, rationale, building blocks and recommendations for the forthcoming Mining Strategy of Well-being for the Region of Antofagasta 2023-2050 (hereafter the Mining Strategy). The OECD, together with the Catholic University of the North, Chile, supported the regional government of Antofagasta in the preparation of this medium- and long-term strategy that aims at promoting sustainability and prioritising the well-being standards of citizens living in Antofagasta.

Assessment

Located in northern Chile, Antofagasta – a region carved by the natural contours of the arid Atacama Desert, with a rich presence of mining resources and home to several Indigenous communities – has the fourth lowest population density among the 16 Chilean regions and ranks amongst the 25% least densely populated of the OECD's 50 mining regions (see the next chapter for an explanation of this benchmark).

Antofagasta is the world's leading copper and second-largest lithium-producing region, with strategic importance for the global energy transition and Chile's economic development. Antofagasta's mining ecosystem includes several globally leading mining companies, suppliers and universities specialised in mining-related research. Antofagasta's export-oriented mining sector has propelled economic development in the region and the country, contributing to 72% of the region's gross domestic product (GDP) and 39.4% of Chile's total exports (March 2023). The region's GDP per capita is the highest in the country and is almost twice as high as the average of 50 OECD mining regions. Beyond mining, Antofagasta benefits from a growing astronomy sector, energy sector and dynamic tourism sector.

Despite the wealth brought by mining, communities in Antofagasta lag in a number of well-being dimensions. Economically, Antofagasta's income inequality (Gini coefficient of 0.51 in 2019) is above the national average (0.46) and its unemployment rate (9.6% in 2021) surpasses the national average (9.1%) and the average of 50 OECD mining regions (7%). Socially, the region records the lowest life expectancy (79.2) and the fifth lowest life satisfaction amongst Chile's 16 regions, reflecting concerns about the shortage of parks and areas for recreation activities. Environmentally, Antofagasta emits 38% more greenhouse gas emissions per unit of electricity generated than the average of 50 OECD mining regions. Moreover, as one of the most arid regions in the world, it has considerable challenges in water resource management.

Antofagasta's mining industry is entering a new phase of development, driven by the expected surge in global demand for its minerals and the imperative to adapt to the green and digital transitions. To meet the net zero emissions scenario, the global demand for Antofagasta's main minerals, copper and lithium, is projected to almost double and increase tenfold respectively by 2040. As of January 2023, Antofagasta has the second-highest total expected investment for the next 5 years in Chile (24% of the total investment of projects), mainly driven by the mining (51% of the total) and energy (44%) sectors. Most of the expected investments in mining aim at either modernising and expanding existing operations, mainly in copper mines or increasing exploration of non-traditional minerals, such as lithium. Many of the projects in current mine sites involve improvements in both the environmental sustainability and the productivity of the processes,

for example by increasing the use of renewable energy and desalinated, reused water in mining or automation of operations. On top of these investments, the growing mining ventures in neighbouring countries provide the region with an opportunity to become a logistics gateway for minerals, given its favourable geographic location and export infrastructure (ports and railways).

Despite the potential benefits that these new developments can bring to local companies and workers, many challenges remain to ensure that communities benefit from them and, in turn, that the private sector obtains the social license for their implementation. Some of these challenges include adapting local skills and businesses to the transitions in mining operations, complex processes to access land for industrial or community projects and lack of information about mining impacts on the environment.

Against this backdrop, a new development vision with a long-term strategy is warranted in the region to leverage mining benefits in view of improving well-being standards and taking advantage of the opportunities brought by the digital and green transition in mining. The Mining Strategy of Well-being for the Region of Antofagasta 2023-2050 is this coherent long-term plan. Its elaboration requires the involvement of a variety of societal stakeholders in agreeing on common objectives and strategic projects focused on improving well-being standards. A multi-stakeholder governance mechanism is needed to help plan and monitor the implementation of this strategy and ensure its continuity beyond political cycles. Likewise, the national government, with its national agencies in the region, need to support the regional institutional capacity to implement this strategy and, in turn, advance Chile's mining strategy and sustainable development plan.

Key recommendations

	Recommendations	
I	**Formalise and implement the Mining Strategy of Well-being for the Region of Antofagasta 2023-2050 with concrete objectives and a timeframe of strategic projects based on the priorities of the different regional stakeholders**	
1.	Formalise the strategy with a dedicated budget within the institutional and policy framework of the government of Antofagasta	
2.	Recognise in the strategy the need for a new pact among communities and the private sector in the region of Antofagasta, to build trust across different actors and promote common agreements to improve future developments of the region and move forward with the mining strategy	
3.	Ensure that the strategy provides a medium- and long-term vision that reflects the aspiration for the region to increase well-being standards in economic, social and environmental dimensions, building on the competitive and environmentally responsible mining sector	
4.	Establish specific objectives in the strategy that address local priorities and are based on common agreements across the different actors of the region to attain the final vision of the strategy	• Improve the quality of life of local communities and Indigenous peoples. • Increase the participation of regional businesses in the mining value chain. • Strengthen skills and the regional knowledge ecosystem. • Improve governance for a more productive and sustainable mining sector. • Rehabilitate and preserve the environment.
5	Implement short- and medium/long-term strategic projects to attain each of the strategy's objectives. Several strategic projects have been identified throughout different multi-stakeholder meetings in the region	
II	**Establish a governance mechanism to monitor progress and ensure the sustainability of the strategy over the long run and beyond government cycles**	
6.	Define a new role for a public official in the government, with responsibility for co-ordinating the Mining Strategy and ensuring its implementation and continuity, with a defined budget and a team for operation and co-ordination	
7.	Establish a steering committee in charge of prioritising projects, monitoring and proposing new orientations to the strategy, composed of representatives of relevant actors in the region	
8.	Establish a technical committee in charge of overseeing the projects, providing updates on the progress of projects and the budgets and responding to other requests from the steering committee	
9.	Ensure that the strategy upholds Indigenous peoples' rights and promotes meaningful participation in the decision making and prior and informed consent in the design and implementation of relevant strategic projects for these communities	

	Recommendations
III.	**Define a monitoring and evaluation framework with different levels of indicators**
10.	Set up an evaluation framework that can recurrently measure the outputs and outcomes of the various strategic projects to attain each of the objectives of the strategy
11.	Monitor the progress of the overall strategy in improving well-being standards in the region through specific impact indicators that are horizontal to the strategic projects in each objective
IV	**Ensure a formal channel of communication and involvement of regional stakeholders on the construction, progress and changes of the strategy**
12.	Establish an appropriate communication strategy to disseminate the strategy and its construction process with annual public reports on the progress of the strategy via media or public gatherings
13.	Map and publicly report information on the environmental, social and corporate governance initiatives from the mining companies in the region
V	**Improve the institutional capacity of the national agencies operating at the regional level. The national government is crucial to the success of the regional mining strategy and to ensuring a more sustainable mining sector.** To this end, the national government should:
14.	Co-ordinate with the regional government of Antofagasta to identify institutional needs in the region and define methods to increase the capacity and upgrade the Regional Ministerial Secretary (SEREMIs) – especially the SEREMI of the Environment and the SEREMI of National Goods – and the Superintendence of the Environment
15	Improve government co-ordination to better involve Indigenous communities in policy making around mining and their territories

1 Assessment and recommendations

Assessment

Antofagasta's mining industry is of strategic importance for the global energy transition and sustainable development in the region

Home to an abundant reserve of minerals that are vital for a low-carbon future, including copper and lithium, the Antofagasta region is in a unique position to become a global leader in responsibly sourced minerals. Antofagasta has world-class geological resources and large global mining companies, including some of the world's major copper mines, top lithium reserves and important production of molybdenum and boron. The diverse set of assets supporting Antofagasta's mining sector potential include:

- **Geological attractiveness and global mining companies**: Antofagasta's copper and lithium deposits have attracted some of the world's largest mining companies. This includes four out of the top five global mining companies and seven out of the top ten global copper producers, among which is the state-owned CODELCO, the world's largest copper producer.
  - *Copper*: Antofagasta is the world's largest copper-producing region (approximately 3 million tonnes in 2021), accounting for half of Chile's production and ahead of Peru, the world's second-largest copper producer (U.S. Geological Survey, 2023[1]). The region hosts the world's largest copper mine (BHP Escondida).
  - *Lithium*: Antofagasta produces all of Chile's lithium, placing the country as the second-largest lithium producer in the world (U.S. Geological Survey, 2022[2]). The region hosts one of the largest lithium mines in the world (Salar del Carmen).
- **Mid-sized mining companies**: There are a few mid-sized operations in the region (Franke, Mantos Blancos, Mantos de la Luna, Michilla and Taltal) that account for a small fraction of total copper production and produce some other minerals in larger proportions, most notably gold and silver.
- **Export-oriented infrastructure**: Antofagasta's infrastructure, including ports and trains, has been tailored to support its heavyweight mining industry. The region also benefits from the highest broadband access in the country (84.3% of households), which can facilitate economic transformation and diversification.
- **National universities** such as the University of Antofagasta and the Catholic University of the North, together with **research and development centres** such as the Scientific and Technological Research Centre of the Antofagasta Region and the upcoming Lithium Institute offer highly qualified training and research. These institutions contribute to the region's technological advancements, environmental sustainability and the cultivation of a skilled workforce.

Antofagasta's export-oriented mining sector has propelled economic development in the country and the region. Antofagasta's gross domestic product (GDP) per capita is the highest in the country and almost twice as high as the average of 50 OECD mining regions.[1] The region's contribution to national GDP at 12.8%, is over five times its population share of 2.2%.

The main economic benefits from mining in the region include (next chapter provides further details):

- As of March 2023, Antofagasta accounted for 39.4% of Chile's total exports, of which approximately 95% were mining-related products.
- The mining sector contributed around 72% of the region's GDP (March 2023), 7 percentage points higher than in 2022.
- The mining sector accounted for 113 thousand jobs in the region (May 2023), which represents 28.3% of the total employed population and 41% of the nation's total employment in the mining sector.

The green and digital transition in mining offers new opportunities to attain a more inclusive and sustainable development

The increasing global demand for minerals and the green and digital transition in mining will likely represent a greater inflow of investments for Antofagasta in the coming years. As of January 2023, Antofagasta had the second-highest total expected investment in Chile for the next 5 years (24% of total investment of Chilean projects). The mining sector, responsible for 51% of the total expected investment, aims to modernise and expand existing mining operations, primarily in copper mines, or enhance exploration of non-traditional lithium minerals. Most of these mining projects aim to improve environmental sustainability and productivity, using renewable energy sources, desalinated or reused water in mining operations, and greater automation of processes. Under current forecasts, Chilean copper production is set to reach 6.6 million tonnes (Mt) per annum by 2033 (from 5.7 Mt in 2021), with Antofagasta increasing its output to 3.26 Mt (from 3.0 Mt in 2021) (COCHILCO, 2022[3])

The energy sector accounts for 44% of total expected investments in Antofagasta for the next five years, mainly greenfield projects of solar and wind energy production and transmission projects. Antofagasta has registered 13 new renewable energy projects (including solar, wind and hydrogen) for a total of 6 982 megawatts (MW), leading among all Chilean regions (Ministerio de Energía, 2022[4])

Due to its favourable geographic location and export infrastructure, the region can become a logistic gateway for increasing mining ventures in neighbouring countries, such as Argentina and Bolivia, which are attracting investments mainly for lithium production but currently lack adequate transport infrastructure.

However, without a proactive strategy, the region may miss out on opportunities to benefit from digital and green projects in mining and, instead, increase the exposure of the regional workforce and companies to adverse environmental and social risks. For instance, automation in mining operations will require a new set of skills and types of inputs that are adapted to the new technologies. Similarly, new mining and energy investments and the opportunity to become a strategic player in mining in Latin America require an agile regulatory and permitting process, clear communication on the potential of mining for local development and standard benefit-sharing agreements to improve impacts on communities and secure a social license for new developments.

Beyond its mining industry, Antofagasta benefits from additional assets that can contribute to economic and social development.

Beyond mining, Antofagasta has additional assets to support its development. Its tourism sector benefits from the Atacama Desert, known for its prominent natural landscapes, preserved ecosystems and unique biodiversity. The region is also home to several natural preservation areas, offering opportunities for ecotourism, adventure tourism and wildlife observation. Additionally, Antofagasta boasts a rich cultural heritage, including significant archaeological sites and Indigenous communities that uphold their traditions and customs. This cultural wealth presents opportunities for cultural tourism, promoting cultural exchanges and fostering understanding and appreciation of the region's Indigenous heritage.

Another noteworthy asset is the region's growing astronomy sector. Antofagasta benefits from its exceptional astronomical conditions, including clear skies and low light pollution, making it an ideal location for stargazing and astronomical research. The region hosts several observatories (e.g. Gemini Sur, Paranal) and research centres, attracting scientists, astronomers and astronomy enthusiasts from around the world. Supporting the growth of this sector can not only contribute to scientific advancements but also stimulate tourism and educational initiatives centred around astronomy. Table 1.1 summarises some of the main assets of the region.

Table 1.1. Main assets of Antofagasta

Assets	Description
Economic	
Strong mining sector	Antofagasta's mining sector provides the largest mineral production and exports in the country, with a pool of multinational companies and a network of globally competitive mining service companies. Geological potential with essential minerals for the global green transition, such as copper and lithium.
Export-oriented infrastructure and high broadband connectivity	Antofagasta's export-oriented infrastructure facilitates the transportation of mining products to global markets, driving economic growth and international trade. Additionally, the region's robust broadband connectivity, with over 83.4% of households having Internet access, supports various digital activities, including business operations, remote work and online education.
Social	
Young and growing population	The region has a population growth rate of 2.5%, above the national average (1.53%). The population is young, with the 25-44 age range representing 53.2% of the total population, providing a vibrant workforce.
Institutions of education and research	The region has several higher education and research institutions, including the University of Antofagasta, the Catholic University of the North and the upcoming public technological institute for the research of lithium. These institutions support the local economy and workforce development by providing training and conducting research in relevant fields.
Environmental	
Renewable energy potential	In addition to its vast mineral reserves, Antofagasta is rich in solar energy potential due to its high level of sunshine hours, offering opportunities for renewable energy development.
Ecotourism	Antofagasta's diverse assets, including its vibrant tourism sector in the Atacama Desert and rich cultural heritage with significant archaeological sites and Indigenous traditions, provide a robust foundation for economic and social development, emphasising ecotourism, adventure, wildlife observation and cultural tourism.

Mining wealth has led to rapid population growth relative to both the national average and comparable OECD mining regions

Spanning a considerable geographic expanse alongside the Pacific Ocean, Antofagasta's population density (5.7 individuals per square kilometre) is around one-quarter of the average in Chile (24.06), ranking as the fourth least densely populated region in the country and in the bottom 25% of 50 OECD mining regions.

Population growth over the past decade (2.5% annual average) has outpaced the national average (1.53%) and the average of 50 OECD mining regions (0.8%). The steady increase in Antofagasta's population is largely driven by international migration. As of December 2021, the region hosted 106 000 foreign residents, comprising about one-seventh of the total regional population. About half of the region's foreign residents live in Antofagasta (15% of the city's population) and one-fifth are in the city of Calama (16% of the municipal population). In particular, the region is attractive to a working-age population, with 53.2% of all foreign residents between the ages of 25 and 44, contributing to the demographic shift and rapid growth in the region.

While the region's population increase holds potential for Antofagasta's development, it also presents specific challenges, including the integration of the migrant population, the efficient provision of services to all citizens and land use planning. For instance, the rapid growth of the migrant population has added pressure on the local labour market and the community infrastructure. This population experiences a higher share of housing overcrowding (20.6% vs. 5.8% for those born in Chile) and a lower attendance rate for higher education (11.4% among 18-24 year-olds vs. 38.8% for those born in Chile). This situation highlights the need for better mapping the skills of the migrant population to improve labour demand matching and inclusive policies that foster social cohesion and cultural understanding.

Despite the vast amount of wealth brought by mining, many communities lag across a wide range of well-being dimensions

Initiatives so far have tried to translate mining wealth into greater well-being standards but in an isolated manner

Different policies and initiatives in Chile and the region of Antofagasta have tried to better translate mining wealth into greater well-being standards for the local population. At the national level, the Ministry of Mines and the Production Development Corporation (CORFO) have promoted policies and strategies to promote development in Antofagasta (e.g. the Alta Ley Corporation), mainly targeting economic objectives in the region.

At the regional level, the Mining Cluster of Antofagasta was one of the first plans to improve the interaction of the local economy with the mining process. Private companies CODELCO have also undertaken initiatives to improve the impacts of mining in local communities. They include initiatives such as Calama Plus, Creo Antofagasta and the World Class Supplier Program.

However, those different programmes and policies have been spurious and isolated, lacking effective co-ordination amongst each other and scalability to deliver higher well-being standards. For example, the mining cluster initiative, in its different forms, has fallen short in unifying support actions and local procurement of mining companies and in improving knowledge transfer to promote national and international growth of local businesses. This policy alone was not enough to address the increasing outsourcing of mining activity and relocation of production chains outside the region (Atienza et al., 2015[5]). Likewise, the Calama Plus initiative, a joint effort between the public and private sectors of Calama, did not manage to meet expectations and implement the agreed projects. Part of the obstacles to this initiative's success included a governance body with unequal decision power and mining companies with more power to prioritise their projects. In turn, local communities lacked the capacity to structure and implement their preferred projects.

Structural well-being gaps remain across the region of Antofagasta

Despite its high potential, many communities and citizens in Antofagasta have so far been left behind across economic, social and environmental dimensions of well-being.

Economically, Antofagasta's income inequality (Gini coefficient of 0.51 in 2019) is above the national average (0.46), as well as its unemployment rate (9.6% in 2021 vs. 9.1% in Chile and 7% across 50 OECD mining regions). Most of the copper production in Antofagasta is done by large companies, with small and medium-sized enterprises (SMEs) being marginal producers of copper (0.4% and 0.94% of the regional copper production in 2021). Despite the prominence of the mining industry in Antofagasta's economy, local businesses have little involvement in value-added mining activities in the region. Despite being the first mining region in the country, only 26% and 12% of the mining industry suppliers of copper and lithium in the country respectively are registered in the region (Atienza et al., 2015[5]). Moreover, the copper industry in the region currently provides few opportunities for forward linkages with local businesses, as most of the

copper extracted in the region (99%) is exported to Asia for refining. This is linked to a relatively lower cost-efficiency of Chile's smelting industry, with an average of USD 211 per tonne (USD/t) of copper produced, far above the industry average of 114 USD/t (COCHILCO, 2022[6])

Socially, the region records the lowest life expectancy (79.2 years) amongst Chile's 16 regions and the fifth lowest life satisfaction index in the country. Low levels of life satisfaction in the region reflect community concerns about the scarcity of parks and green areas for recreation and leisure activities.

Moreover, Indigenous communities face acute challenges across a number of areas. These communities in 2017 represented 9.5% (18.5% of the rural population and 8.2% of the urban) of the regional population and recorded higher income poverty rates (14.5%) than non-Indigenous communities (8%); yet, between 2011 and 2017, the extreme income poverty rate decreased by over 10 percentage points (14.5% to 4%). Indigenous people also report greater difficulties in accessing quality health, with malnutrition affecting Indigenous children aged 0 to 6 years. For instance, the percentage of children aged 0-6 years who picked up free food at the clinic or hospital in the last 3 months was 10.4 percentage points higher in Indigenous populations (63.9% compared to 53.5%). Furthermore, Indigenous individuals face challenges in education, with 45% of those aged 19 and above not completing secondary education (compared to 36.6% for non-Indigenous individuals) (CASEN, 2017[7]).

This calls for more inclusive and equitable benefit-sharing arrangements between Indigenous peoples and mining companies that can deliver poverty reduction, improve access to public services, offer meaningful participation in decision making and better track their progress. To address these issues, other mining regions, such as Northwestern Territories and Ontario in Canada, have improved institutional and financial conditions for Indigenous communities to participate in decision making, share the benefits of mining or even own mining operations.

Environmentally, the region emits, on average, 38% more greenhouse gas (GHG) emissions per unit of electricity generated compared to 50 OECD mining regions. This issue underscores the need for sustainable practices and the introduction of energy-efficient technologies within the region's key industries. Among Antofagasta's sub-regions, Tocopilla exhibits the highest per capita GHG emissions, placing it within the higher range of emitters across OECD mining regions. Furthermore, water resource management, especially considering the arid nature of Antofagasta, emerges as a crucial environmental challenge. This was highlighted between 2018 and 2019 when the region's sub-regions experienced drier conditions when compared to other OECD mining regions. El Loa faces a significant impact, with a higher ranking among the OECD mining regions for soil water content anomalies.

Mining activities in the region have also been associated with higher levels of fine particulate matter 2.5 (PM2.5) particles in the air. This poses potential health risks for residents, with the possibility of increased incidences of respiratory and cardiovascular diseases. The transformation of the region's natural landscape due to these activities has implications for residents' quality of life and future tourism prospects. Addressing these concerns calls for a more comprehensive and up-to-date environmental data collection and monitoring system. These enhancements will allow for more accurate assessments of the environmental impact of mining and enable the development of more effective responses.

All of the gaps described are multidimensional (see Table 1.2 for a summary of the main challenges) and will not be solved overnight. Approaches so far have left many communities and citizens behind despite the wealth generated through mining activities. Thus, there is a need to develop a new development strategy that is bottom-up led, reflects local priorities, offers opportunities for local firms and entrepreneurs, has a medium- to long-term perspective, is holistic and better co-ordinates efforts by different levels of government, the private sector and academia to align strategies and efforts of all actors towards delivering higher well-being standards.

Table 1.2. Main challenges of Antofagasta

Challenge	Description
Economic	
Dependency on mining	Antofagasta's economy relies heavily on mining, making it vulnerable to fluctuations in global commodity prices and demand for minerals. Economic downturns in the mining sector can lead to job losses, reduced investment and a decline in overall economic activity in Antofagasta. Therefore, diversifying the economy and reducing the reliance on mining is crucial to enhancing the region's economic resilience and stability.
High unemployment and income inequality	Despite its economic prosperity, Antofagasta has a higher unemployment rate (9.6% as of 2021) than the national average. Furthermore, the region's income inequality, as represented by a Gini coefficient of 0.51, is also higher than the national average. Addressing this disparity and creating more job opportunities across various sectors is a major economic challenge for the region.
Social	
Limited access to quality services	While Antofagasta is the leading Chilean region in broadband access, it may face challenges in other areas of service provision due to its low population density and remote location. There might be issues in the quality and access to education, healthcare and other important services, especially for the more isolated and vulnerable populations (e.g. Indigenous peoples).
Low perception of quality of life	Despite the region's high GDP per capita, life satisfaction is relatively low. This could reflect a variety of issues, including dissatisfaction with public services (e.g. health, education, etc.), security levels, recreational and cultural infrastructure, as well as environmental concerns.
Environmental	
Risk of lack of water resources	Antofagasta is one of the driest regions in the world, with nearly all of its freshwater coming from outside sources. This presents significant challenges in terms of securing sustainable and affordable water supplies for both residents and industries.
GHG emissions and lack of environmental information	The region's reliance on mining contributes to high GHG emissions and potential water contamination, posing a threat to the local environment and people's health. Improvement of environmental information systems is critical to monitor biodiversity, freshwater quantity and quality together with air pollution levels.

At the same time, the mining sector is facing increasing challenges to remain competitive

Global megatrends, including demographic change, climate change and the transition to a low-carbon economy, as well as digitalisation and automation, are bringing new challenges and opportunities to the mining sector. The main challenges affecting the future competitivity of the Chilean mining sector include:

- **Productivity and diminishing ore grades**: The productivity of mining in Chile and Antofagasta has been in decline for the past 20 years (De la Huerta, 2018[8]; OECD, 2022[9]). This decline can be attributed to deteriorating ore grades and extraction to greater depths that require longer processing and internal transportation times and higher energy and water consumption.
- **Availability of skills**: There is a significant deficit both in terms of employees and competencies needed in mining-specific skills. For the period 2021-30, a 25 000-employee gap is foreseen due to the compound effects of the retirement of current workers and the expected creation of new jobs resulting from the sophistication of mining operations (CCM and Programa Eleva, 2021[10]).
- **A complex and centralised land management system**: An overly centralised public land administration and management system, coupled with widespread mining property speculation, has resulted in land scarcity and a costly, bureaucratic process for obtaining public lands for productive purposes, such as downstream activities in mining processes (Martorell Awad, 2020[11]).
- **The imperative to swiftly align with evolving environmental requirements**: Persistent concerns and doubts about the long-term environmental effects of mining persist, with an absence of coherent and systematic strategies to address these concerns. These issues encompass doubts regarding the long-term impact of marine water capture and desalination, as well as the region's substantial carbon footprint. At the same time, norms aiming at reducing the use of continental

water have excessively encouraged the use of desalinated water, providing fewer incentives for other alternatives, like water reuse. This disproportionately affects medium-sized mines that lack the capacity to invest in desalination infrastructure.

- **Social concerns**: The equitable allocation of benefits from the industry, both at the regional and local community levels, may become challenging due to the changes in procurement and labour demand brought by digitalisation in mining.

A long-term strategy is warranted to leverage mining benefits in view of reducing well-being gaps and taking advantage of the green and digital transition in mining

Mining has been the central engine of growth for the region of Antofagasta and Chile as a whole. Still, it is clear that a new social pact is needed to ensure both an equitable distribution of wealth and opportunities across the region and the development of a competitive mining sector with more environmentally sustainable practices.

The forthcoming Mining Strategy of Well-being for the Region of Antofagasta 2023-2050 (hereafter the Mining Strategy) can be that new social pact that sets a roadmap to strengthen Antofagasta's mining sector and ensures that the mining wealth provides a long-lasting increase in well-being standards for its citizens. It can also align different strategies and actions towards common efforts, unify different visions within the regions and improve co-ordination with Chile's mining national strategy and other regional development policies.

The ongoing decentralisation process in Chile presents a new setting to establish a new vision for development

The ongoing decentralisation process in Chile provides the institutional and political momentum to establish a new mining strategy in Antofagasta. Since 2021, regional governors in Chile can be elected by popular vote every four years (La Biblioteca del Congreso Nacional de Chile, 2021[12]). Under this framework, the governor has acquired new responsibilities and tools, including the development of investment strategies and land use planning. This represents an important shift from the previous multilevel governance structure, where each region was governed by an *Intendent*, a delegate appointed by the president of Chile to administer the resources and design the policies for the region.

This change provides scope for improved adaptions of regional and national policies to better meet local needs, opportunities and challenges, enhance accountability and help facilitate institutional channels for communities to participate in decision making.

A medium- and long-term vision that moves from past challenges towards a common path for the future

Setting a clear and ambitious goal in the strategy is useful to align efforts across different levels of government and other regional stakeholders to meet common goals, attract skilled workers and new investors and create partnerships with international actors that support the region's long-term plan.

To build trust across different parts of society, improve policy certainty and move towards a common regional goal, this strategy would benefit from recognising the priorities raised by different societal stakeholders:

- On the one hand, recognising that some communities have been left behind in several well-being dimensions, more must be done to deliver development opportunities locally. This involves prioritising a range of issues, from access to quality public services such as childcare and secondary care to the availability of parks and green spaces for recreation and leisure activities, with the active involvement of the community.

- On the other hand, recognising the strategic role of the mining sector in the future development of Antofagasta involves improving efficiency in government processes to facilitate the expected investments and ensure certainty in their implementation.

The regional government has already anchored the process of elaborating the strategy in the construction of a new regional pact. The former recognition, demanded from both the private sector and the communities, will facilitate discussions about a shared future for the region. This transition involves shifting from a perspective overly focused on past challenges towards a narrative centred on collaboratively constructing a better future.

The new strategy can materialise the main development priorities via common objectives and strategic projects in the short, medium and long terms

The new strategy needs to set concrete and common medium- to long-term objectives and agreements that address the main development priorities in the region and set the path for regional development policies that can leverage mining to improve well-being. These objectives need to be agreed with regional stakeholders and be based on bottom-up-led development priorities. Five areas of action are identified as the highest priorities to achieve the vision of this strategy:

- Improved well-being standards for all, with focalised actions for Indigenous and non-Indigenous communities.
- Expanded participation of the local economy and regional businesses in current and new mining development projects. This requires strategies that target business opportunities throughout the value chain, including exploration, extraction and transformation of minerals.
- Enhanced skills and regional knowledge ecosystem to ensure that the workforce and regional innovation ecosystem make the most of the digital and green transition in mining.
- A more efficient institutional framework to provide certainty in the process of permits and other government processes for mining projects, including greater government capacity to study environmental and land use permits and monitor private sector compliance.
- Greater efforts to rehabilitate and preserve the environment from the effects of mining and industrial processes, which needs to start by improving baseline information on the impact of mining on inland water, air pollution and biodiversity.

Attaining the objectives and agreements requires specific actions that build trust in the strategy over the short term and ensure a long-term implementation. To this end, a timeframe of strategic projects should be put in place by indicating the projects that are a priority and feasible to implement in the coming years (e.g. 2023-30) and those others that are inscribed in the medium and long terms (2030-50). A series of common agreements, strategic projects and public policy proposals have been identified from the meetings with regional stakeholders in the preparation of this strategy and the direct information provided to the regional government since October 2022 by key stakeholders. The short-term projects can leverage the pipeline of projects to be developed i the regional plan or the corporate social responsibility plans of mining companies. These short-term projects can help create local alliances to work towards a unified vision and improve social acceptance of the strategy.

A governance system to oversee, monitor and adjust the strategy in the medium and long terms

For the strategy to be successful and lasting, a governance mechanism must be implemented and capable of making the strategy last beyond political cycles, which allows prioritising projects and deciding the best way to implement them, as well as monitoring their results until 2050. This governance must be made up of various actors in the region, with a clear structure of participants and an established decision-making capacity and frequency of meetings. Other OECD regions like Brainport Eindhoven the Netherlands or

Morelos in Mexico have adopted multi-stakeholder governance models to oversee the design and implementation of key strategies for regional development.

Moreover, Antofagasta's Mining Strategy needs to be accompanied by a monitoring framework with different types of indicators to ensure a sound implementation at the different stages of the strategy. This can include impact indicators to measure the long-term policy effect of achieving each of the strategic objectives and outcome indicators to monitor the implementation of the common agreements and the strategic projects in each objective. In turn, a set of output indicators is needed to measure the implementation of the operative tasks in each strategic project.

Recommendations

Formalise and implement the Mining Strategy with a timeframe of strategic projects based on the priorities of the different regional stakeholders

To this end, the regional government should:

1. Formalise the Mining Strategy with a dedicated budget within the institutional and policy framework of the government of Antofagasta.
2. Recognise in the Mining Strategy the need for a new regional pact among Antofagasta communities and private sector to build trust across different actors and promote common agreements to improve future developments of the region and move forward with the Mining Strategy.
3. Ensure that the Mining Strategy provides a medium- and long-term vision that reflects the aspiration for the region to increase well-being standards in economic, social and environmental dimensions, building on a competitive and environmentally responsible mining sector.
4. Establish concrete objectives in the Mining Strategy that address local priorities and are based on common agreements across the region's different actors to attain the Mining Strategy's final vision. These objectives should help to:
    - Improve the quality of life of local communities and Indigenous peoples with strategies that improve access to services in mining communities, support projects to diversify the economy (e.g. tourism or desert-based agriculture) and co-ordinate corporate social responsibility programmes of mining companies.
    - Increase the participation of regional businesses in the mining value chain. This includes supporting suppliers and technologies that can address key regional mining priorities (e.g. water and air pollution management), promoting local entrepreneurship in the circular economy in mining and supporting sustainable practices of small/medium mining companies.
    - Strengthen skills and the regional knowledge ecosystem, including supporting the Lithium Institute with a roadmap of innovative projects, promoting apprenticeships in mining, establishing formal spaces for exchange between businesses and academia, and improving the quality of education from pre-school onwards across the region.
    - Improve governance for a more productive and sustainable mining sector, including through improving the capacity of environmental institutions in the region, promoting shared mining infrastructure (e.g. desalinated water facilities) and greater connections with renewable energy projects, attracting companies interested in other minerals (e.g. rare earth minerals) or ensuring a just transition in water management by mining companies.
    - Rehabilitate and preserve the environment. This involves supporting civic environmental monitoring, improving information on the effects of mining on air or water pollution and incentivising a more efficient use of water (e.g. technologies for water reuse).

5. Implement short- and medium/long-term agreements, strategic projects and public policy proposals to attain each of the objectives of the Mining Strategy. Several strategic projects have been identified throughout different multi-stakeholder meetings in the region.

Table 1.3 depicts the suggested objectives and examples of strategic projects, building on multiple meetings with regional stakeholders.

Table 1.3. Suggested objectives and timeframe of the strategic project for the Mining Strategy

Timeframe	Improve the quality of life of local communities and Indigenous peoples	Increase the participation of regional businesses in the mining value chain	Strengthen skills and the knowledge ecosystem in the region	Improve governance for a more productive or sustainable mining sector	Rehabilitate and preserve the environment
Short term (2023-30)	Improve drinking water and sewerage systems in mining communities	Measure the participation of regional companies in the mining value chain and establish a roadmap of opportunities	Set a roadmap of local value-added projects within the Lithium Institute (e.g. water management)	Improve the capacity of environmental institutions in the region (e.g. the Superintendence of the Environment)	Support civic environmental monitoring
	Facilitate the upgrade or installation of quality health centres	Expand the participation of local businesses in mining companies' programmes to upscale providers	Promote apprenticeships in mining across regional schools	Facilitate approval of industrial land (in collaboration with the SEREMI of Public goods)	Reduce air pollution from mining operations
	Expand the number of recreational and green infrastructure, and public lighting	Promote synergies among mining companies' programmes on local procurement	Complement mining companies' training programmes to extend coverage	Improve collaboration between large and small/medium mining companies	Reduce mining waste generation and facilitate its valorisation
Medium to long term (2030-2050)	Fund/structure to support the creation of Indigenous businesses	Support technology transfer to regional companies	Adapt basic education to prepare students for the automation of mining processes	Enhance the capacity of local governments to structure, submit and approve projects	Reduce to a minimum the use of inland water for mining activities
	Fund/structure to promote economic diversification (e.g. agriculture in the desert, artisanal fishing)	Internationalise the regional mining providers	Support a network of research centres for the mining of the future	Ensure that processes for metal recovery or extraction (e.g. oxide leaching) are achieved on time and with high environmental standards	Evaluate the mechanisms to return water rights to the communities
	Improve tertiary roads, broadband and satellite infrastructure	Support local entrepreneurs/ SMEs to boost circular economy activities in mining (recycling of lithium)	Improve the quality of education with a focus on reducing inequalities across the region	Promote greater use of renewable energies in mining operations (e.g. speeding up permits for interconnection and generation)	Produce an environmental diagnosis of the region

Establish a governance mechanism to monitor progress and ensure the sustainability of the Mining Strategy over the long run and beyond government cycles

This mechanism could benefit from the following elements:

6. Define a new role for a public official in the government, with responsibility for co-ordinating the Mining Strategy and ensuring its implementation and continuity, with a defined budget and a team for operation and co-ordination.

7. Establish a steering committee in charge of prioritising projects, rendering accounts of monitoring and evaluation, and proposing new orientations to the Mining Strategy. It should comprise representatives of relevant actors in the region (private and public sector, civil society and Indigenous communities), with periodic rotation to expand possibilities of participation and representation (e.g. two years) and a consensus-based decision process.
8. Establish a technical committee in charge of overseeing the projects, providing updates on the progress of projects and budgets and responding to other requests from the steering committee. This committee is made up of an executive secretary and a team of professionals, in collaboration with personnel from academia and the private sector.
9. Ensure that the Mining Strategy upholds Indigenous peoples' rights and promotes meaningful participation in the decision making and prior and informed consent in the design and implementation of relevant strategic projects for these communities.

Define a monitoring and evaluation framework with different levels of indicators

10. Set up an evaluation framework that can recurrently measure the outputs and outcomes of the various strategic projects to attain each of the objectives of the Mining Strategy.
11. Monitor the overall Mining Strategy's progress in improving the region's well-being standards through specific impact indicators that are horizontal to the strategic projects in each objective.

Ensure a formal channel of communication and involvement of regional stakeholders in the Mining Strategy's construction, progress and changes

12. Establish an appropriate communication strategy to disseminate the Mining Strategy and its construction process with annual public reports on the progress of the strategy via media or public gatherings.
13. Map and publicly report information on the environmental, social, and corporate governance (ESG) initiatives from the mining companies in the region.

Improve the institutional capacity of the national agencies operating at the regional level

The national government is crucial to the regional Mining Strategy's success and ensuring a more sustainable mining sector in Chile. To this end, it should:

14. Co-ordinate with the regional government of Antofagasta to identify institutional needs in the region and define methods to increase the capacity and upgrade the Regional Ministerial Secretaries (SEREMIs) – especially the SEREMI of the Environment, the SEREMI of National Goods and the National Geology and Mining Service – and the Superintendence of the Environment. This support should be aligned with the needs of the region's SEREMIs as listed by the regional government during the development of the strategy.
15. Improve government co-ordination to better involve Indigenous communities in policy making around mining and their territories.

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Note

[1] The OECD's Toolkit to Measure Well-Being in Mining Regions identifies 50 OECD mining regions with a high specialisation in mining activity relative to their respective countries to better benchmark well-being trends relative to other OECD regions and identify challenges and strengths.

2 Strengths and challenges for regional development in Antofagasta

The Antofagasta region, located in northern Chile, is a global player in the mining industry and Chile's main producer of copper and lithium. This chapter benchmarks Antofagasta's trends with comparable OECD regions also specialised in mining and extractive activities. The benchmark allows the identification of the region's main strengths and weaknesses. The results of the analysis provide the overall diagnosis and development priorities for the mining strategy of the region of Antofagasta.

Assessment and main takeaways

Antofagasta is located in northern Chile, a region carved by the natural contours of the arid Atacama Desert, with a rich presence of mining resources and home to Indigenous communities. Antofagasta is the largest producer of copper and second of lithium in the world, placing it as of strategic importance for the global energy transition and an economic powerhouse for Chile. The regional share of the national gross domestic product (GDP) (12.8%) is over 5 times as high as the share of the country's population (2.2% that comprises 719 000 inhabitants in 2022). Its GDP per capita ranks the highest in the country and is almost twice as high as the average value of the OECD benchmark for mining regions. Spanning a considerable geographic expanse alongside the Pacific Ocean, Antofagasta's population density (5.7 individuals per square kilometre) is almost four times below the average in Chile (24.06), ranking it the fourth least densely populated region in the country and among the 25% least dense across the OECD benchmark of 50 mining regions.

Antofagasta's export-oriented mining sector has propelled the economic development of the region, creating over 113 thousand direct jobs (28.3% of the total employed population[1] in May 2023) and contributing to 39.4% of Chile's total exports (March 2023). Nevertheless, the mining wealth has not translated equally to all of the population, leaving important well-being gaps in mining communities. Unemployment in Antofagasta (9.6% in 2021) is slightly above the national average of 9.1% and exceeds the OECD mining region benchmark (7%) (OECD, 2022[1]). Inequality (Gini coefficient of 0.51 in 2019) also remains above the national average (0.46) and the region records the lowest life expectancy (79.2 years) among Chile's 16 regions. Well-being gaps are acute in Indigenous communities, which perceive 6.4% less income than non-Indigenous communities. These figures reveal that the mining sector's benefits have fallen short for many inhabitants of Antofagasta, pointing to an ongoing social debt amidst the region's prosperity.

Antofagasta's prosperity is highly dependent on its copper mining activity, which makes it volatile in terms of global commodity prices. The regional economy tends to experience pronounced cycles of boom and bust. During boom periods, the labour market attracts mining workers to its communities, including fly-in fly-out workers from the country and overseas as well as permanent migration. During bust periods, the region sees a substantial drop in GDP per capita. For instance, amidst plummeting copper prices between 2011 and 2016, Antofagasta's GDP per capita saw a net decrease of 4.2% from its peak over the 2011-20 decade. This economic downturn directly impacted the labour market, leading to job losses, consequently affecting local businesses and the wider economy.

The chapter systematically compares economic, social and environmental trends in Antofagasta to other Chilean regions and an international benchmark of OECD mining regions at the TL2 level [2]. The report also benchmarks smaller geographic units between Antofagasta and OECD mining regions at the TL3 level. The results of the analysis provide the overall diagnosis and development priorities for the mining strategy of the region of Antofagasta.

Main takeaways

Economy:

- The highest GDP per capita in the country (USD 68 661 vs. the national average of USD 21 019 in 2020), it is almost twice as high as the average GDP per capita of the benchmark of mining regions (USD 39 225).
- Close to three-quarters of the region's economic growth is primarily driven by mining activities (around 72% of the regional GDP in 2023, 7 percentage point increase in relation to 2022). This sector provided 131,000 jobs, which represents 28.3% of the region's total employment and

41% of the total national employment in the mining sector. Nearly half (45.4%) of these workers are based in Antofagasta but reside elsewhere in Chile (INE, 2023[2]). This leaves room for improvement to employ more workers locally. Additionally, mining boosts the economy by creating indirect jobs in related sectors like transport and services (Cardemil Winkler, 2023[3])

- Antofagasta accounts for 39.4% of Chile's total exports (USD 3.240 billion in March 2023, approximately 95% of which are mining products). Generally, Antofagasta holds significant economic relevance for Chile, contributing 12.8% to the country's GDP, second only to the capital city of Santiago Metropolitan Region (43.5%).
- Antofagasta is a significant contributor to Chile's exports but its growth performance is associated with high levels of volatility due to limited economic diversification. The region's mining exports rely on a few trade partners, making it vulnerable to fluctuations in global commodity prices. Moreover, value-added manufacturing or service activities are relatively marginal in the region.
- Despite its strong economic performance, Antofagasta exhibits a relatively high unemployment rate (9.6% in 2021) compared to the OECD benchmark of mining regions (7%), and high-income inequality levels (Gini coefficient of 0.51 in 2019) relative to the national average (0.46).
- Antofagasta stands out in Chile in terms of access to broadband, with 84.3% of households having broadband access with an average Internet speed of 72.5%. The region ranks first in Chile.

Social

- The Antofagasta region has seen rapid growth in its population, boasting an average yearly increase of 2.5% over the last decade, significantly outpacing both the national average growth rate of 1.53% and the mining regions benchmarked by the OECD (0.8%). By 2022, the region's population reached 719 000, primarily concentrated in the cities of Antofagasta and Calama.
- The steady increase in Antofagasta's population is largely driven by international migration. Between 2017 and 2021, the region received 14 451 immigrants and, as of December 2021, there were 106 000 foreign individuals residing in the region (1/7 of the total), mostly in the cities of Antofagasta (15% of the total population) and Calama (16%). The region's foreign population primarily comprises individuals from the 25-44 age range (53.2%), with a significant proportion of minors, making Antofagasta the region with the highest proportion of minors among foreign residents.
- As for social perception, the region exhibits a strong sense of community, with a perceived social support network of 92.0%, ranked second in Chile and in the top 36% across all OECD regions.
- The region is relatively younger and has a lower share of elderly population compared to both the national average of Chile and the OECD benchmark, indicating a demographic advantage.
- However, the region shows higher mortality data, recording 6.4 deaths per 1 000 people and a life expectancy of 79.2 years, which places it last in mortality among Chile's 16 regions.
- Indigenous peoples face higher income poverty, with a 6.4% disparity in Indigenous communities compared to non-Indigenous communities. Additionally, Indigenous peoples have a 20% childhood poverty rate, higher than the 13% rate for the rest of the country's children.
- The life satisfaction index stands at 6.0 (on a scale of 0 to 10), ranking Antofagasta the fifth Chilean region with the lowest life satisfaction and in the bottom 22% of all OECD regions, despite the economic prosperity brought by the mining activities.

Environment

- Antofagasta records higher greenhouse gas (GHG) emissions per unit of electricity generated than the average of OECD mining regions. The 3 subregions of Antofagasta emit, on average, 38% more GHG per unit of electricity generated (457 tonnes of CO_2 equivalent per gigawatt hour) than the OECD benchmark of mining regions and 82% more than the average of OECD regions. Tocopilla is the subregion with the highest emission per capita, ranking as the fifth OECD mining region with the highest emissions.
- As one of the most arid regions in the world, Antofagasta faces unique challenges in water resource management. Between 2018 and 2019, the three subregions of Antofagasta registered average drier conditions than usual (based on the 1981-2010 period), in contrast to fewer anomalies in the average of OECD mining regions. In fact, El Loa ranks as the second region with the greatest anomalies in soil water content in the group of OECD mining regions. Intensive mining activities put significant pressure on the region's already limited water resources, posing a risk to local ecosystems and the long-term sustainability of mining operations.
- Copper extraction and other mining activities in Antofagasta potentially contribute to elevated levels of fine particulate matter (PM2.5) in the air, which might have harmful health impacts on the population, including respiratory and cardiovascular diseases. These impacts underscore the need for better information systems to better monitor air quality across population settlements and eventually reduce particulate emissions and improve air quality in the region.
- Mining activities also have a significant visual impact on the landscape, altering the natural shape of the region and potentially affecting tourism and quality of life for residents. It is important to consider ways to minimise the visual impact of mining, fostering projects and existing programmes on landscape rehabilitation practices. Interestingly, on average, the three sub-regions of Antofagasta register an increase in green land cover above the average of OECD mining regions.
- There is a need for improved regional environmental data collection and monitoring systems in the region. Currently, gaps in reliable, up-to-date information limit the ability to accurately assess and respond to environmental impacts. Enhancing these systems would allow for a more accurate representation of environmental conditions, facilitate informed policy decisions and enable more effective management of environmental resources in Antofagasta.

Despite its low population density, Antofagasta stands out by its economic relevance for Chile and strategic importance for the global energy transition. The region also benefits from a younger population relative to OECD mining regions, with a higher share of the population with secondary education than the national average, sound social support networks and an incipient but growing share of green areas relative to OECD mining regions. These strengths can be leveraged in the development of a comprehensive mining strategy that ensures the region's sustainable growth.

In contrast, the region has high levels of unemployment rates, relative to the country and OECD average, and is economically vulnerable given its long-standing dependency on a single mineral and higher inequality levels than the national average, particularly with the Indigenous population. The region also faces gaps in healthcare and tertiary education access and insufficient environmental-related monitoring. The subsequent chapters will present policy recommendations that feed into a robust mining strategy designed to leverage the region's strengths and mitigate its weaknesses. This strategy will contribute to Antofagasta's continued economic, social and environmental prosperity by promoting a sustainable mining sector.

Introduction

This chapter offers a comprehensive diagnosis of the Antofagasta region in Chile. It compares Antofagasta's development against national trends and a benchmark of other OECD mining regions at Territorial Level 2 (TL2) and Territorial Level 3 (TL3) (see OECD toolbox of mining regions' well-being) (OECD, 2023[4]). Based on these comparisons, the analysis identifies major strengths and bottlenecks in Antofagasta's development and well-being. While mining is the main contributor to the region's GDP and employment, this diagnosis reveals the relevance of leveraging Antofagasta's mining potential to create a prosperous and sustainable future.

The chapter first describes the mining sector in the Chilean and Antofagasta context. It then examines the demographic patterns in the region, followed by its main economic trends. The final section of the chapter examines the main factors for regional development, including the quality of life of its citizens.

The Antofagasta region is a crucial component of the Chilean economy as it possesses an array of mineral resources such as copper, lithium, silver and gold. Nevertheless, the area's economic fortunes are tied solely to the mining and extractive industry, which is exposed to fluctuations in global commodity prices. This sector is also heavily reliant on fly-in fly-out workers, which has resulted in significant challenges concerning access to affordable housing, quality education and childcare, and high levels of GHG emissions from transportation.

The region also has opportunities emerging from these challenges, including the potential for infrastructure development and innovative solutions to address inequality. In this context, this chapter not only explores the key challenges and opportunities facing the Antofagasta region and provides takeaways for sustainable development but also frames a roadmap for a robust mining strategy (see Chapter 4) to stimulate regional development.

Megatrends affecting regions specialised in mining and extractive activities

The geographically concentrated nature of mining leads to a highly specialised economy, bringing with it challenges and opportunities to mining regions and the well-being of its inhabitants. Global megatrends, including demographic change, climate change, the transition to a low-carbon economy, and digitalisation and automation, are transforming industries and societies. These megatrends are also bringing new challenges and opportunities to the development of mining regions (Table 2.1).

Table 2.1. Opportunities and challenges of megatrends for the mining industry and regions

	Opportunities	Challenges
Changes in demographic trend (population ageing and migration)	• Successful integration of migrants may enhance labour supply. • Lifelong learning can enable the old workforce to keep adding value.	• Ageing population/local demographic decline leads to a shortage of labour. • Unsuccessful migrants' integration may lead to social problems. • Many migrants tend to reside only temporarily and eventually move south to larger cities.
Climate change and environmental pressures	• Competitive advantage from high environmental standards in mining. • New jobs from the development of environmentally friendly technologies.	• Pressures for the mining industry to improve its performance and reduce its environmental footprint. • Harder policies and regulations for issuing permits to operate in the future. • Higher public reticence to accept

	Opportunities	Challenges
		mining explorations and openings.
Technological innovation (e.g. digitalisation, automation, decentralised energy)	• Digitalisation/automation may compensate for shortages of labour in some sectors. • Can make mining regions more attractive to live in by providing quality public services, including remote healthcare solutions. • Creation of new jobs by involving regional actors to develop new digital and automated solutions. • Offer greater labour opportunities for women and various segments of the population.	• Displace certain workers in the mining sector, mainly the ones that perform more repetitive tasks. • If technological innovation is produced outside the region, it can affect the competitiveness of the region. • Can reduce the need for certain minerals by replacing them with laboratory products or by extracting them from the recycling process.

Source: OECD elaboration based on inputs from the OECD Mining Regions and Cities network.

The report iscusses the challenges faced by mining environments in the Antofagasta region, including demographic challenges and environmental concerns. However, the region's mining sector has the potential to address these challenges through workforce availability, gender balance, high retention capacity and the supply of minerals and materials needed for green technologies. Technological change and digitalisation can also increase productivity and sustainability in mining activities. The impact of these megatrends on mining municipalities in the Antofagasta region will depend on policy responses to address changes and prepare firms and communities for the future.

Antofagasta's future: Mining and its communities

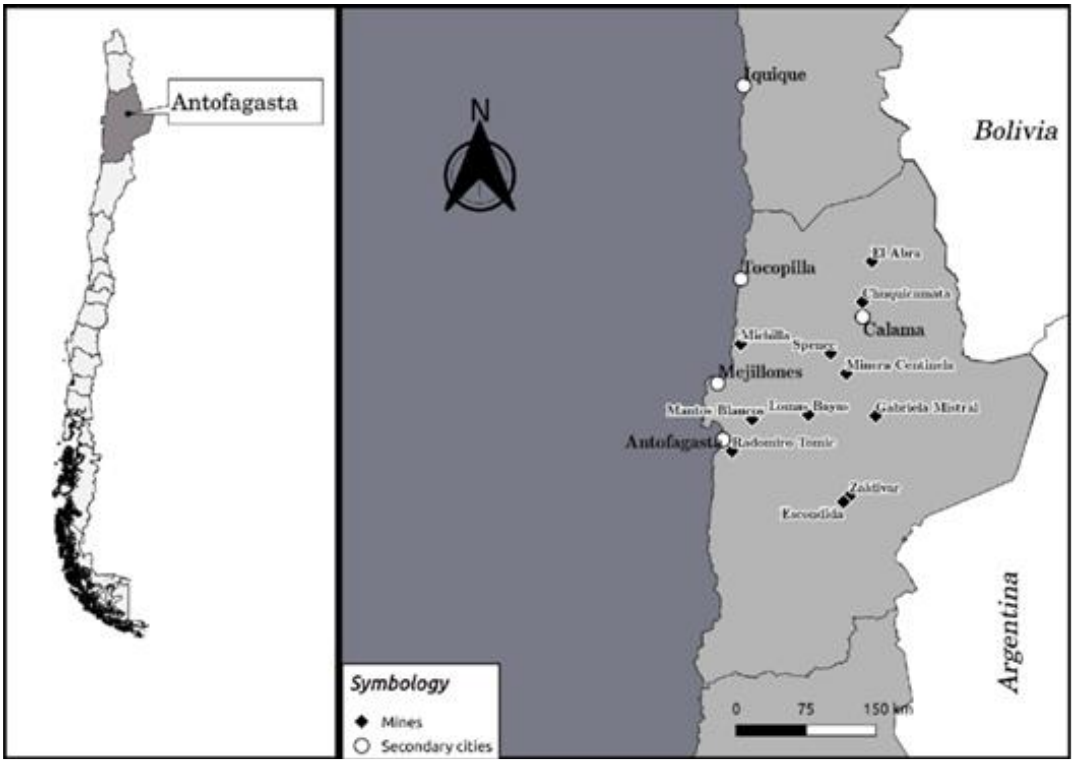
Antofagasta is a region located in the northern part of Chile. The region's largest city and commercial centre is also named Antofagasta. The region (of about 126 049 square kilometres) is known for its unique natural beauty, warm climate, rich mineral resources and cultural heritage. The region of Antofagasta is bordered by Peru to the north, Bolivia to the east and the Pacific Ocean to the west. The TL2 region of Antofagasta is made up of three TL3 regions: Antofagasta, El Loa and Tocopilla.

The landscape of Antofagasta is dominated by the Atacama Desert, which is considered one of the driest places on the planet. The climate is arid and varies greatly depending on the location, with temperatures ranging from below-freezing at high altitudes to over 38 degrees Celsius in the lower elevations. Despite the harsh climate, the region is a popular tourist destination, attracting visitors with its unique natural beauty, outdoor activities such as hiking and stargazing, and historical and cultural attractions.

Antofagasta's economy is heavily reliant on mining, particularly copper. The region is home to some of the largest copper mines in the world, including the Chuquicamata and Escondida mines. The region is also a major producer of other minerals such as gold, silver and lithium. In recent years, the region has also become an important location for solar energy production, with several large-scale solar power plants operating in the area.

Antofagasta has a rich cultural heritage that reflects its history as a crossroads between different civilisations. The region is home to several important archaeological sites, including the famous Atacama Giant geoglyphs, as well as numerous pre-Columbian ruins and ancient rock art. The region's cultural heritage is also evident in its distinctive music, dance and cuisine, which reflect the influence of Indigenous and colonial traditions. Some of the most popular destinations include the Atacama Desert, the La Portada natural monument, the Tatio Geysers and the town of San Pedro de Atacama. The region is also known for its beautiful beaches, particularly in the towns of Mejillones and Taltal.

Figure 2.1. Distribution of selected mines and city locations, Antofagasta, 2020



Source: Velásquez, D. (2020[5]), "Industrial agglomeration and union resources mobilisation: A comparison between Antofagasta Enclave and Los Lagos Cluster, Chile", in *The Political Economy of Work in the Global South*, Red Globe Press.

Comparing Antofagasta using an international benchmark of mining regions

Establishing a benchmark for OECD mining regions and comparing it with Antofagasta is driven by a multi-faceted motivation grounded in the ambition for holistic growth, integrating economic, social and environmental dimensions. Within this context, Antofagasta serves as a vital mining region and can be comprehensively understood – capturing its strengths, weaknesses and potential growth opportunities – when placed within an international framework. This is where the benchmark of mining regions within the OECD comes into play, offering a structured platform for analysis that enables robust comparative examination and underpins evidence-based policy making.

The comparison with an international benchmark is pivotal, as Antofagasta shares common traits with other mining regions (Box 2.1). These include economic dependencies on mining, demographic dynamics, environmental concerns and societal impacts. When juxtaposed with other OECD mining regions, a clearer picture emerges of how Antofagasta fares on a global scale. Such comparison can uncover transformative insights, inspire innovative solutions gleaned from regions tackling similar challenges and highlight successful strategies towards achieving balanced and sustainable growth. This benchmarking exercise can illuminate patterns and trends which might otherwise remain tainted when viewing Antofagasta in isolation. It can spotlight potential areas for improvement, such as healthcare and life satisfaction, thereby opening avenues for learning and adaptation. Moreover, this international comparison can fuel shared learning, encourage the adoption of best practices and catalyse innovative approaches to tackle common challenges confronting mining regions.

The scale at which trends, assets and challenges are analysed is crucial for policy design and implementation. Recognising the importance of the subnational level in leveraging mining for people's well-being, this section presents an approach to identifying mining regions across OECD countries and to

constructing a representative benchmark. This comparison enables a well-rounded analysis of well-being levels across mining regions and other OECD regions.

The mining regions are identified at the smallest comparable regional level, TL3. This granularity allows the capture of the positive and negative effects of mining and enables the comparison of common international trends. Additionally, a macro-perspective analysis is conducted at the larger scale of TL2 regions. While these regions may encompass various sub-regions with a diverse range of economic activities, this broader lens is valuable for assessing data that require a comprehensive overview.

At the TL3 level, the benchmark encompasses a diverse array of regions from multiple countries. For instance, regions like Queensland Outback and Western Australia Outback in Australia, and Athabasca-Grande and Yorkton/Melville in Canada, among 50 others, are renowned for their substantial mining activities and strategic contributions to their national economies.

At the TL2 level, the benchmark expands to include regions from a broader spectrum of countries. Similarly, 50 mining regions across the OECD, such as New South Wales, Queensland and Western Australia in Australia, Alberta and Saskatchewan in Canada, and Brandenburg, North Rhine-Westphalia and Saxony-Anhalt in Germany have been used to benchmark Antofagasta.

Box 2.1. What is a mining region?

While mines are located in one specific area, namely a village or municipality, the mining activity often has the potential to impact the development of more than one community. Functional labour markets and economies that are linked with the mining activity can thus involve several municipalities or even regions.

Regions or provinces in a country play an important role in promoting synergies among municipalities around economic, social and environmental activities. They can help attain economies of scale, bridging urban and rural assets, co-ordinating investments and local labour markets as well as promoting shared protection of natural assets. Across OECD countries, this level of government also establishes development plans and creates links with external markets and investors. This is even more relevant for mining countries with federal structures (e.g. Australia, Canada or the United States), where regions define and conduct mining development strategies and manage natural resources. Moreover, at this level, most well-being data are available and comparable across the country and internationally.

OECD defines two types of regions at different geographical levels for which comparative data are collected. The first type of region is classified as Territorial Level 2 (TL2), which is the first administrative tier of subnational government (i.e. states in the United States, *estados* in Mexico or *32egions* in France). Smaller regions are classified as Territorial Level 3 (TL3), which are smaller territorial units that make up each TL2 region. In most countries, these regions are aligned with small administrative structures, such as provinces in Chile and Spain or counties in Sweden. For some countries, like Australia, Canada, Mexico or the United States, these TL3 regions do not have an official political-administrative level but only statistical and geographical representativeness. These TL3 regions also vary in their degree of rurality, differentiating between the metropolitan and highly densely populated regions and different types of rural regions.

Therefore, the process to identify the OECD mining regions follows three steps:

1. **Identify the small regions in the OECD country (Territorial Level 3)**. The OECD has more than 2 400 TL3 regions in its 38 member countries. The distribution of these regions by country is a mix of statistical and administrative boundaries that are at a geographically comparable scale and consistent with national classifications. Thus, the segmentation of the country into

these territories is consistent for the cross-country analysis. The OECD territorial classification (OECD, 2022[6]) provides a list of all TL3 regions for OECD countries.

2. **Defining regional mining specialisation based on employment location quotients (LQ)**.[3] The degree of regional specialisation in mining is obtained by comparing the share of mining employment in the region with the share of mining employment in the country.[4] A value of LQ above one implies that the region is more specialised than its respective country. The employment specialisation in mining, based on LQ values, is ranked from highest to lowest. The threshold selected to categorise a mining region is an LQ above 1.5, so a region is considered to be specialised if it exceeds 50% of the country's mining specialisation. Applying this threshold to the sample of OECD TL3 regions, 360 OECD regions are 1.5 times more specialised in mining than their own country.
3. **Final adjustment based on desk research**. To build a geographically balanced benchmark and control by country effects of the LQ (e.g. countries highly specialised in mining with a relatively even geographical distribution of the activity), the methodology assigns the regions with a higher LQ than the benchmark by following the country's weight in total OECD mining employment (Annex 2.A lists the countries included). In other words, the number of regions in the benchmark is in line with the share of the country's mining employment in the total number of mining workers across the OECD. A desktop research process examines each selected region to ensure there is a good geographical balance in the benchmark (and avoid overrepresentation of a given country). As a result of this process, 50 mining regions constitute the OECD mining regional benchmark.

Source: OECD (2021)

Acknowledging the impacts of mining activities on the territory and looking beyond economic performance

Antofagasta stands at an important crossroad. Its rich mining resources and capable workforce make it a key player in the mining world. But this does not come without environmental, social and technological challenges and these are not isolated: they are woven into a bigger picture, influenced by global shifts. These shifts are towards cleaner energy, the rise of digital technologies, city growth and older populations. They offer new opportunities but also bring new challenges for Antofagasta.

In order to secure a future for the mining industry, Antofagasta needs to find the right balance. This balance must consider the needs of the mining industry, the well-being of local communities and the sustainable sourcing of minerals that are crucial for our world's transition to greener technologies. The region has a key role to play in supplying minerals for a greener future whilst also protecting the environment and supporting its communities. It is not a straightforward target but, with planning, Antofagasta can help shape a sustainable future for mining and communities alike.

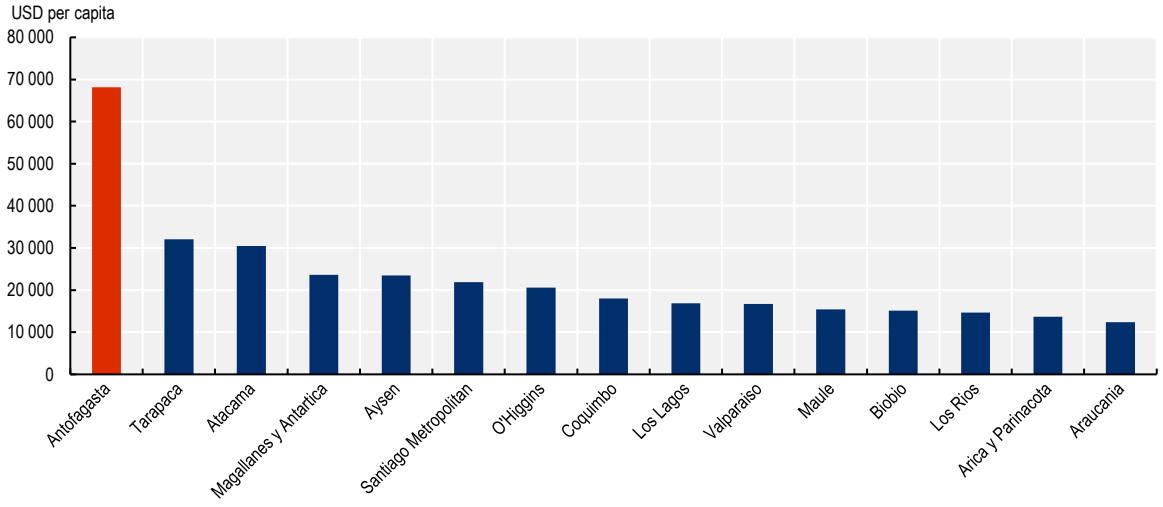
Mining has led to a mix of outcomes within the region, creating substantial prosperity yet also fostering considerable disparity. The growth and evolution of the area have been largely shaped by mining operations, producing side effects that have influenced the well-being of local communities, most notably in terms of environmental impact. While mining activities are progressively adopting more sustainable and ecofriendly practices, they continue to present intricate challenges related to externalities management. Generally, the impacts of mining within the Antofagasta region are multi-faceted and can be classified with an economic, social and environmental lens.

- **Economically**, the prosperity generated by mining is largely attributable to the value of the minerals, ranging from copper to lithium, extracted in the region. This places Antofagasta as the

region with the highest GDP per capita in the country (Figure 2.2), significantly exceeding the average for OECD countries. The regional labour market is largely dependent on mining, with employment opportunities across various mining operations. However, the degree to which local employment is utilised varies from one operation to another. Conversely, the reliance on regional suppliers has seen a decline over the past decade.

- From a **social** perspective, the wealth distribution associated with mining has created a dual-speed economy within the region. Mine workers typically earn higher salaries than non-mining workers, leading to discrepancies in purchasing power that affect local prices from housing to basic goods. Together with the fly-in, fly-out (FIFO) workers culture, Antofagasta ranks as one of the regions with the highest cost of living in Chile. The provision of public services is limited and the infrastructure is primarily designed to support mineral extraction and transportation rather than catering to broader civilian needs (e.g., pavement, electric grids).
- **Environmental** impacts are particularly pronounced, especially regarding air and water quality. The emission of PM2.5 from copper mines located near urban areas (such as Calama and Sierra Gorda) creates a climate of social unrest due to health concerns. Additionally, despite a shift from freshwater to seawater usage in some mining operations, this adaptation has not been sufficient to alleviate the region's water stress.

Figure 2.2. GDP per capita by region in Chile against the national average, 2021



Note: GDP per capita (USD purchasing power parity [PPP] base year 2015). Antofagasta represents 3.24 times the national average.
Source: OECD (2023[7]), *OECD Regional Well-Being (database)*, https://www.oecdregionalwellbeing.org/ (accessed on 27 February 2023).

A future together with its numerous Indigenous communities

The Antofagasta region, known for its mining wealth, houses a significant Indigenous population. Current data indicate that Indigenous communities represent 9.5% of the regional population, which includes 18.5% of the rural population and 8.2% of the urban population (CASEN, 2017[8]). While these communities are constitutionally recognised and Chile has ratified both the International Labour Organization (ILO) Convention No. 169 and the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP), ensuring their free, prior and informed consent for any activities affecting them, the relationship between mining companies and Indigenous peoples continues to be challenging (UN, 2008[9]; ILO, 1989[10]).

This challenge arises from several factors, notably land use conflicts and unequal benefit-sharing arrangements. Mining activities frequently occur in traditional Indigenous territories, leading to disputes over land rights and resource allocation.

Despite these communities experiencing higher income poverty rates (14.5%) than non-Indigenous communities (8%), there has been a significant decrease in the extreme income poverty rate from 14.5% to 4% between 2011 and 2017. Nevertheless, disparities extend beyond income, with Indigenous people often reporting greater difficulties in accessing quality healthcare and education. For example, malnutrition affects Indigenous children aged 0 to 6 years more frequently, with the percentage of children aged 0-6 receiving free food from clinics or hospitals in the last 3 months being 10.4 percentage points higher among Indigenous people (63.9% compared to 53.5%) (CASEN, 2017[8]).

Educational challenges are also prominent among the Indigenous population. About 45% of Indigenous individuals aged 19 and above have not completed secondary education, compared to 36.6% for non-Indigenous individuals. Despite these challenges, the region's resilience and rich cultural heritage are noteworthy. Several programmes have been put in place by the regional government, private companies and Indigenous communities to leverage their strengths and improve the region's living conditions. These initiatives aim to respect Indigenous rights, foster inclusivity and promote the equitable sharing of benefits derived from the region's abundant resources.

Table 2.2. Share of Indigenous population by region over the total of the country

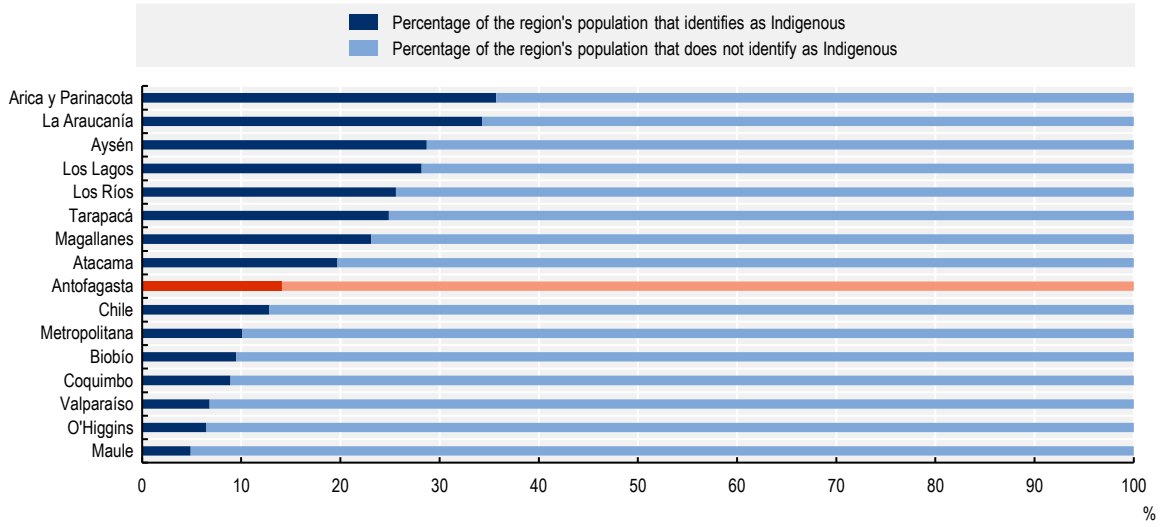
	Indigenous population	Percentage of the region's Indigenous population over the total Indigenous population of the country
Metropolitana	695 116	32
La Araucanía	321 328	15
Los Lagos	228 766	11
Biobío	189 632	9
Valparaíso	119 751	6
Los Ríos	96 311	4
Antofagasta	**82 412**	**4**
Tarapacá	80 065	4
Arica y Parinacota	78 883	4
Coquimbo	64 956	3
O'Higgins	57 280	3
Atacama	55 413	3
Maule	49 013	2
Magallanes	37 791	2
Aysén	29 075	1
Chile	2 185 792	100

Source: INE (2017[11]), *Censo 2017 [Census 2017]*, http://www.censo2017.cl/.(accessed on 12 May 2023).

Despite the region's wealth, the relationship between mining companies and Indigenous peoples remains a challenging issue, including land use conflicts and varied benefit-sharing agreements. Mining operations often take place on traditional Indigenous territories, leading to disputes over land rights and resource allocation. Indigenous populations are often found in concentrated areas within specific regions, experiencing levels of inequality across multiple areas, including access to education and health,

vulnerability to climate change and access to business opportunities. Some of these inequalities are further exacerbated by the impact of the mining activities on their territories, which in turn leads to socio-economic disparities.

Figure 2.3. Percentage of Indigenous population within each Chilean region, 2017



Source: INE (2017[11]), *Censo 2017 [Census 2017]*, http://www.censo2017.cl/. (accessed on 10 February 2023).

Several programmes have been implemented by the regional government, private companies and Indigenous communities to harness their strengths and improve the region's liveability. These initiatives recognise the resilience and rich cultural heritage these communities maintain despite obstacles. Antofagasta's mining success should not overshadow the needs of its Indigenous communities. The regional strategy proposed in this study will strive to encourage inclusive policies that promote equitable and prosperous communities and minimise disparities in education, health and overall living conditions. A more balanced coexistence can pave the way for a stronger, more united Antofagasta, harnessing the region's wealth for the benefit of all of its inhabitants.

Charting mining's future, Antofagasta captures the spotlight

The economic significance of mining in the Antofagasta region is undeniable, with mining activities contributing approximately 35% of Chile's GDP. A large part of it is derived from copper and lithium mining. In recent years, however, the region has become an increasingly important source of mineral resources, with Atacama, the driest desert in the world, being home to 80% of Chile's lithium reserves. The lithium industry in the region has brought significant economic benefits, with the GDP per capita in the Antofagasta region being among the highest in Chile; but it has also generated social and environmental challenges. Generally, mining still nowadays employs a substantial portion of the regional workforce. Copper mining is the largest contributor to Antofagasta's mining industry and this makes it a major global supplier of copper, which is a key input in various industries.

The mining industry in Antofagasta also has a significant impact on other industries. When taking into account its multiplier effects on other industries, its contribution to the national GDP could reach around 20% (Cardemil Winkler, 2023[3]). This industry not only impacts GDP per capita, wages, and local investments but also generates jobs in sectors such as construction, transportation, and services like

lodging and dining. Moreover, mining has the potential to foster social benefits, including housing, education, and health, ensuring that the regions benefit from the resources generated.

- Some of the biggest copper mines in the world, such as Chuquicamata and Escondida, are located in Antofagasta and have been in operation for decades.
- Lithium production has become increasingly important in the region in recent years, with major mines like Maricunga and Salar de Atacama being operated by multinational companies such as Albemarle and SQM.
- While many of the mines listed have been in operation for years, there are also several new lithium exploration projects in the region, including Aguas Calientes, Pedernales and Rincon, which could potentially become major producers in the future.

Overall, the data illustrate that mining plays a pivotal role in the regional development of Antofagasta, providing not only direct employment and revenue but also fostering indirect effects on other industries and contributing to community development and infrastructure. The region houses several large mining operations, primarily focused on extracting copper (Table 2.3).

However, it is important to balance this perspective by acknowledging that this heavy reliance on mining can also pose challenges to certain aspects of development. For instance, the mining sector's dominance may inadvertently overshadow or hinder more traditional forms of living and economic activity. Moreover, while mining brings considerable economic benefits, the environmental impact of these activities could potentially affect the sustainability of other sectors, particularly those dependent on the region's natural resources. As we chart the future of mining in Antofagasta, these considerations underscore the importance of a balanced approach that seeks to maximise the benefits of mining while mitigating potential drawbacks. This approach entails fostering coexistence between mining and other traditional industries, ensuring environmental sustainability and promoting inclusive growth that benefits all communities.

Table 2.3. Key mines in Antofagasta, 2022

Mine name	Material mined	Company owner	Municipality	Year opened/ expected
Chuquicamata	Copper	CODELCO	Calama	1915
Salar de Atacama	Lithium	Albemarle and SQM	San Pedro de Atacama	1984
Escondida	Copper	BHP Billiton	Antofagasta	1990
Zaldivar	Copper	Antofagasta Minerals and Barrick Gold	Antofagasta	1994
Quebrada Blanca	Copper	Sumitomo Metal Mining and Teck Resources	Iquique	1994
Lomas Bayas	Copper	Glencore	Antofagasta	1998
Cerro Vanguardia	Gold and silver	AngloGold Ashanti and Fomicruz	Antofagasta	1998
Collahuasi	Copper	Anglo American and Glencore	Iquique	1999
El Peñón	Gold and silver	Yamana Gold	Antofagasta	1999
Maricunga	Lithium	Albemarle	Copiapó	1996
Sierra Gorda	Copper and molybdenum	KGHM Polska Miedz and Sumitomo Metal Mining	Sierra Gorda	2014
Salar del Carmen	Lithium	Li3 Energy	Antofagasta	2017
Pedernales	Lithium	Lithium Chile	Antofagasta	Exploration stage
Rincon	Lithium	Lithium Power International	Antofagasta	Exploration stage

La Negra	Lithium	Minera Exar	Antofagasta	2020 (expected)
Aguas Calientes	Lithium	International Lithium Corp	Antofagasta	Exploration stage

The strategic importance of Antofagasta's lithium reserves for the global energy transition

As the world moves towards a zero-carbon economy, Antofagasta's mining industry can play a significant role in achieving environmental goals. The region possesses the minerals and materials necessary for the development of green technologies (e.g. lithium-ion batteries, renewable energy, sustainable mobility and large-scale energy storage).

The region mainly produces lithium carbonate, followed by lithium hydroxide and lithium chloride, with lithium carbonate holding the highest commercial transaction value. This type of lithium can be produced through hard-rock mining, which is primarily used in Australia, or through extraction from brine, which is more cost-effective and commonly used in Argentina, Bolivia and Chile, also known as the South American "lithium triangle".

While the lithium sector is smaller than those of copper or gold, it is poised for significant growth in the coming years due to anticipated surges in demand. Lithium is the premier choice for electric vehicle battery production and other low-carbon solutions, attributed to its high density and superior conducting qualities. In merely a decade, the industry has seen a shift, with batteries becoming its primary application. For instance, demand between 2017 and 2021 doubled, with lithium consumption growing an extra 30% in just the past year. The annual output growth has fluctuated between 25% and 35%. Under a net zero scenario, demand is predicted to leap by 422% by 2030, reaching 711 500 tonnes. This is projected to reach a peak at 1.37 million tonnes in 2045, a tenfold increase from 2022 figures (IEA, 2023[12]). Highlighting the industry's regional significance, at the 11th Lithium Supply & Markets Conference in 2019, Mining Minister Baldo Prokurica announced a large amount of lithium project investment totalling over USD 1.8 billion. This includes Albemarle's USD 300 million expansion for La Negra plant's third phase, the USD 527 million Blanco project and SQM's expansion endeavours. Such initiatives underscore lithium's pivotal role in the region's economic prospects.

Table 2.4. Lithium mine production, reserves and resources in tonnes, 2020

Country	Production	Reserves	Resources
Bolivia	-	-	21 000 000
DR Congo	-	-	3 000 000
Germany	-	-	2 700 000
World total	82 000	21 000 000	86 000 000+
Australia	40 000	4 700 000	6 400 000
Chile	**18 000**	**9 200 000**	**9 600 000**
China	14 000	1 500 000	5 100 000
Argentina	6 200	1 900 000	19 300 000
United States	870	750 000	7 900 000
Canada	0	530 000	2 900 000

Note: The symbol '-' indicates that data is not available.
Source: United States Geological Survey (USGS, 2020[13]) (accessed on 21 November 2022).

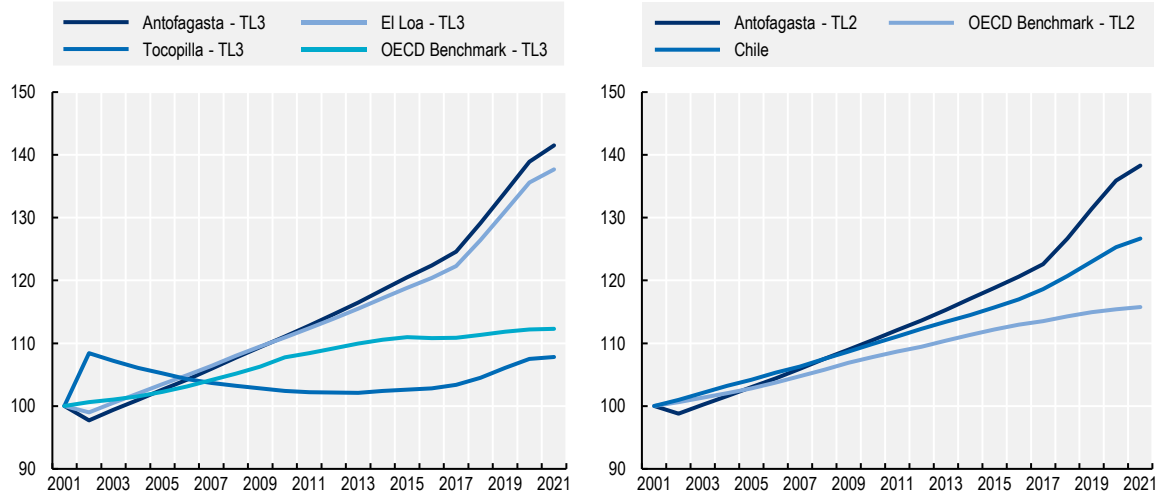
Demographic patterns

Population growth in Antofagasta has accelerated in the last decade

The population of Antofagasta has consistently grown over the last two decades. While this trend mirrors that of the mining regions benchmarked by the OECD at both TL2 (average yearly increase of 0.8%) and TL3 (0.6%) levels, the pace of growth in Antofagasta has been notably more rapid (1.9%). As a region, Antofagasta's situation mirrors a broader trend, with population growth rates surpassing national averages. This is particularly evident in the last decade, when Antofagasta's population growth has significantly accelerated. The region has seen an average yearly increase of 2.5%, distinctly outpacing the national average growth rate of 1.53%. This trend underscores the region's dynamic demographic landscape and its ability to attract an ever-growing population (Figure 2.4). As a result, by 2022, Antofagasta's population reached 719 000 individuals, primarily concentrated in the cities of Antofagasta (437 000 residents), Calama (195 000 residents) and, to a lesser extent, smaller municipalities like Tocopilla (28 000 residents) and Mejillones (15 000 residents).

As a region, Antofagasta's situation mirrors a broader trend, with population growth rates surpassing national averages. This is particularly evident in the last decade, when Antofagasta's population growth has significantly accelerated. The region has seen an average yearly increase of 2.5%, distinctly outpacing the national average growth rate of 1.53%. This trend underscores the region's dynamic demographic landscape and its ability to attract an ever-growing population.

Figure 2.4. Growth population index, Antofagasta, El loa, Tocopilla, OECD Mining regions benchmark and Chile, TL2 and TL3 levels, 2001-21



Note: 2001=100.
Source: (OECD, 2022[1]) *OECD Regional Statistics database* (accessed on 14 January 2023).

Foreign migration as a key driver of the population increase in the region

This steady population increase is largely driven by migration. As of December 2021, it was reported that 106 000 foreign individuals were residing in the region. Indeed, between 2017 and 2021, Antofagasta welcomed 14 451 immigrants who established their residence in the region, predominantly from Bolivia (38.6% of total migrants), followed by Colombia (29.4%). This influx positions the region as the second highest in absolute increase during this period, trailing only behind the Santiago Metropolitan Region (INE,

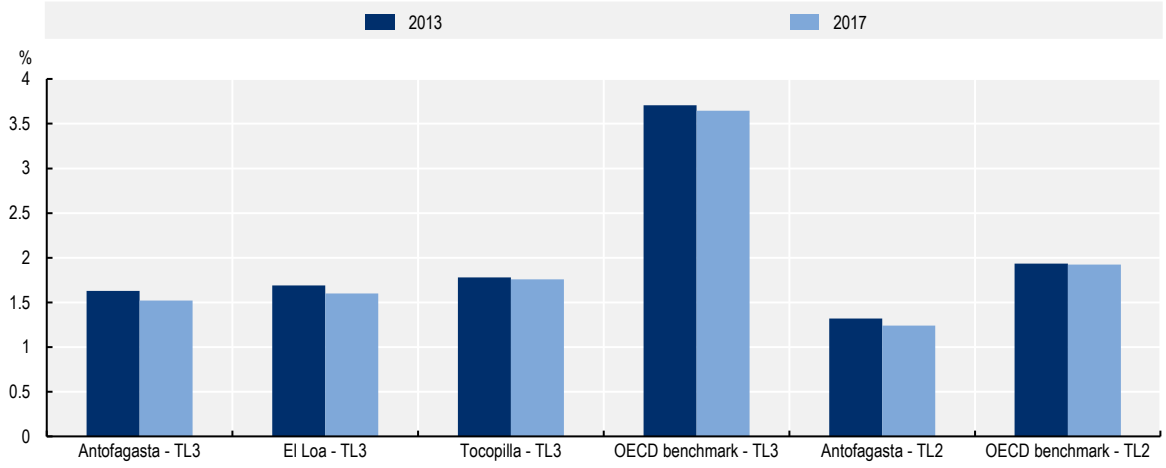
2022[14]). In 2021, at the regional level, the metropolitan region concentrates the majority of the foreign population residing in the country, with 61.3%. Antofagasta is the region with the second highest number of foreigners, with 7.2% of the foreign population, slightly surpassing Valparaíso, with 6.5% (INE, 2021[15]). Meanwhile, the commune of Calama ranks 8th, providing a home to 31 812 foreign residents.

When delving deeper into the data on the foreign population residing in the region, it is worth noting that 53.2% are in the 25-44 year-old age range. In addition, 11.6% are concentrated between the ages of 0 and 14, making Antofagasta the area with the highest proportion of minors across the Chilean regions (INE, 2021[15]).

Within Chile, the inter-regional mobility rate of Antofagasta was 1.63% in 2013 and decreased slightly to 1.52% in 2017. Similarly, the mobility rate for El Loa declined from 1.69% in 2013 to 1.6% in 2017. Tocopilla, on the other hand, maintained a relatively steady mobility rate with 1.78% in 2013 and 1.76% in 2017. These values, while demonstrating some level of inter-regional movement, are significantly lower than the OECD TL3 benchmark, which stands at 3.71% in 2013 and 3.65% in 2017. At the TL2 level, Antofagasta's mobility rate decreased from 1.32% in 2013 to 1.24% in 2017. This rate is also lower than the OECD TL2 benchmark, which remained constant at 1.93% over the same period.

Figure 2.5 suggests that Antofagasta and its municipalities, while experiencing some degree of inter-regional mobility, attract fewer new residents from other regions than the average OECD region. This could potentially indicate factors such as economic opportunities, living conditions and regional policies that might be less attractive to potential movers. Therefore, efforts to enhance the attractiveness of Antofagasta and its municipalities could potentially increase their inter-regional mobility rates.

Figure 2.5. Inter-regional mobility rate



Note: Calculated as the percentage of newcomers from another region over the population.
Source: (OECD, 2022[1]) *OECD Regional Statistics database* (accessed on 4 December 2022).

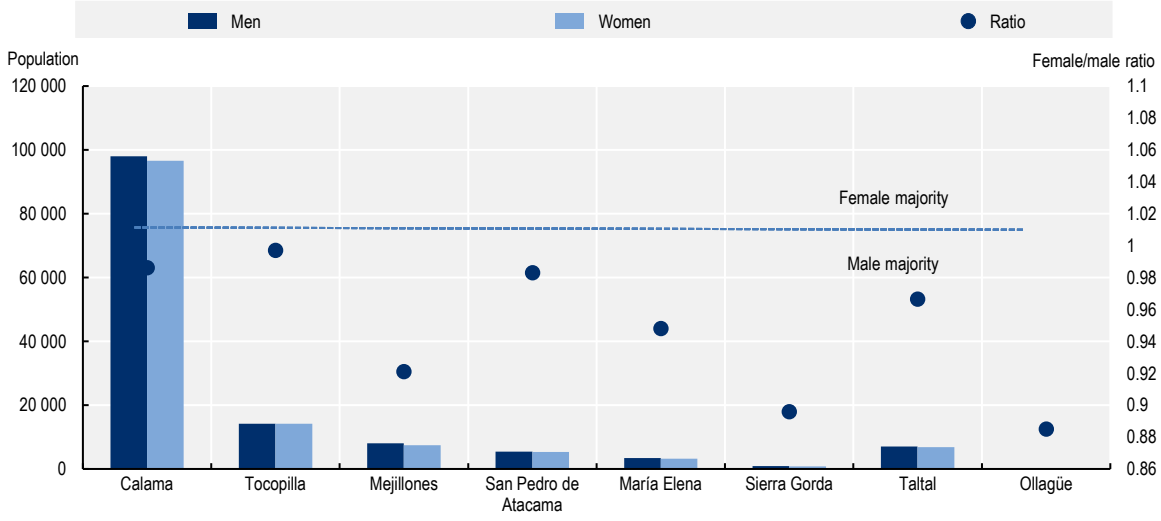
Yet more efforts are needed towards gender parity for social prosperity in Antofagasta

The population in Antofagasta's municipalities is predominantly male. Meaning the region experiences a significant gender imbalance. For instance, there are 97 966 men in Calama for 96 609 women, yielding a female-to-male ratio of approximately 0.99. Similarly, in Tocopilla, the count of males stands at 14 171, slightly higher than the female population of 14 130, resulting in a similar ratio of 0.997. This pattern not only applies to the city of Antofagasta (219 709 men for 218 174 women) but also extends to smaller municipalities. In Mejillones, the male population of 8 032 outnumbers the female population of 7 398, presenting a female-to-male ratio of 0.92. Likewise, in the rural commune of Ollagüe, the male count (148) also surpasses the number of females (131), resulting in a significantly lower ratio of 0.89. This trend, with

female-to-male ratios ranging from around 0.89 to 0.99, underscores the broader demographic landscape of the Antofagasta region, reflecting a more male-dominated population structure across its municipalities (Figure 2.6).

Indeed, the notable male majority in Antofagasta's municipalities, likely due to the historically male-dominated mining sector, has implications for regional development. However, mining companies are now implementing programmes to attract female talent, gradually helping to rebalance the gender dynamics and foster a more diverse labour market. For instance, predominantly male populations could influence social dynamics and the labour market structure within the region. This male dominance might also subtly shape community interests and public policies. Moreover, the region's appeal to potential families or residents seeking a balanced gender demographic could be affected.

Figure 2.6. Gender balance across the municipalities of Antofagasta region, 2022



Source: INE (2022[14]), *Demografía*, https://www.ine.gob.cl/estadisticas/sociales/demografia-y-vitales/demografia-y-migracion/2022/10/12/poblaci%C3%B3n-extranjera-residente-en-chile-lleg%C3%B3-a-1.482.390-personas-en-2021-un-1-5-m%C3%A1s-que-en-2020.

Antofagasta has a demographic bonus but ageing is an increasing trend

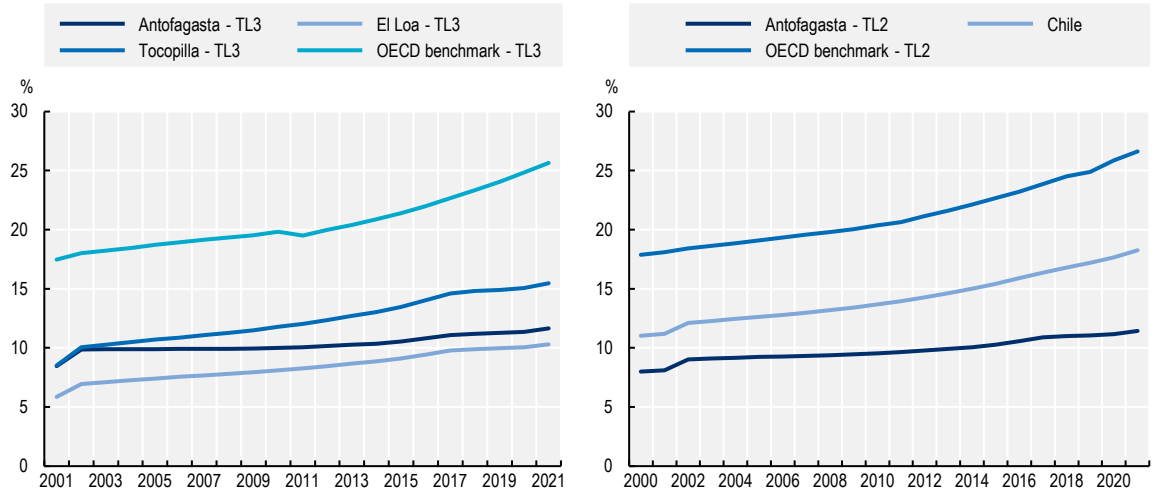
Antofagasta, at the TL2 level, has seen a gradual increase in its elderly dependency ratio from 2001 to 2021, rising from 8% to 11% (Figure 2.7). Despite this growth, the region maintains a significantly lower elderly dependency rate than both the national average of Chile and the OECD TL2 benchmark. In 2021, while Chile's elderly dependency rate stood at 18%, the OECD TL2 benchmark was at a notable 27%. This figure reflects a demographic advantage for Antofagasta, with a relatively smaller proportion of the population in the "elderly dependent" category, which can have positive implications for the region's workforce.

At the TL3 level, Antofagasta, El Loa and Tocopilla all show a similar pattern of a slow yet steady increase in their elderly dependency ratios over two decades. Antofagasta's rate rose from 8% to 12%, El Loa's from 6% to 10% and Tocopilla's from 9% to 15%. Like their TL2 counterpart, these rates remain below the OECD TL3 benchmark, which reached 26% in 2021. This gap highlights the regions' demographic advantage with a relatively lower elderly dependency ratio, signifying a larger proportion of the population in the active workforce. In particular, El Loa's consistently low elderly dependency ratio points to a strong demographic bonus that can bolster the region's economic vitality. On the other hand, Tocopilla, while still below the OECD benchmark, has experienced a higher rate of increase, indicating a more rapidly ageing

population. This calls for a proactive approach in these regions to manage the ageing trend while capitalising on their demographic advantage.

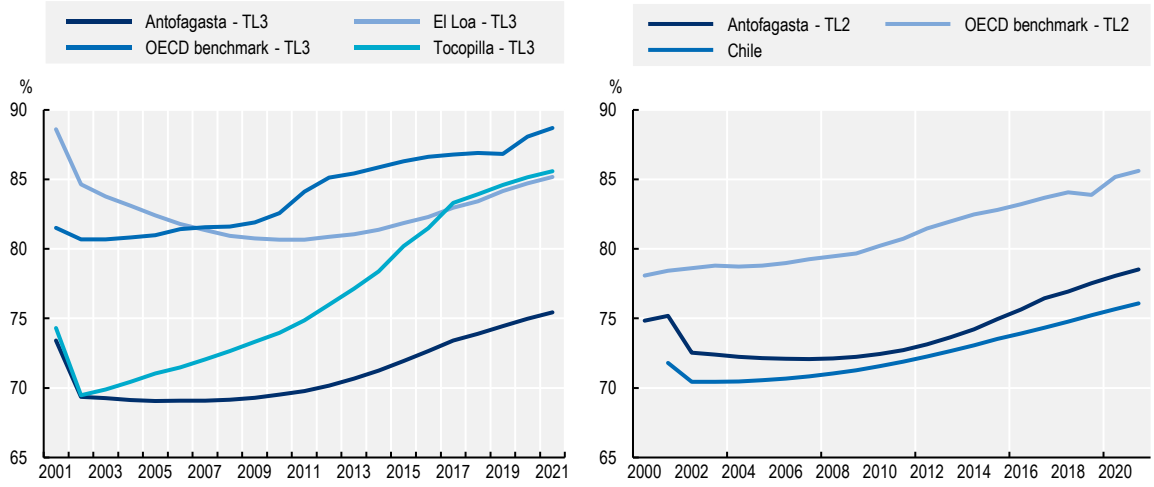
However, despite Antofagasta's relatively low elderly dependency rate compared to national and OECD benchmarks, the region has seen a steady increase in this rate over the past two decades. This suggests a gradual ageing trend of the population in Antofagasta, similar to what is seen in many places around the world. That being said, efforts to attract and retain a dynamic and diverse working-age population can help Antofagasta maintain its demographic advantage and support its long-term economic and social prosperity.

Figure 2.7. Elderly dependency ration in Antofagasta, El loa, Tocopilla, OECD mining regions benchmark and Chile, TL2 and TL3 levels, 2001-21



Note: Calculated as a share of individuals over 65 years old over the working-age population (15-65 year-olds).
Source: (OECD, 2022[1]) *OECD Regional Statistics database* (accessed on 14 January 2023).

Figure 2.8. Gender ratio, elderly population, Antofagasta, El loa, Tocopilla, OECD mining regions benchmark and Chile, TL2 and TL3 levels, 2001-21



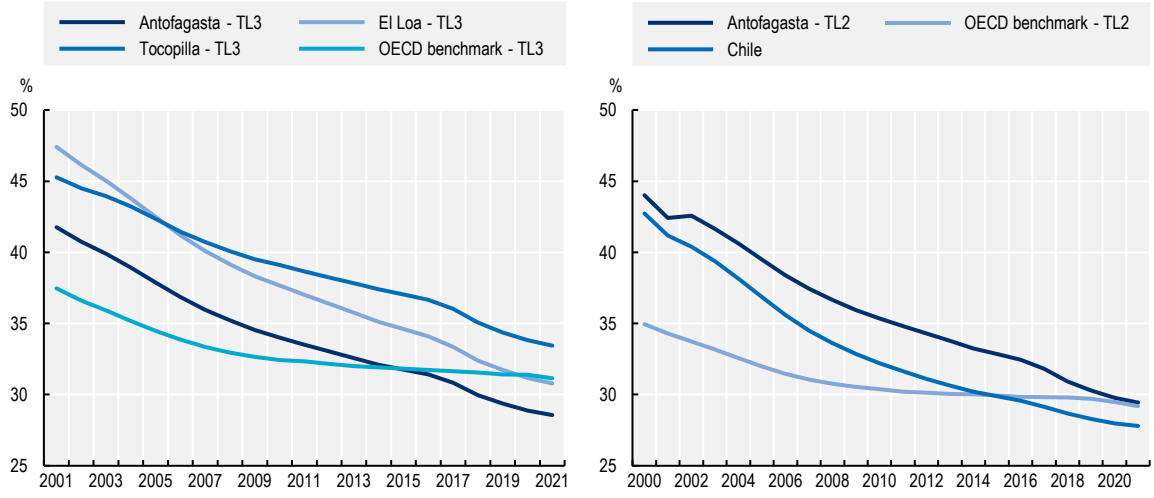
Note: The ratio is calculated as a percentage of 65-year-old and more population, males over females. A high value indicates there are more elderly males compared to elderly females, while a low value suggests there are fewer elderly males relative to elderly females.
Source: (OECD, 2022[1]) *OECD Regional Statistics database* (accessed on 14 January 2023).

From 2001 to 2021, data from Antofagasta, El Loa, Tocopilla, and the TL2 and TL3 levels of the OECD mining regions benchmark, alongside Chile, show distinct trends. For instance, the TL2 level, Antofagasta showed a gender ratio ranging from 72% to 79%, while the OECD mining regions benchmark remained relatively stable between 78% and 86%. In Chile, the gender ratio fluctuated between 70% and 76% during the same period. Moving to the TL3 level, Antofagasta experienced a slight decrease from 73% to 75%, El Loa remained consistently around 82% to 85%, and Tocopilla saw an increase from 69% to 86%.

Antofagasta's declining youth dependency ratio since 2000 signals an evolving demographic landscape, yet the region still retains a demographic bonus

From 2000 to 2021, Antofagasta at the TL2 level experienced a steady decrease in its youth dependency ratio, from 44% to 29% (Figure 2.9). This trend signifies a declining proportion of young dependents relative to the working-age population, potentially indicating shifts in family size, fertility rates or other demographic factors over the last two decades. Despite the decrease, Antofagasta's youth dependency ratio has consistently remained above the OECD TL2 benchmark, which was at 29% in 2021, and is now closely aligned with the national average of 28%.

Figure 2.9. Youth dependency ratio in Antofagasta, El Loa, Tocopilla, OECD mining regions benchmark and Chile, TL2 and TL3 levels, 2001-21



Note: Calculated as a share of 15 year-old individuals over the working-age population (15-65 years old).
Source: (OECD, 2022[1]) *OECD Regional Statistics database* (accessed on 14 January 2023).

From 2001 to 2021, the youth dependency ratios at the TL3 level in Antofagasta, El Loa and Tocopilla exhibited a similar decreasing trend. Antofagasta's ratio decreased from 42% to 29%, while El Loa's declined from 47% to 31%. Tocopilla also experienced a decrease, with the ratio dropping from 45% to 33%. Comparing these figures to the OECD TL3 benchmark, which remained relatively stable at around 31% throughout the period, Antofagasta, El Loa and Tocopilla all initially had higher youth dependency ratios. However, their ratios have gradually converged with the benchmark, suggesting a shift in the demographic structure towards a more balanced age distribution.

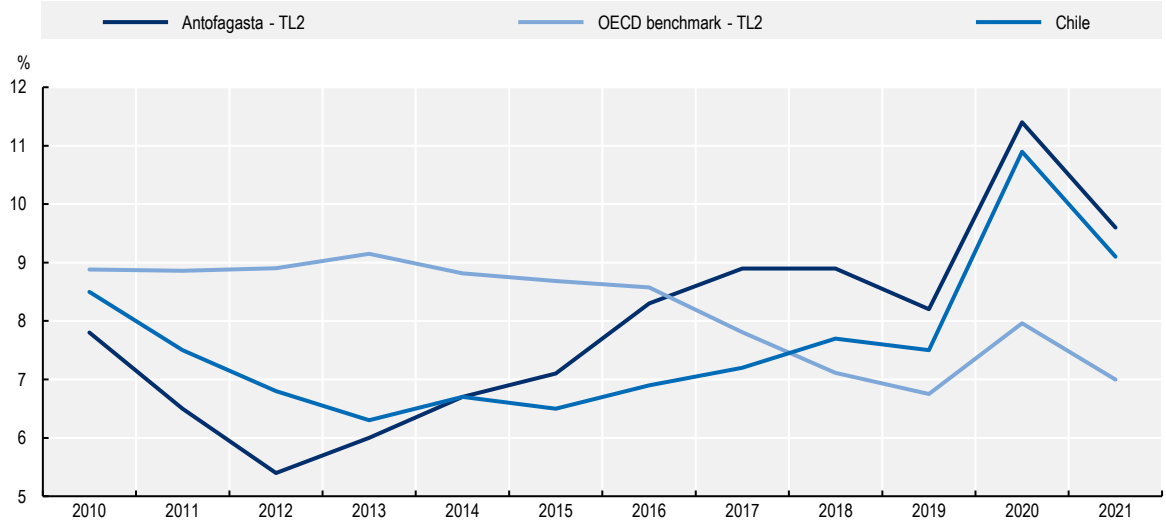
This decrease in the youth dependency ratio represents an evolving demographic profile in Antofagasta that could have implications for its social and economic landscape. While a lower youth dependency ratio can ease pressure on resources allocated for education and childcare, it also highlights the need for focused investments in the workforce to capitalise on the productive potential of the region's relatively larger working-age population.

Antofagasta's recent rise in unemployment has created a stark economic challenge offsetting the region's demographic advantage

While the region of Antofagasta enjoyed lower unemployment rates relative to the OECD TL2 benchmark and the national average from 2010 to 2021, it has experienced considerable volatility over this period (Figure 2.10). In 2010, the unemployment rate in Antofagasta was 7.8%, lower than both the OECD TL2 benchmark of 8.9% and the national average of 8.5%. This relative advantage was maintained until 2015, when the unemployment rate in Antofagasta increased to 7.1%, edging closer to the national average and the OECD benchmark.

However, the region was unable to sustain this positive trend. Between 2015 and 2021, the unemployment rate in Antofagasta increased, reaching a peak of 11.4% in 2020 before falling to 9.6% in 2021. The fluctuations in Antofagasta's unemployment rate during this period contrast with the relative stability of the national average and the OECD benchmark. In particular, the gap between the unemployment rate in Antofagasta and the OECD benchmark, which had been shrinking until 2015, widened significantly by 2021.

Figure 2.10. Unemployment rate in Antofagasta, OECD mining benchmark and national average, 2010-21



Note: Unemployment rate (% unemployed over labour force 15-64)
Source: (OECD, 2022[1]) *OECD Regional Statistics database* (accessed on 20 November 2022).

The experience of Antofagasta underlines the importance of looking beyond demographic trends when assessing regional economic conditions. Even with a favourable age structure, the region has faced challenges in maintaining stable employment levels. As will be explained in the following section, these unemployment trends have implications for Antofagasta's working-age population. The year-over-year increases in unemployment rates from 2015 to 2021 indicate the region's growing struggle with joblessness, notably outpacing the national average and OECD TL2 benchmark. By 2021, despite a slight

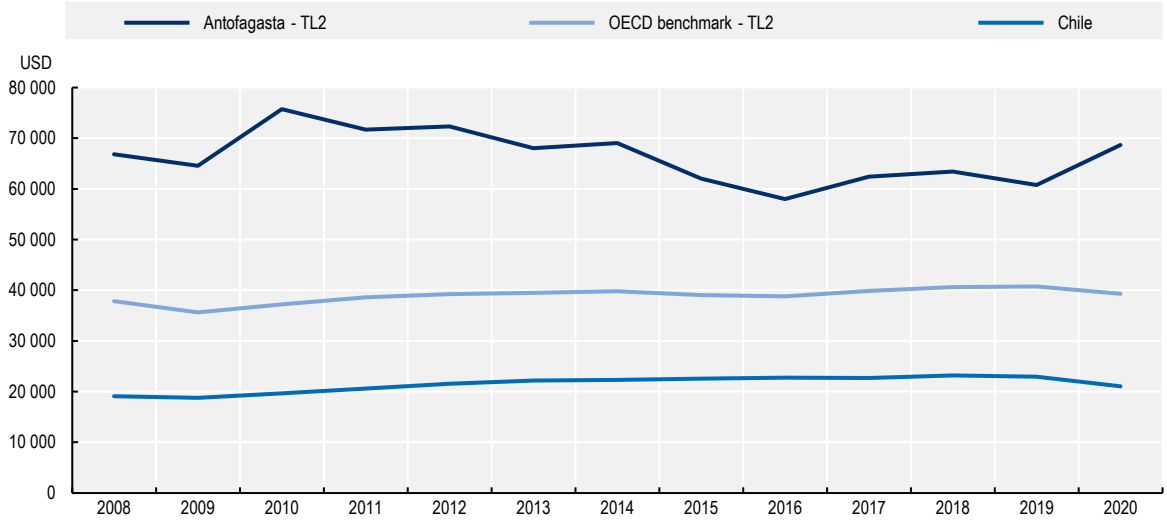
recovery, Antofagasta's unemployment rate remained above both the Chilean national average and the OECD TL2 benchmark.

Regional economic trends

Antofagasta is thriving, with the mining sector fuelling robust economic growth in the region

In 2022, Antofagasta contributed 12.8% to Chile's total GDP, ranking second only behind the Santiago Metropolitan Region, which contributed 38.1%. Since 2008, Antofagasta's GDP per capita has consistently surpassed both the OECD TL2 benchmark and Chile's national average (Figure 2.11). Starting from a robust USD 66 809 in 2008, Antofagasta's GDP per capita notably exceeded the OECD TL2 benchmark of USD 37 833 and the national average of USD 19 072. By 2020, Antofagasta's GDP per capita was 175% of the OECD TL2 benchmark and over 326% of Chile's national average.

Figure 2.11. GDP per capita of Antofagasta, OECD mining regions and national average, 2008-20

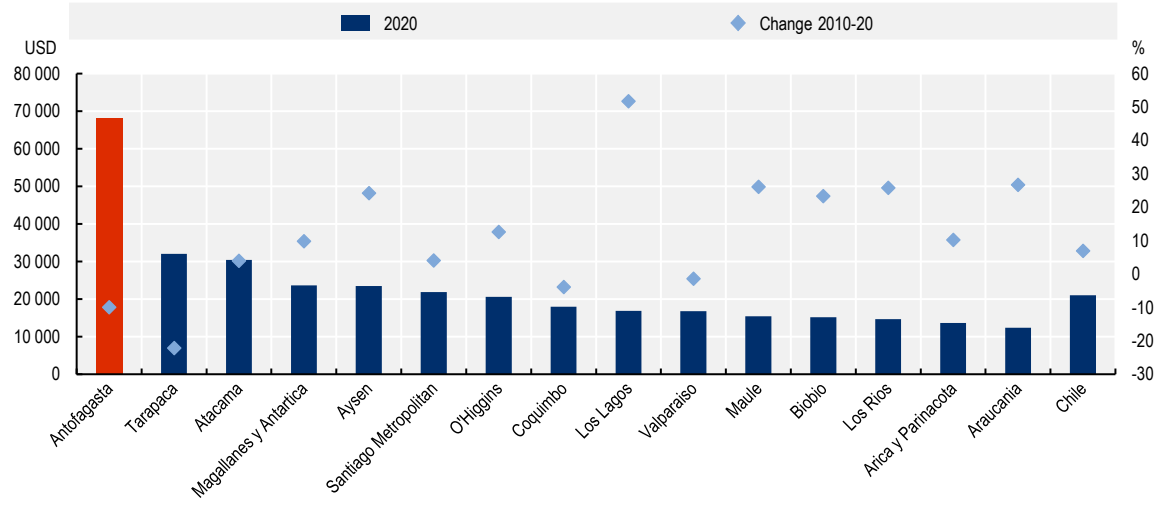


Note: GDP per capita (USD PPP base year 2015).
Source: (OECD, 2022[1]) *OECD Regional Statistics database* (accessed on 20 November 2022).

The region's dependency on copper extraction underlines the region's pivotal economic role, as global copper demand and pricing can significantly affect its economic performance. Between 2010 and 2016, influenced by a downturn in global copper prices, Antofagasta's GDP per capita decreased by 23.5%. In contrast, from 2016 to 2020, it saw a recovery. However, even with this resurgence, it did not surpass its 2011 peak (USD 75 748). This pattern reveals the region's sensitivity to fluctuations in global copper prices. Overall, while Antofagasta's GDP per capita experienced these variations due to its copper reliance, the GDP per capita of the OECD TL2 benchmark and Chile's national average remained more consistent over the same period.

Between 2008 and 2020, Antofagasta consistently topped the list of Chilean regions in terms of GDP per capita, following the Santiago Metropolitan Region (Figure 2.12). While Antofagasta's prominence stands out, the dynamics of other regions offer nuanced insights into Chile's regional disparities and growth trajectories. Each region's GDP per capita is not only a reflection of its economic productivity but also provides insights into its unique social and economic conditions.

Figure 2.12. GDP per capita in 2020 and GDP change across regions of Chile and national average, 2010-20



Note: GDP per capita (USD PPP base year 2015).
Source: (OECD, 2022[1]) *OECD Regional Statistics database* (accessed on 14 January 2023).

For instance, other Chilean regions like Tarapacá began the period with a GDP per capita of USD 38 392, which is nearly 83% higher than the national average of that year. However, by 2020, it adjusted to USD 32 053 – a value still 52% higher than the national average but falling short of the OECD TL2 benchmark by approximately 18%. On the other hand, Aysén's economic performance showcased an increase from an initial GDP per capita of USD 17 434 in 2008, slightly below the national average, to a notable peak of USD 30 190 in 2019. Even though it adjusted down to USD 23 489 in 2020, it remained 11.7% above the national figure, yet still around 40% less than the OECD TL2 benchmark.

For instance, during this timeframe, Tarapacá saw its GDP per capita decrease from USD 38 392 to USD 32 053, a decline of 16.5%. On the other hand, Aysén experienced a more dramatic swing: a growth of almost 73% from its 2008 GDP per capita of USD 17 434 to a peak of USD 30 190 in 2019 before settling at USD 23 489 in 2020, still a net gain of 34.8% from 2008. Certain regions, such as Los Lagos and Magallanes y Antartica Chilena, demonstrated progress, with their GDP per capita growth rates surpassing the national average. Los Lagos, for instance, increased from USD 11 287 in 2008 to USD 16 828 in 2020, indicating substantial economic development in the region. These shifts underscore the diverse economic landscapes and growth patterns across Chile's regions.

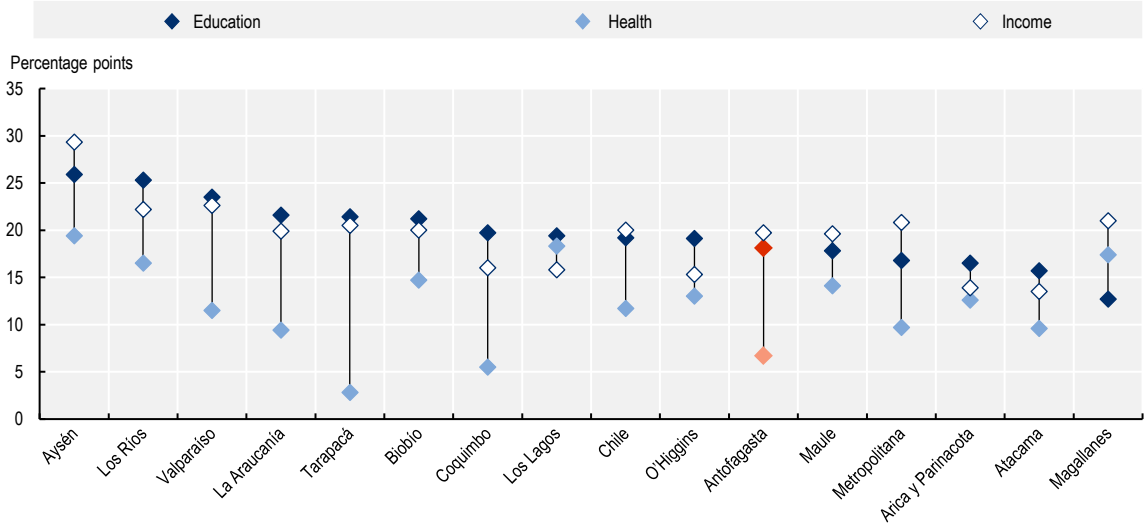
Yet, the region is still not using all of the wealth generated to improve living standards at a faster pace

Antofagasta faces one of the most significant social challenges associated with the mining industry in the region: a high level of income inequality. While the mining industry has generated considerable wealth for the region, this wealth is concentrated among a small group of individuals and companies, resulting in a significant gap between the rich and poor. According to data from the Chilean National Statistics Institute (INE), the Gini coefficient for the Antofagasta region was 0.51 in 2019, higher than the national average of 0.46, indicating a high level of income inequality. Consequently, this region boasts the highest per capita GDP in Chile, with the mining sector contributing over 72% of the regional GDP. All in all, the concentration of wealth has led to social tensions and has been identified as a significant obstacle to improving the quality of life in the region.

Figure 2.13 underscores the central challenge for Antofagasta: ensuring that the wealth generated by its robust mining sector is utilised to drive faster improvements in key areas of human development. While the region's economic prosperity is notable, it has yet to fully capitalise on this wealth to enhance education and health outcomes at a rate that would allow it to close the gap with the ideal target[5]. The task ahead lies in focusing on these key areas to ensure a more equitable distribution of wealth and an improved standard of living for its inhabitants. The gap reduction percentages between 2006 and 2017 across the Chilean regions show that Antofagasta has reached its disparities levels compared to the ideal targets in education and health.

- **Education**: Antofagasta ranks sixth lowest in the country in terms of gap reduction, indicating a slow pace of improvement compared to other regions. A score of 18.1 suggests that, although progress has been made, the region has not fully harnessed its wealth to improve education at a pace commensurate with its economic growth.
- **Health**: Antofagasta's situation is more pronounced. With a gap reduction score of just 6.7, it ranks as the third lowest region in the country. This low score shows that the region's robust GDP has not translated into health advancements, a key component of living standards.
- **Income**: The income dimension shows a similar picture for Antofagasta. Despite its high per capita GDP, Antofagasta only ranks 11th out of the 16 Chilean regions in terms of income gap reduction, with a score of 19.7. This difference indicates a significant income inequality within the region, illustrating that the considerable wealth, primarily generated by the prosperous mining industry, is not evenly distributed among its inhabitants.

Figure 2.13. Reduction of the gap with respect to the ideal target between 2006 and 2017 across the Chilean regions



Source: UNDP (2020[16]), *Regional Inequality in Chile*, https://www.estudiospnud.cl/wp-content/uploads/2020/04/DesigualdadRegionalPDF.pdf; based on data from the Casen survey, INE and the Ministry of Health.

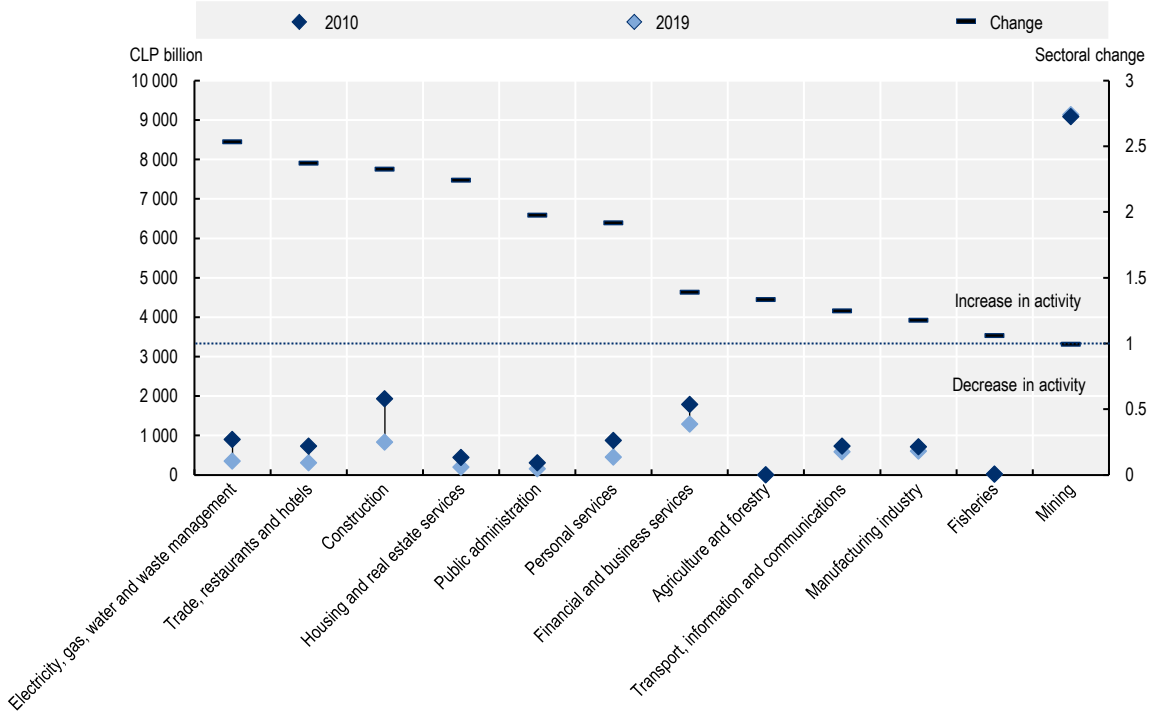
With a solid foundation in mining, Antofagasta's economy needs to steadily diversify and expand into new sectors to sustain its growth

Overall, these changes in the sectorial specialisation of Antofagasta reflect the evolving economic landscape of the region, marked by significant growth in service-oriented sectors and a slight contraction in the traditionally dominant mining sector (Figure 2.14). From 2010 to 2019, Antofagasta experienced substantial shifts in its sectorial specialisation, marked by significant growth in certain sectors and a decrease in others.

Sectors such as electricity, gas, water and waste management saw the most substantial growth, more than doubling in size from 354 billion Chilean pesos in 2010 to 897 in 2019, a change of 2.53 times. Likewise, the trade, restaurant and hotel sector experienced substantial growth, with 2.37 times increase over the same period. The construction sector also showed robust growth, more than doubling its size from 831 billion Chilean pesos in 2010 to 1 931 in 2019. Housing and real estate services and public administration saw growth rates of approximately 2.24 and 1.97 times respectively, suggesting an expanding service sector in the region. Personal services, financial and business services, and transport, information and communications also expanded during this period, but at slower rates. The agriculture and forestry sector saw a marginal increase, showing limited growth potential within the timeframe.

Interestingly, the manufacturing industry showed only modest growth of about 1.18 times from 2010 to 2019, which might indicate a shift in the region's industrial dynamism. The fisheries sector also showed very minimal growth. Contrary to the growth trend in most sectors, the mining sector, a significant contributor to the region's economy, remained stable.

Figure 2.14. Economic participation by sector and change between 2010 and 2019, Antofagasta



Note: GDP by economic activity, Antofagasta region, current prices, spliced series, 2013 benchmark.
Source: BCC (2023[17]), *Base de Datos Estadísticos (BDE) - Cuentas Nacionales 2010-2020*, https://si3.bcentral.cl/Siete/ES/Siete/Cuadro/CAP_CCNN/MN_CCNN76/CCNN2013_PIB_II_ACT_N/CCNN2013_PIB_II_ACT_N?cbFechaInicio=2010&cbFechaTermino=2020&cbFrecuencia=ANNUAL&cbCalculo=NONE&cbFechaBase=.

Despite mining's dominance, Antofagasta's employment allocation has shown signs of diversification, particularly into public services and hospitality

Antofagasta's employment landscape has evolved substantially over the last decade, reflecting a dynamic labour market between traditional economic pillars and emerging sectors (Table 2.5). From 2013 to 2023, the region experienced a robust 30.3% surge in total employment, rising from 255 590 to 333 040 jobs.

Central to Antofagasta's identity, the **mining and quarrying** sector posted an 8.4% growth, showcasing its great relevance for the region. With numbers climbing from 56 160 to 60 910, this sector remains the economic bedrock, even if its relative growth appears stable against the broader employment landscape. However, a deeper dive into the data reveals transformative trends.

The **accommodation and food service** sector's growth – nearly doubling its numbers – might be indicative of an increasing tourism industry coupled with local consumerism. Its contribution to the regional job market leapt from 3.38% in 2013 to 5.08% by 2023.

Administrative and support service activities experienced a more than twofold increase, elevating its regional labour market representation from 1.97% to 3.61%. Meanwhile, **public administration and defence** grew from 10 170 to 19 870 jobs, suggesting a regional emphasis on bolstering public services and security. Its stake in regional employment transitioned from 3.98% in 2013 to 5.97% a decade later.

As for **human healthcare and social work** activities, the figure rose from 11 010 to 18 980, and its employment share increased from 4.31% to 5.70%. This points to a heightened focus on public health, welfare programmes and a society necessitating more healthcare services.

Conversely, the decline in sectors like **agriculture, livestock, forestry and fishing** might be attributed to factors such as industrialisation, urbanisation or perhaps challenges posed by climate change. The dip in **manufacturing** industries, from 23 460 to 18 850, could be due to shifts in global manufacturing hubs, technological advancements leading to automation or changes in regional economic policies.

Table 2.5. Employees by sector in Antofagasta, 2013 vs. 2023

Employees, January-March, first quarter (Q1)

Sector	2013 Q1	2023 Q1	Change (%)
Agriculture, livestock, forestry and fishing	5,540	2,860	-48
Mining and quarrying	**56,160**	**60,910**	**8**
Manufacturing industries	23,460	18,850	-20
Electricity, gas, steam and air conditioning supply	3,110	2,900	-7
Water supply	1,280	4,430	246
Construction	15,380	21,130	37
Wholesale and retail trade	47,410	52,290	10
Transport and warehousing	21,510	29,150	36
Accommodation and food service activities	8,640	16,910	96
Information and communications	1,890	3,290	74
Financial and insurance activities	3,750	2,230	-41
Real estate activities	250	2,880	1032
Professional, scientific and technical activities	6,180	9,220	49
Administrative and support service activities	5,030	12,020	139
Public administration and defence	10,170	19,870	95
Education	22,400	27,670	24

Sector	2013 Q1	2023 Q1	Change (%)
Human healthcare and social work activities	11,010	18,980	72
Arts, entertainment and recreation activities	2,290	5,090	122
Other service activities	5,650	12,410	119
Activities of households as employers	4,470	8,950	100
Total employed	255,590	333,040	30

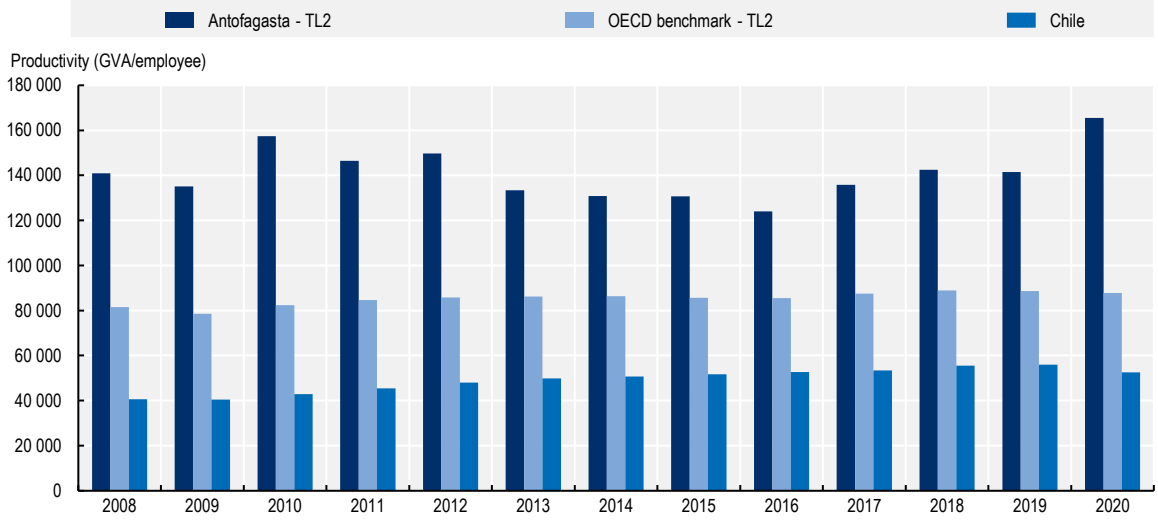
Note: Sectorial classification according to *Clasificador de Actividades Económicas Nacional para Encuestas Sociodemográficas* (CAENES), adapted from the Chilean Classifier of Economic Activities ISIC4.CL 2012.
Source: INE (2023[2]), *Ocupación y Desocupación*, https://regiones.ine.cl/antofagasta/estadisticas-regionales/sociales/mercado-laboral/ocupacion-y-desocupacion.

Antofagasta, the productivity powerhouse amidst an extractive economy

Productivity in Antofagasta, marked by its high economic reliance on mining, significantly outpaces both Chile and the OECD average, demonstrating the region's robust economic performance. Indeed, figures for Antofagasta, Chile and the OECD in 2008 were approximately USD 140 890, USD 40 626 and USD 81 453 respectively (Figure 2.15).

When analysing these numbers, the productivity in Antofagasta was about 3.46 times higher than Chile's average and 1.73 times higher than the OECD average in 2008. By 2020, Antofagasta's productivity escalated to about USD 165 549, representing a growth of 17.5%. In comparison, Chile's overall productivity witnessed a growth of approximately 29.4% to reach around USD 52 564 by 2020. However, it is worth noting that despite a higher growth rate percentage-wise for Chile, in absolute terms, Antofagasta's productivity was still 3.15 times greater. The OECD TL2 benchmark regions had an average productivity figure of approximately USD 87 691 in 2020. This is almost half Antofagasta's productivity, revealing a growth rate of about 7.6% from 2008.

Figure 2.15. Productivity in Antofagasta, OECD Benchmark TL2 and National average, 2008-2020



Note: Gross value added (GVA) as USD millions, constant prices, constant PPP, base year 2010.
Source: BCC (2023[17]), *Base de Datos Estadísticos (BDE) - Cuentas Nacionales 2010-2020*, https://si3.bcentral.cl/Siete/ES/Siete/Cuadro/CAP_CCNN/MN_CCNN76/CCNN2013_PIB_II_ACT_N/CCNN2013_PIB_II_ACT_N?cbFechaInicio=2010&cbFechaTermino=2020&cbFrecuencia=ANNUAL&cbCalculo=NONE&cbFechaBase=.

However, around 2015 and 2016, Antofagasta did experience a brief dip in productivity, hitting a trough of roughly USD 123 959 in 2017. The region's strong economic performance, primarily due to its robust mining industry, allowed for a relatively swift recovery, with productivity rebounding to new heights by 2020. In summary, Antofagasta maintained high productivity levels throughout the 2008-20 span, consistently overshadowing Chile and the OECD average.

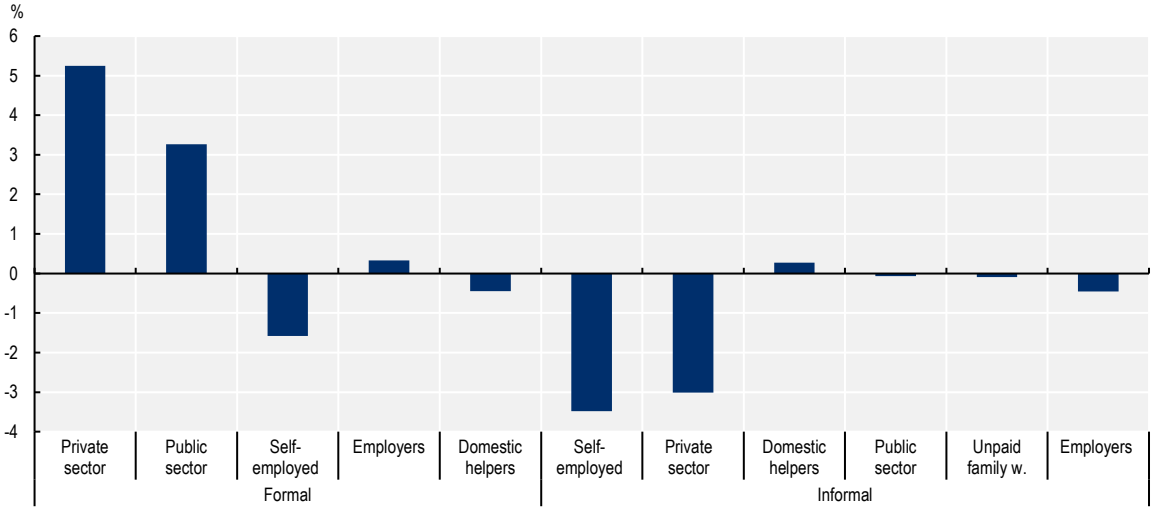
Antofagasta's level of formal employment, when compared to Chile, displays less dependence on informal self-employment

Analysing the labour composition of Antofagasta in 2023, we can spot interesting differences compared to Chile's national averages (Figure 2.16). These variations exist in both the formal and informal employment sectors, adding layers of complexity to the region's employment landscape. In the formal sector, 57% of Antofagasta's workforce is employed in the private sector, compared to the national average of 51%. This 5.2% differential is a clear sign of a stronger private sector in Antofagasta, likely underpinned by the region's prosperous mining industry. The public sector in Antofagasta also outperforms the national average, with 14% of the workforce compared to 11% across Chile, reflecting a 3.3% higher rate.

However, it is not all positive. The data reveal Antofagasta lags behind the national average by 1.6% for self-employed workers in the formal sector, with a rate of 5% compared to 6% in Chile. The region's rates for employers and domestic helpers in the formal sector align with the national average, sitting at 3% and 1% respectively.

The region's labour sector shows that Antofagasta (21%) has a lower degree of informality in its labour market compared to the national average (27%). With fewer self-employed workers and a smaller private sector within the informal economy, the region demonstrates a stronger emphasis on formal employment. This highlights the significance of the formal sector in supporting Antofagasta's workforce.

Figure 2.16. Percentage point difference by occupation, formal/informal situations, between Antofagasta and the national average, 2023



Note: Data correspond to March 2023.
Source: Based on data from INE (2023[2]), *Ocupación y Desocupación*, https://regiones.ine.cl/antofagasta/estadisticas-regionales/sociales/mercado-laboral/ocupacion-y-desocupacion.

Well-being in Antofagasta region

Quality of life in the region of Antofagasta

Progress in the region and the development of its business environment are relevant to ensure the well-being of Antofagasta. Retaining and attracting people and businesses are some of the aspects which depend directly on policies aimed at the well-being of the citizens. This is partly achieved by offering sufficient high living standards to make the region attractive to both foreigners and locals. The OECD regional well-being analysis provides a tool for policy makers to assess the region's strengths and weaknesses, monitor trends and compare their results with those of other regions, nationally and internationally (Box 2.2). To better understand the relationship between well-being and mining regions, the analysis presented in this section adopts the OECD regional well-being framework to compare the quality of life outcomes in Antofagasta with the average for OECD TL2 mining regions and for Chile.

Box 2.2. OECD Regional Well-being indicators

Building comparable well-being indicators at a regional scale

The OECD framework for measuring regional well-being builds on the OECD Better Life Initiative at the national level. It goes further to measure well-being in regions with the idea that well-being data are more meaningful if measured where people experience it. Besides place-based outcomes, the framework also focuses on individuals since both dimensions influence people's well-being and future opportunities.

Figure 2.17. Indicators by well-being dimension

Source: OECD (2023[7]), *OECD Regional Well-Being (database)*, https://www.oecdregionalwellbeing.org/ (accessed on 27 May 2019).

In line with national well-being indicators, regional well-being indicators concentrate on informing about people's lives rather than on means (inputs) or ends (outputs). In this way, policies are directed to well-being features that can be improved by policies. Regional well-being indicators also serve as a tool to evaluate how well-being differs across regions and groups of people.

Regional well-being indicators are multi-dimensional and include both material dimensions and quality of life aspects. They also recognise the role of citizenship, institutions and governance in shaping policies and outcomes.

Although well-being dimensions are measured separately, the regional well-being framework aims to allow for comparisons and interactions across multiple dimensions to account for complementarities and trade-offs faced by policy makers. At the same time, the comparison of regional well-being indicators over time allows for comparing dynamics of well-being over time, as well as the sustainability and resilience of regional development.

Regional well-being in Chile is measured along 12 well-being dimensions: income, jobs, housing, health, access to services, education, civic engagement, environment and safety – for which there are comparable statistics at the regional level – and the 3 additional dimensions of work-life balance, community (social connections) and life satisfaction. Figure 2.17 shows the indicator used for each dimension.

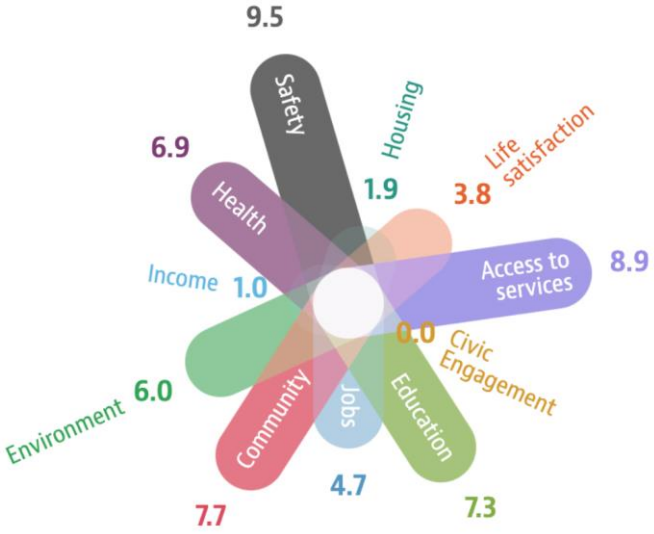
In light of Antofagasta's diverse well-being indicators, we gain a more nuanced understanding of life in this thriving region of Chile, as presented by the OECD Regional Well-being database (OECD, 2023[7]). The region of Antofagasta has uneven well-being results compared to the average of the OECD TL2 mining regions (see Figure 2.18). Antofagasta shows an above-average performance of the OECD regions in 5 dimensions of well-being out of the 11 total. The region, therefore, ranks particularly high in health, environment, civic engagement, housing and community. The lowest well-being scores compared to the OECD TL2 regions refer to education, jobs and income. The downside of Antofagasta and Chile lies in the low-performance dimensions that are far from the results of the OECD TL2 average mining regions, which poses a great challenge for the development of policies capable of reducing this gap. In particular, dimensions such as jobs or education require great efforts to catch-up with the other OECD regions.

The region lags in health and life satisfaction, ranking last and 12th respectively among Chile's 16 regions. The region's mixed performance, with its strengths in infrastructure and education juxtaposed with pressing needs in healthcare and general life satisfaction, illustrates the complexity and uniqueness of Antofagasta's development path. A comprehensive, balanced approach is needed to further boost the region's overall well-being and ensure sustainable growth. Generally, the indicators highlight Antofagasta's positive attributes but also shed light on areas where improvements can be made. Further expanding on these findings:

- **Education**: The region's performance in education is exemplified by its high ranking in Chile, with 78.2% of the population having at least a secondary education. It is worth noting that Antofagasta outperforms the Chilean average, scoring 7.3 on the composite indicators compared to Chile's 5.9 (on a scale from 0 to 10). Yet when compared to all regions across the OECD, Antofagasta is among the bottom 45% of regions.
- **Jobs**: Despite a lower employment rate of 59.5% and an unemployment rate of 9.7%, Antofagasta's robust private sector presence, with higher formal employment rates than the national average, may offer future growth opportunities but still ranks among the bottom 25% compared to all OECD regions and 9th across the 16 regions of Chile.

- **Community**: Antofagasta's sense of community shines, securing second place with a remarkable perceived social support network of 92.0%. This is reflected in the composite indicators where Antofagasta scores 7.7, significantly above Chile's average of 5.2 and top 36% across all OECD regions.
- **Environment**: Antofagasta's environmental efforts are reflected in its air quality (PM2.5) of 13.1 micrograms per cubic metre, ranking second among the Chilean regions. However, we have previously noted the potential inaccuracy due to data collection challenges in this area. As the next section will show, granular environmental indicators within the subregions of Antofagasta display some challenges in GHG emissions.
- **Income**: Antofagasta's disposable income per capita stands at USD 8 737, resulting in fourth place among Chile's regions. This aligns with Antofagasta's strong performance in the income composite indicators, equal to Chile's average.
- **Access to services**: Standing tall, with 84.3% of households with broadband access and Internet speed averaging 72.5%, Antofagasta leads in Chile.
- **Health**: With a mortality rate of 6.4 deaths per 1 000 people and a life expectancy of 79.2 years, Antofagasta ranks among the last in health outcomes across OECD regions.
- **Safety**: Despite growing concerns about safety, Antofagasta's current safety metrics present a relatively reassuring picture. With a low homicide rate of 2.1 homicides per 100 000 people, the region ranks fourth. Furthermore, Antofagasta surpasses the Chilean average in the safety composite indicators, registering a score of 9.5 compared to Chile's 8.8. However, it is worth noting that regional trends can change. In 2022, for instance, 34% of residents identified crime and drug trafficking as the region's most pressing issues (IPP, 2023[18]).
- **Housing**: The region ranks at the bottom 25% across all OECD regions, with 1.2 rooms per capita. Antofagasta also underperforms the Chilean average in the composite indicators, scoring 1.9 compared to Chile's 2.2.
- **Life satisfaction**: The life satisfaction index stands at 6.0. Antofagasta ranks 12th, trailing Chile's average of 4.6 in the composite indicators, indicating a critical area for improvement. Similarly, this indicator ranks Antofagasta among the bottom 22% across all OECD regions.

Figure 2.18. Well-being spider of Antofagasta compared to OECD, 2023



Note: No data available for civic engagement.
Source: OECD (2023[7]), *OECD Regional Well-Being (database)*, https://www.oecdregionalwellbeing.org/ (accessed on 27 May 2019).

In conclusion, Antofagasta exhibits remarkable strengths, particularly in access to services and education. However, it also faces challenges in health and life satisfaction. This in-depth analysis underscores the need for a comprehensive approach to ensure that all aspects of well-being are addressed. Looking at a lower regional level will help understand the internal dynamics.

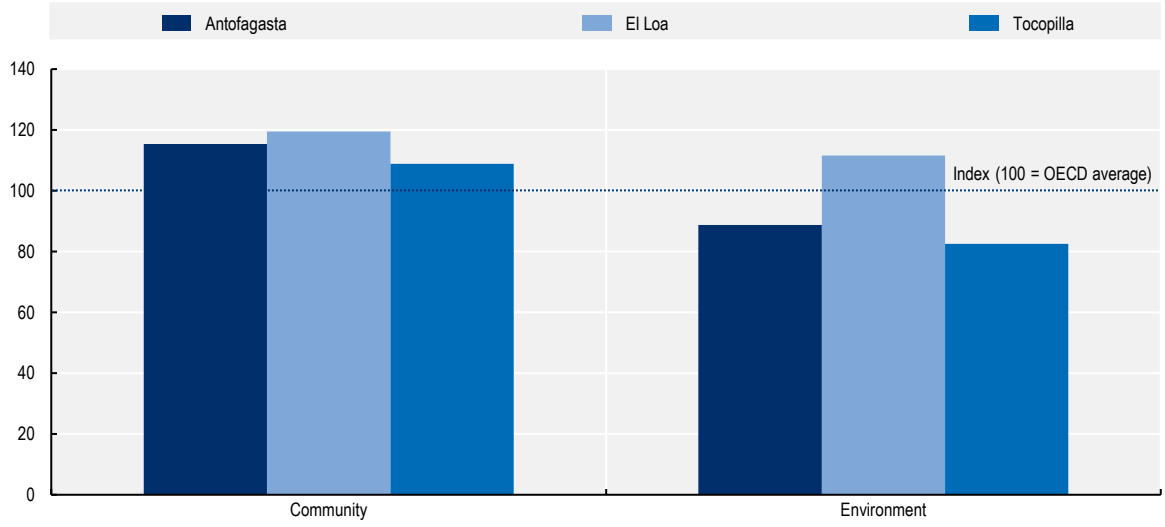
Snapshot of quality of life in the different subregions of Antofagasta

Looking at the subregions of Antofagasta (Level TL3; City of Antofagasta, El Loa and Tocopilla), well-being data provide a more nuanced picture of the strengths and challenges across the regions specialised in mining activities. To better comprehend the impact of mining on regional development, the report utilises its Regional Well-being framework. Within this framework, and in alignment with the characteristics of the OECD mining toolbox, 13 internationally comparable indicators have been identified. These indicators are aptly suited to gauge the well-being standards in OECD mining regions, as detailed in (Annex Table 2.A.3). Antofagasta in the composite index of the OECD toolkit to measure the well-being of mining regions in the community dimension is 115.35 points, above the OECD average of 100 points, reflecting the strong societal fabric of the region (OECD, 2023[7]).

However, in the environmental dimension, Antofagasta scores 88.75 points, below the OECD average, indicating the need for further efforts towards sustainable practices (Figure 2.19). The diverse sub-regions of the city of Antofagasta, El Loa and Tocopilla, each with its unique characteristics, further enhance this picture, providing a more nuanced view of well-being in the region.

The necessity for a robust assessment framework capable of effectively capturing the nuances of well-being at the local level is apparent. While Antofagasta's economy is strong in some sectors, the holistic picture of well-being goes beyond traditional economic indicators and thus requires a multi-faceted approach. This would involve incorporating a range of additional factors to gain a more complete understanding of local conditions. This could include factors such as environmental conditions, access to quality healthcare and education, social cohesion and the distribution of opportunities within the region. By broadening the spectrum of indicators used to measure well-being, we can provide a more balanced and comprehensive view of the region's strengths and areas for development.

Figure 2.19. Toolkit for mining regions' well-being applied to Antofagasta City, El Loa and Tocopilla, as compared to the OECD average



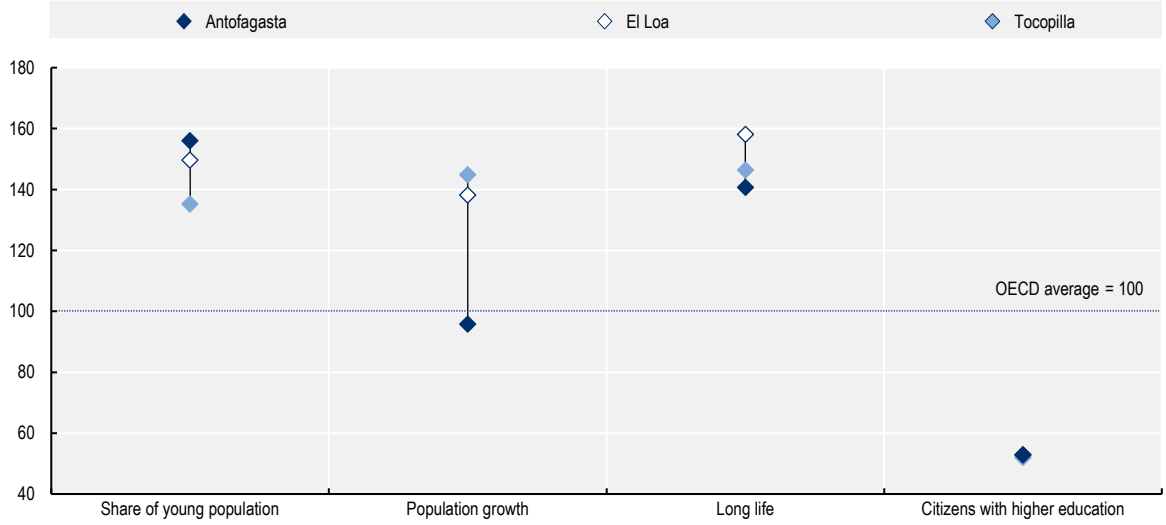
Note: The overall performance in each category (community, economy and environment) is summarised with a simple average of the indicators in that domain.
Source: OECD (2023[4]), *Toolkit for Mining Regions Well-being*, https://oecd-main.shinyapps.io/mining-regions-wellbeing/.

Community dimension

The community dimension measures elements such as the share of the young population, population growth, life expectancy and citizens with higher education (Figure 2.20). Both Antofagasta City and El Loa score above the OECD average, with 135.16 and 149.62 index points respectively in the young population share, indicative of vibrant communities with a youthful workforce. Antofagasta stands out with its robust population growth at 144.88 points and high life expectancy at 146.36 points, while El Loa showcases a similar trend in population growth and life expectancy with 138.13 and 158.08 points respectively.

Higher education attainment, though trailing behind at 52 points for both regions, lags behind in the community dimension. Tocopilla, although scoring slightly lower, maintains a similar demographic profile, highlighting the prevalence of a youthful across the regions.

Figure 2.20. Community indicators for the TL3 regions of Antofagasta, 2020



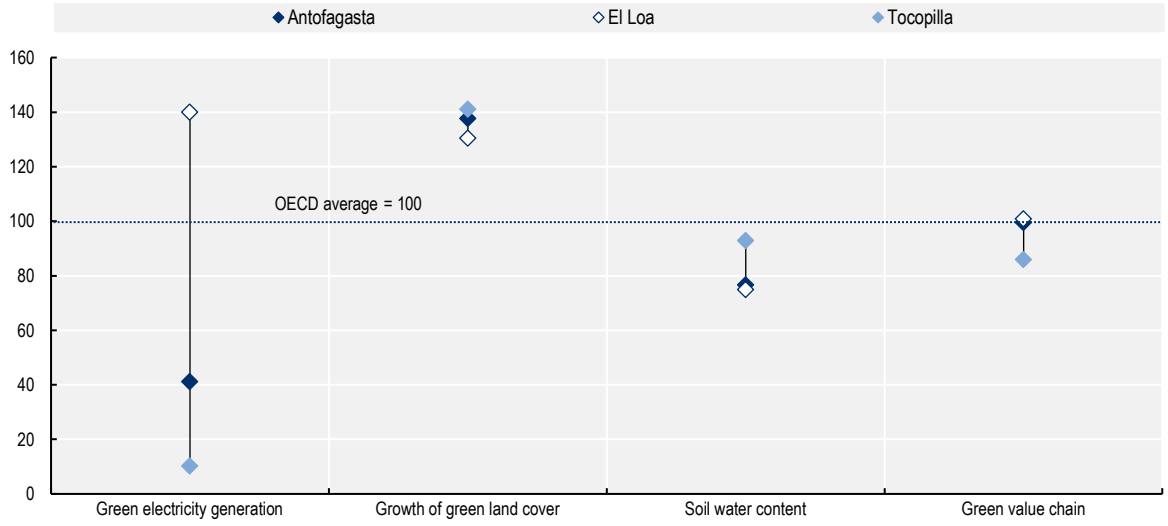
Note: Please see Annex 2.A for a description of each indicator. Antofagasta in the figure refers to the area covered by the city.
Source: OECD (2023[4]), *Toolkit for Mining Regions Well-being*, https://oecd-main.shinyapps.io/mining-regions-wellbeing/.

Environmental dimension

The environmental dimension includes three indicators that are feasible for international comparisons at a granular level: green electricity generation (GHG emissions from electricity production), growth of green land cover (growth of vegetation and forest land area), soil water content and green value chain (GHG emissions per capita from the energy, industry and transport sector) (Figure 2.21).

In terms of GHG emissions, most were generated by the power sector, i.e. electricity generation, combined heat and power generation, and heat plants (43% of the total GHG emissions in 2018), followed by the industry sector (29%) and transport (18%). In Tocopilla, emissions from the power sector alone represent 89%, almost double the average of the OECD mining regions benchmark (Figure 2.22).

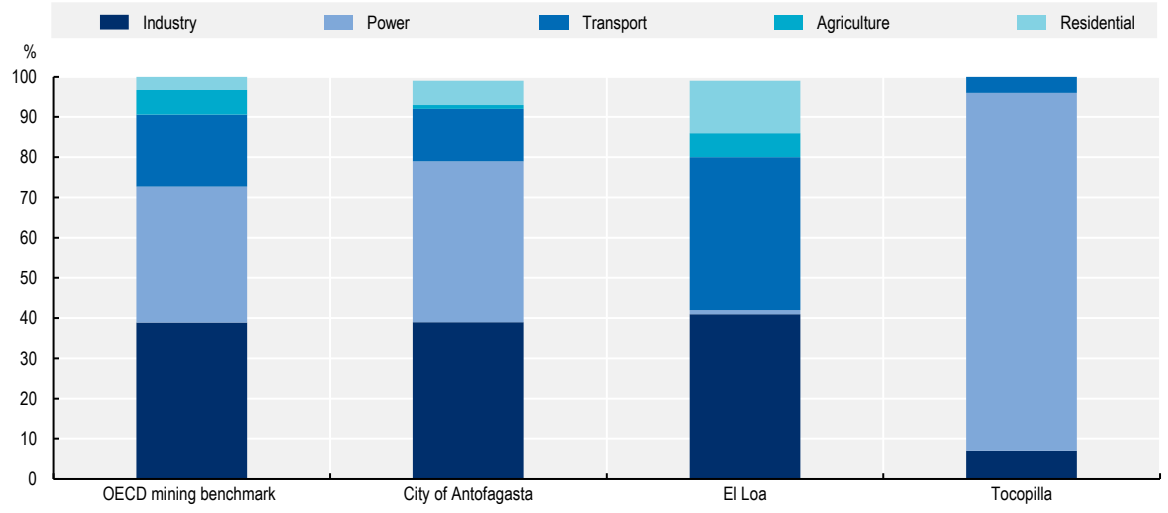
Figure 2.21. Environmental indicators for the TL3 regions of Antofagasta, 2020



Note: Please see Annex 2.A for a description of each indicator. Antofagasta in the figure refers to the area covered by the city.
Source: OECD (2023[4]), *Toolkit for Mining Regions Well-being*, https://oecd-main.shinyapps.io/mining-regions-wellbeing/.

Figure 2.22. Sectoral contribution to GHG emission production-based estimations in the subregions of Antofagasta and OECD mining regions, 2018

Share of sector GHG emissions over regional GHG emissions



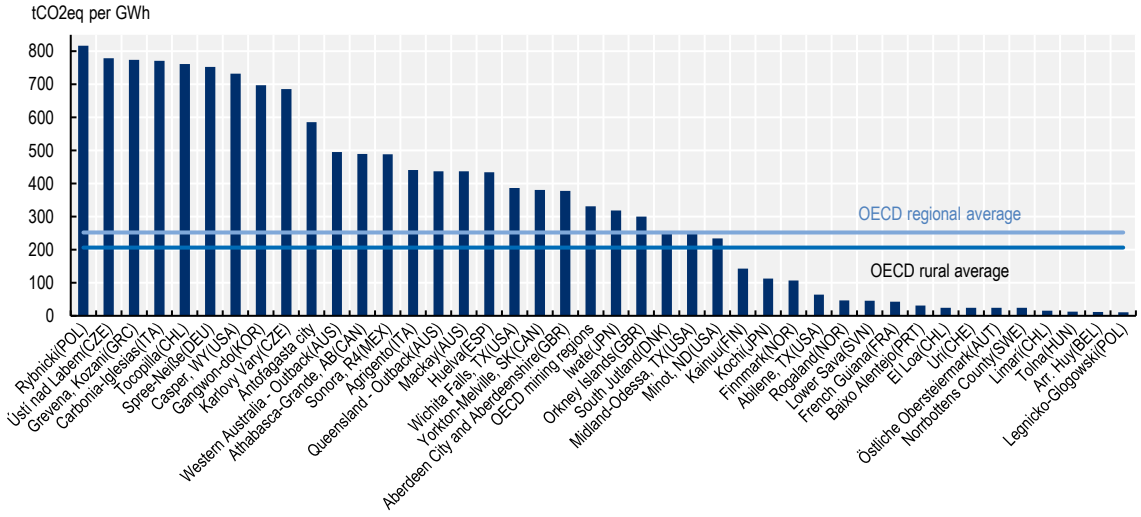
Note: GHG emissions exclude emissions from land use and land use change. Power refers to GHG emissions from main activity producers of electricity generation, combined heat and power generation, as well as heat plants (IPCC 1996:1A1a).
Source: OECD (2022[1]), *OECD Regional Statistics (database)*, http://dx.doi.org/10.1787/region-data-en; calculations based on OECD (2023[4]), *Toolkit for Mining Regions Well-being*, https://oecd-main.shinyapps.io/mining-regions-wellbeing/.

The three subregions of Antofagasta produce, on average, 38% more GHG emissions per unit of electricity generated than the OECD benchmark for mining regions and 82% more than the average of OECD regions (Figure 2.23). This is particularly notable in Tocopilla and Antofagasta, where coal accounts for 92% and 46% of the energy supply respectively, a marked contrast to the 23% average in OECD mining regions (OECD, 2023[19]). While these emissions are compliant with Chile's national air decontamination plans,

they exceed the stricter standards set by the World Health Organization. In Tocopilla, which has the highest per capita emissions in the region, the primary contributors to pollution are the thermoelectric plants Electro Andina and Norgener.

In 2020, Chile announced ambitious legislation aiming for net zero emissions by 2050 as part of its Framework Law on Climate Change. As part of this commitment, regions like Antofagasta will play a crucial role in transitioning towards cleaner energy sources. The El Loa sub-region exemplifies this shift, predominantly generating electricity from renewable sources. To fulfil Chile's net zero emissions target, it will be necessary to enforce stringent emissions standards and tap into the nation's potential for renewable energy, emphasising the need for a balanced and sustainable approach to economic development in mining regions like Antofagasta.

Figure 2.23. CO_2 emissions from electricity generation in the sub-regions of Antofagasta and OECD mining regions, 2019



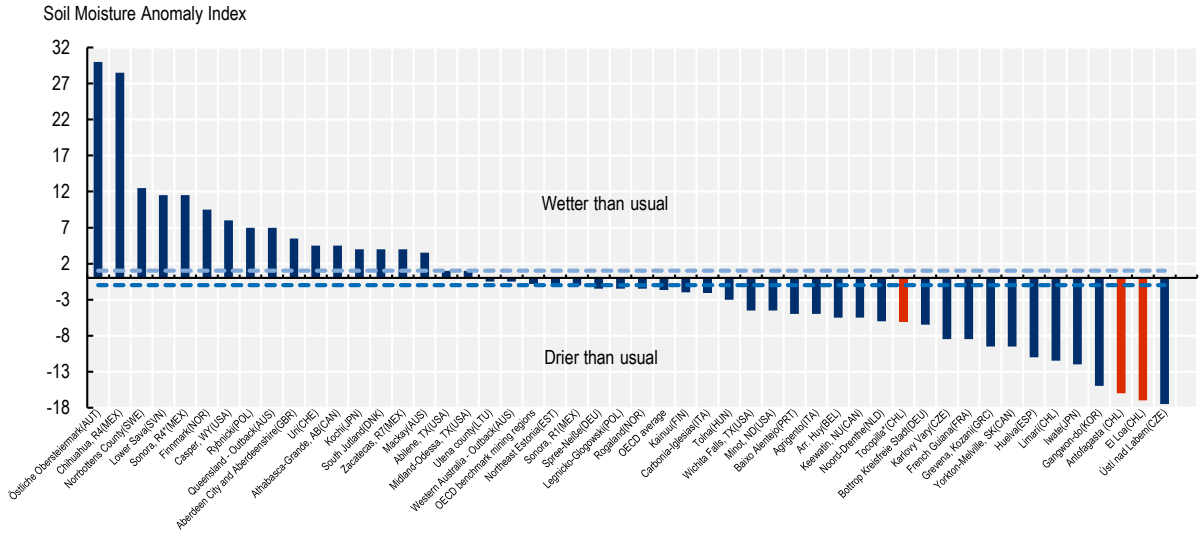
Source: OECD (2023[4]), *Toolkit for Mining Regions Well-being*, https://oecd-main.shinyapps.io/mining-regions-wellbeing/.

The arid nature of the region places it as one of the mining regions with a low share of green land cover (34% of the total land on average, made up of trees, vegetation, grassland or shrubland) relative to the OECD benchmark of mining regions (60%) and OECD regional average (52%) (Figure 2.24). Despite this arid nature, during 2004-19, the 3 sub-regions of Antofagasta reported an increase in the share of green land cover (20% on average), above a relatively stable share across the OECD mining regions benchmark (1%). This can be mainly explained by the construction of parks or the repopulation of native trees. Greater growth of green land cover was seen in Tocopilla, followed by Antofagasta City.

In terms of anomalies in soil water content, between 2018 and 2019, the three regions of Antofagasta have registered average drier conditions than usual (based on the 1981-2010 period), which contrasts with lower anomalies in the average of OECD mining regions. In fact, El Loa ranks as the second region in the group of OECD mining regions with the greatest anomalies in soil water content, meaning drier conditions than usual during 2018 and 2019. The recorded anomalies in soil water are possibly attributable to a combination of climate change and human activities, including intensive mining operations and land use changes. These factors have contributed to decreased rainfall and high water usage, resulting in a change of usual conditions, particularly noticeable in the El Loa region with still undefined impacts on local communities.

Figure 2.24. Anomalies in soil water content in the sub-regions of Antofagasta and OECD mining regions

Anomaly during 2018-19 vs. average conditions during 1981-2010



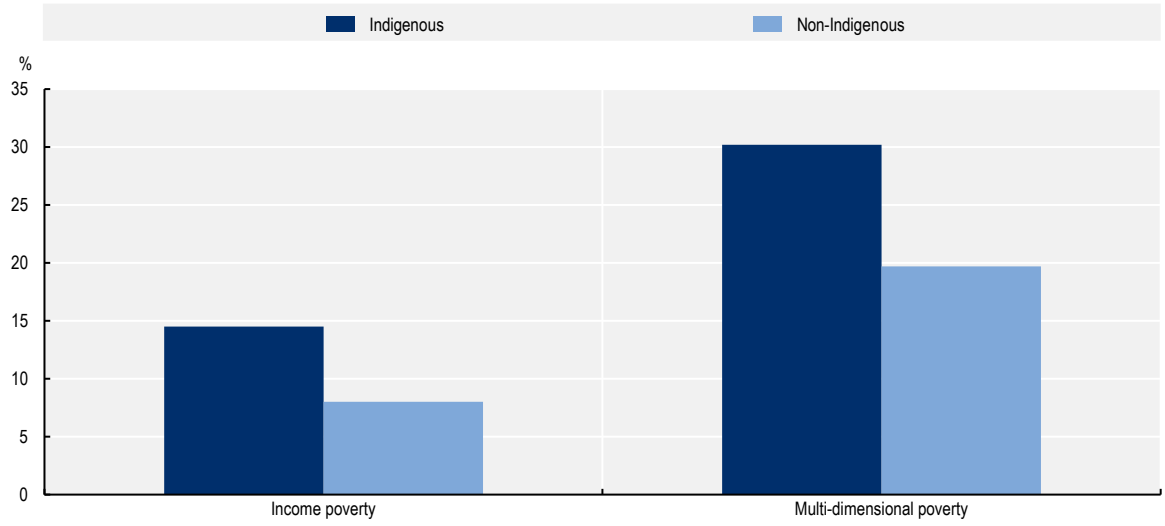
Note: Value is considered an anomaly in soil water content if it is above 1 (wetter than usual) or below -1 (drier than usual). This interval is represented in the figure by the dotted lines. Antofagasta in the figure refers to the area covered by the city.
Source: OECD (2023[4]), *Toolkit for Mining Regions Well-being*, https://oecd-main.shinyapps.io/mining-regions-wellbeing/.

A snapshot of well-being in Indigenous communities

Indigenous populations often find themselves among the most disadvantaged groups in Chilean society. This inequality also manifests itself territorially. In regions such as Antofagasta, where wealth is generated predominantly through mining, disparities in poverty, health and education between the Indigenous and non-Indigenous populations are apparent (see Figure 2.25). The following dimensions of well-being correspond to Indigenous communities all across Chile:

- **Poverty**: Indigenous peoples experience higher levels of both income poverty and multi-dimensional poverty. The rate of childhood poverty among Indigenous peoples reaches 20%, compared to 13% for the rest of the country's children. Moreover, income poverty in Indigenous communities is 6.4% percentage points higher than in non-Indigenous. Similarly, multi-dimensional poverty increases to a 10.5 percentage point difference (CASEN, 2017[8]).
- **Education**: Indigenous populations have less access to tertiary education compared to their non-Indigenous counterparts. This educational disparity contributes to the cycle of poverty and limits opportunities for upward mobility. In 2017, 45% of Indigenous people aged above 19 years old had not completed secondary education, whereas this figure decreased to 36.6% for non-Indigenous (CASEN, 2017[8]).
- **Health**: Indigenous communities report more significant difficulties accessing health treatments and their living conditions are more likely to be deficient. For instance, malnutrition affects 23.5% of Indigenous children aged 0 to 6 years, compared to 17.2% of non-Indigenous children. Other figures related to health, such as Papanicolaou (pap) tests or medical check-ups for Children (*Control del Niño Sano*), had similar performances among Indigenous and non-Indigenous communities (CASEN, 2017[8]).

Figure 2.25. Poverty comparison between Indigenous and non-Indigenous communities in Chile, 2017



Source: CASEN (2017[8]), *Ministerio de Desarrollo Social*, http://observatorio.ministeriodesarrollosocial.gob.cl/storage/docs/casen/2017/Casen_2017_Pueblos_Indigenas.pdf.

Annex 2.A. Selected OECD TL2 and TL3 mining regions

Annex Table 2.A.1. Benchmark of OECD TL2 regions used for comparison with the TL2 region of Antofagasta

Country	Region
Australia	New South Wales
	Queensland
	Western Australia
Canada	Alberta
	Antofagasta
	Nunavut
Chile	Atacama
	Coquimbo
	Saskatchewan
Finland	Eastern and Northern Finland
France	French Guiana
Germany	Brandenburg
	North Rhine-Westphalia
	Saxony-Anhalt
Greece	Western Macedonia
Italy	Sardinia
Mexico	Jalisco
	San Luis Potosi
	Sonora
	Zacatecas
Netherlands	Groningen
Norway	Agder and Rogaland
	Northern Norway
Poland	Silesia
	Lower Silesia
Romania	South West Oltenia
Spain	Andalusia
Sweden	Upper Norrland
United Kingdom	Northern Ireland
	Scotland
United States	Kansas
	New Mexico
	North Dakota
	Oklahoma
	Texas
	Wyoming

Annex Table 2.A.2. Benchmark of OECD TL3 regions used for comparison with the TL3 region of Antofagasta

Country	TL3 mining regions	Corresponding TL2 region
Australia	Mackay	Queensland
	Queensland Outback	
	Western Australia Outback	Western Australia
Austria	Östliche Obersteiermark	Styria
Belgium	Arr. Huy	Wallonia
Bulgaria	Starazagora	North West
Canada	Athabasca-Grande	Alberta
	Keewatin	Nunavut
	Yorkton/Melville	Saskatchewan
Chile	El Loa	Antofagasta
	Tocopilla	
	Limarí	Coquimbo
Czech Republic	Karlovy Vary	Northwest
	Ústí nad Labem	
Denmark	South Jutland	Southern Denmark
Estonia	Northeast Estonia	Estonia
Finland	Kainuu	Eastern and Northern Finland
France	French Guiana	French Guiana
Germany	Bottrop Kreisfreie Stadt	Rhine-Westphalia
	Grevena, Kozani	Western Macedonia
Greece	Spree-Neiße	Brandenburg North
Hungary	Tolna	Southern Transdanubia
Italy	Agrigento	Sicily
	Carbonia-Iglesias	Sardinia
Japan	Iwate	Tohoku
	Kochi	Shikoku
Korea	Gangwon-do	Gangwon region
Lithuania	Utena county	Central and Western Lithuania
Mexico	Caborca/Puerto Peñasco	Sonora
	Cananea/Fronteras	
	Concepción del Oro/Mazapil	Zacatecas
	Guerrero/Madera	Chihuahua
Netherlands	Noord-Drenthe	Drenthe
Norway	Finnmark	Northern Norway
	Rogaland	Agder and Rogaland
Poland	Rybnicki	Silesia
	Legnicko-Glogowski	Lower Silesia
Portugal	Baixo Alentejo	Alentejo
Romania	Gorj	South West Oltenia
Slovenia	Lower Sava	Eastern Slovenia
Spain	Huelva	Andalucia
Sweden	Norrbottens County	Upper Norrland
Switzerland	Uri	Central Switzerland
United Kingdom	Aberdeen City and Aberdeenshire	Scotland
	Orkney Islands	
United States	Abilene	Texas
	Midland-Odessa	
	Wichita Falls	
	Casper	Wyoming
	Minot	North Dakota

The table below presents the 13 indicators of the OECD mining well-being toolkit to measure well-being standards across the economic, social and environmental dimensions, taking into account the specific characteristics of regions specialised in mining activities and data availability.

Annex Table 2.A.3. Indicators to monitor well-being in OECD mining regions

Dimension	Outcome indicator	Underlying formula	Unit	Period
Economic	Jobs	Unemployment rate for 15 year-olds or more	Percentage	Latest year available (…2020)
	Economic diversification	Herfindahl index (based on employment distribution)	Index	Latest year available (…2020)
	Economic growth	Growth of total employment at place of work	Percentage	Latest year available (…2020) vs Midyear (…2007…)
	Innovation level	Patents per million inhabitants	Per million inhabitants	Latest year available (…2020)
Community/social	Share of females in the workforce	Gender ratio in working-age population 15-64 years old (male/female)	Percentage	Latest year available (…2020)
	Share young population	Share of 0-14 year-olds in population	Percentage	Latest year available (…2020)
	Population growth	Growth of total population	Percentage	Latest year available (…2020) vs Midyear (…2007…)
	Long-life	Death rate (deaths per 1 000 total population)	Per 1 000 inhabitants	Latest year available (…2020)
	Education level	Share of population 25-64 years old with tertiary educational attainment	Percentage	Latest year available (…2020)
Environment	Change of trees/vegetation	Change in the share of grassland, shrubland, sparse vegetation and forest cover	Percentage points	Latest year available (…2020) vs. midyear (…2007…)
	Green electricity generation	GHG emissions per unit of electricity generated	Tonnes of CO_2 equivalent per gigawatt hour (tCO_2eq per GWh)	2019
	Green value chains	GHG emissions per capita from the energy, industry and transport sector	Kilograms of CO_2 equivalent per capita	2018
	Soil water content	Mean soil moisture anomaly of 2018 and 2019 compared to the 1981-2010 reference period	Index	Average of 2019 and 2018

Source: OECD (2023[4]), *Toolkit for Mining Regions Well-being*, https://oecd-main.shinyapps.io/mining-regions-wellbeing/.

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Velásquez, D. (2020), "Industrial agglomeration and union resources mobilisation: A comparison between Antofagasta Enclave and Los Lagos Cluster, Chile", in *The Political Economy of Work in the Global South*, Red Globe Press. [5]

Notes

[1] The calculation of workers in mining in Antofagasta has been done by calculating the percentage between the workers who work and live in Antofagasta in mining with all the employed people from Antofagasta and those who come from other regions and come to work in Antofagasta in mining.

[2] The OECD regional database collects and publishes regional data at two different geographical levels, namely large regions (Territorial Level 2, TL2) and small regions (Territorial Level 3, TL3). Both levels encompass entire national territories. With some exceptions, TL2 regions represent the first administrative tier of subnational government (i.e. states in the United States, *estados* in Mexico or *régions* in France). TL3 regions are smaller territorial units that make up each TL2 region.

The OECD has adopted a new typology to classify administrative TL3 regions. This classification allows measuring socio-economic differences between regions, across and within countries. It is based on the presence and access to functional urban areas (FUAs) – a concept defining cities and the urban hinterland, in other words, urban economic agglomerations.

By controlling for these regional characteristics, the typology classifies TL3 regions into two groups, metropolitan and non-metropolitan regions. Within these two groups, five different types of TL3 regions are identified. The metropolitan regions (MRs) adopt 50% of the population of the TL3 (small) region living in an FUA of at least 250 000 people as a threshold; non-metropolitan regions (NMRs) 60-minutes' driving time as a threshold, a measure of access to an FUA.

[3] Location quotient for mining specialisation is measured as follows:

LQ: $\frac{(regional\ employment\ in\ mining)/(regional\ employment)}{(national\ employment\ in\ mining)/(national\ employment)}$.

[4] The share of workers in mining is obtained from the following sources: for Denmark, Finland, Japan, Korea, Portugal, Switzerland and the United Kingdom, mining employment data were obtained from the Structural Business Statistics (International Standard Industrial Classification rev. 4) using the sector “B - Mining and quarrying” and taken out regions specialised in “extraction of crude petroleum and natural gas”. For Chile and Mexico, the national mining department’s information along with discussion with experts from those countries helped select the top mining TL3 regions in terms of employment. For the remaining 27 countries, mining employment values were obtained from the OECD database (OECD, 2023[7]) with an estimation of mining employment based on the subtraction of manufacturing employment from industry.

[5] The 'ideal target' is rooted in the adapted Human Development Index (HDI) for Chile—a metric consolidating data on health, education, and income. While globally recognized, the HDI is adjusted for each country's specifics, with values normalized between 0 and 1 based on an 'ideal' parameter for each variable.

3 Mobilising the strengths of Antofagasta's mining ecosystem

This chapter identifies strategies to mobilise the strengths of the mining business ecosystem of Antofagasta, to accelerate its green transition and promote regional economic diversification. These strategies intend to identify areas of opportunities to be unlocked within the new mining strategy of the region. The chapter begins with an overview of the region's strengths and challenges in the ecosystem. It then outlines areas of opportunity to accelerate the environmental transition in mining. Finally, it examines possible strategies to support economic diversification inside and outside mining activities.

Main takeaways

Assessment

- The region of Antofagasta is a global player in the mining industry, especially in copper and lithium. Its traditional expertise in mining operations, presence of rich geological resources, a mature mining ecosystem composed of leading mining companies, suppliers, universities with mining know-how, organised civil society actors and a recently strengthened regulatory framework with greater regional decentralisation make Antofagasta highly attractive for ongoing and future mining activities.
- The global green energy transition represents an opportunity for Antofagasta to remain competitive in mining and diversify its economy, including in value-added activities. In addition to a growing demand for its mineral portfolio, there is great potential for renewable energy production and to become a green hydrogen production hub. The region has important advantages as a potential leader in making mining more sustainable. These include: i) mining companies' initiatives, societal demand and innovative practices in overcoming environmental challenges, particularly in addressing water scarcity through water reuse initiatives or seawater desalination technologies and decarbonisation of mining operations; and ii) a favourable geographic location to become a logistic gateway to Pacific markets for mining ventures in neighbouring countries.
- However, the region must also overcome some of its pressing current challenges. Notably, bottlenecks specific to mining operations (especially productivity and declining ore grades), improving environmental outcomes (including reducing its large industrial carbon footprint) and delivering a more equitable distribution of industry benefits to the entire regional population.

Policy takeaways

In order to make sure its mining potential translates into measurable well-being improvements in the region, Antofagasta will need to:

- **Leverage green innovation to make mining more sustainable** and become a leader of these practices in Latin American. Antofagasta can scale up more sustainable mining practices to provide innovative solutions to other mining regions in Chile and neighbouring countries such as Argentina, Bolivia and Peru. To this end, the regional government and its forthcoming mining strategy should:
  - Provide more transparency on the use of renewable energy sources and desalinated water for mining operations across the region.
  - Incentivise to promote more efficient use of water, with technologies and practices to reuse water or minimise use of continental water.
  - Promote a co-ordinated management of desalinisation facilities, with incentives to approve and develop projects that prioritise sharing facilities among different users.
  - Provide incentives to attract investments for reusing mining tailings. This can be in the form of fiscal benefits, infrastructure or policy incentives.
  - Promote the adoption and maintenance of environmental, social, and corporate governance (ESG)-compliant practices and credentials for the mining sector, with certificates that also include civil society validation. Explanation of certificates and credentials for each mine site should be transparent and available on the website of the forthcoming mining strategy.

- **Diversify the production matrix of the mining sector** by increasing value-added activities in the value chain and supporting the development of other minerals. To this end, the regional government and its forthcoming mining strategy should:
  - Strengthen upstream linkages by developing suppliers and technologies that can create specific knowledge in the region's key priorities, such as water and air pollution management or valorising waste mining.
  - Strengthen downstream linkages to add value to mineral products around two main areas:
    - Prioritising value-added in extracted minerals in areas where Antofagasta has competitive advantages. To this end, the establishment of a public technological institute for the research of lithium and *salars* should promote knowledge in lithium processing (e.g. obtaining speciality chemicals from lithium) and build the basis for a stronger lithium processing industry in the region. In parallel, the region should strengthen skills and accessibility of technology to allow value-added projects in lithium. In the case of copper, the region could promote investments in downstream infrastructure that uses renewable energy to add value to copper with a low-carbon footprint (e.g. smelter/refinery that takes advantage of abundant renewable energy sources).
    - Adding efficiency and sustainability to mining processes and methods. These could include development processes related to the more sustainable extraction and processing of copper and lithium (for example, reducing inputs, waste streams or time involved) and greater traceability and environmental monitoring of production processes.
  - Attract companies interested in other minerals, such as rare earth minerals.
- **Leverage the mining wealth to support economic diversification in activities outside of mining**, such as the production of green hydrogen, that contribute to a sustainable future in the region. To this end, the regional government and its forthcoming mining strategy should:
  - Develop an innovative world-class renewable energy and hydrogen hub to supply the region's mining sector and generate an independent industry outside the mining sector.
  - Foster tourism as one of the region's key economic activities, chiefly developing "special interest tourism" (including astronomy and experience-based tourism) as well as setting forth the conditions for the tourist industry to thrive (including the digitalisation of tourist services).
  - Promote desert-based agriculture (DBA), fuelled by desalinated water, to improve resilience and know-how against possible impacts emerging from climate change (e.g. longer droughts) and worsening conditions for conventional agriculture.

Relevance of Antofagasta in the global mining industry – Present and future

The mining sector is Chile's main economic activity, accounting for an average of 10% of the country's gross domestic product (GDP) during the past decades (OECD, 2018[1]), 9.3% of total fiscal revenue for the period 2010-2020, and, in 2021, for 58% of the country's total exports and as much as 12.5% of total value-added (OECD, 2022[2])(Ministerio de Minería, 2022).

The industry is also one of the largest employers in the country, with a total of 275 575 direct employees[1] (considering large, medium-sized and small companies) (SERNAGEOMIN, 2022[3]). Of large-scale mining jobs, the Antofagasta region accounts for 57 000 (amounting to 47% of total such employment) (Consejo Minero, 2021[4])

Antofagasta is the preeminent mining region in Chile and one of the largest in the world. The sector is of great relevance at the regional level, accounting for approximately 53% of the total regional GDP and over 90% of its exports in 2018 (Ministerio de Minería, 2020[5]; Paredes Araya and Poblete, 2021[6]).

Copper, lithium and, in smaller proportions, molybdenum, gold, iodine, potash and natural nitrates are geologically abundant and – more importantly – in some cases, have been produced in the region at large scales for many decades.

Beginning in pre-Hispanic times, Antofagasta has had a long and eventful relation with the mining industry, starting with the 19th century's guano and saltpetre (i.e. natural nitrates) booms (and corresponding busts), the beginning of copper production in Chuquicamata in 1915 that has endured to the present and, in more recent times, lithium production from its world-class resources. In its long and rich history, Antofagasta has experienced typical industry dynamics, as well as phases that have had profound effects on the region's current shape (Box 3.1)

Box 3.1. Dynamics in the mining history of Antofagasta

Regarding copper, the region's main mineral product, especially notable are:

- The 1990-2005 phase, where the expansion of Escondida and the opening of El Abra, Radomiro Tomic and Zaldívar mines saw the consolidation of large-scale mining and the arrival of large, international mining companies, resulting in an increase in annual regional production from 1 million tonnes (Mt) to almost 3 Mt.
- The commodity "super-cycle" between 2005 and 2013, which triggered a boom in investments resulting in the expansion of CODELCO's Chuquicamata and Radomiro Tomic, and BHP's Spence mines and the opening of Antucoya, Esperanza, Gabriela Mistral and Sierra Gorda mines, among others (these projects, however, did not translate into larger production volumes, mostly on account of diminishing ore grades).
- The post-super-cycle, from 2013 to the present, has seen a partial retraction of the inefficiencies born under the previously prevailing boom conditions and investments directed at extending the life of several mines and of the infrastructure developments related to energy and water provision of the industry. Production has remained stubbornly stable at approximately 3 Mt per annum as in the prior phase.

The above developments have had positive and negative effects on the region's social (including labour and well-being indicators), economic and environmental aspects (CSP, 2019[7]), which will be analysed in further detail below.

Source: CSP (2019[7]), "El super ciclo del cobre y sus efectos en la Región de Antofagasta [The copper super cycle and its effects on the region of Antofagasta]", www.sistemaspublicos.cl (accessed on 20 January 2023).

Currently, the region's two main mineral products per value are copper and lithium. Antofagasta's annual output of 3 Mt of copper and 150 000 tonnes of lithium carbonate equivalent (LCE) (COCHILCO, 2022[8]); (COCHILCO, 2021[9]); (SERNAGEOMIN, 2022[3]) would make the region the second largest global producer of both mineral products.

In addition to its superb geological endowment and strategic geographical location, many factors come into play to make Antofagasta a global mining powerhouse. These include a long mining history, a healthy mining business environment (including some of the world's largest mining companies and a robust mining equipment, technology and services [METS] sector) and a growing innovative approach to sustainable mining and energy transition challenges.

These – and other – factors place Antofagasta in a prime position to benefit from current global trends, which include a changing global value chain context and, especially, a renewed interest in the region's mineral products on account of the energy transition requirements. In fact, in terms of total future mining investment, Antofagasta is set to retain its first place among Chilean regions, with 30% of the total expected investment, for an amount of USD 22 billion (out of a total of USD 73.6 billion) (COCHILCO, 2022[10]).

Yet questions loom regarding some of the significant challenges the region will face if it is to increase – or even maintain – current levels of production while ensuring benefits are evenly and justly distributed, promoting Antofagasta's sustainable development. These include environmental and geological constraints, social inclusivity and leveraging the mining industry's potency to promote diversification of the region's economic activities.

Antofagasta's mining strategy will have to make the most of the region's many advantages while addressing the challenges presented in novel and effective ways, ensuring creating the environment for a sustainable mining development that provides the region's citizens with long-term prosperity and well-being.

The mining business ecosystem in Antofagasta

The mining ecosystem in Antofagasta is complex and multipartite, comprising a large national public sector and a novel regional government setup, public and private mining companies (including some of the world's largest, as well as small and medium-sized enterprises), a significant METS sector, labour and industry organisations, universities and research centres, and civil society actors. Close collaboration and interaction between these players will be key to ensuring Antofagasta's mining industry effectively fosters its sustainable development.

An understanding of Antofagasta's main value chains is essential to better grasp the potential and challenges facing the region in its strategic development. Given their importance relative to all other products, this will mostly hinge on the region's copper and lithium value chains, which are likely to become even more relevant in future.

Mining value chains in Antofagasta

As mentioned above, in addition to gold, silver and industrial minerals such as molybdenum, potash, iodine, natural nitrates and boron, Antofagasta is world-known for its production of copper and lithium.

Both mineral products are part of large and complex global value chains involving different players and features, and both have different regional impacts and offer different opportunities for development. The next sections describe the main characteristics of each sub-sector by outlining its chief assets, companies and production processes.

Copper: Global top producer but with low refinery capacity

Antofagasta is home to some of the world's major copper mines (including Minera Escondida, the world's largest) and, during the past decade, has produced an average of close to 3 Mt of copper per year, mostly exported as copper cathodes, blisters and – increasingly – as copper concentrate (see Box 3.2).

Antofagasta's copper deposits are part of one of the most important copper belts in the world, formed by the convergence of the Nazca and South American tectonic plates and the occurrence of several mineralisation events giving rise to, mainly, porphyry-type deposits (Palacios et al., 2007[11]). These are large low- to medium-grade deposits containing, on average, hundreds of millions of tonnes of ore of varying grades and are currently the world's most important source of copper and molybdenum and an important source of gold (Sinclair, 2007[12]; Stevens, 2010[13]).

Chile's Antofagasta region includes some of the world's giant porphyry deposits (in terms of contained metal), including Chuquicamata, Escondida and Radomiro Tomic (Cooke, Hollings and Walshe, 2005[14]), which – like similar deposits around the world – are polymetallic, containing different proportions of copper, molybdenum, gold and other minerals.

The low grade (typically ranging between 0.25% to over 1% copper content) and large size of these deposits call for large-scale, open-pit mining, although as the pit reaches a certain size and sloping, underground, "block caving" type mining is also sometimes utilised to extend the life of the mine. This is the process recently developed by CODELCO's *Chuquicamata Subterránea* expansion, in operation since 2019, and will likely be adopted by other mines as they approach their open-pit design limits.

Antofagasta's copper deposits are considered "world-class" and have attracted some of the largest global mining companies (Table 3.1), which are also the ones financially and technologically capable of developing the large-scale operations generally needed to extract and process the typical massive porphyries of the region.[2]

These companies include private entities (including seven of the ten world's largest copper producers and four of the five world's largest mining companies) and state-owned CODELCO, the single biggest copper producer in the world.

In addition, there are a few mid-size mining companies and operations in the region (Mantos Blancos, Mantos de la Luna, Michilla and Franke, Taltal), accounting for a small fraction of total copper production (but producing some other minerals in larger proportions, most notably gold and silver) (SERNAGEOMIN, 2022[3]).

Table 3.1. Copper mines in the region of Antofagasta

Mine	Municipality(ies)	Number of workers	Owner(s)	Product	Production (tonnes)
Escondida	Antofagasta	3 621	BHP Billiton (57.5%) Rio Tinto plc. (30%) Jeco Corp. (10%) Jeco 2 Ltd (2%)	Cathodes and concentrates	1 011 000
El Abra	Calama	1 137	Freeport McMoRan (51%) CODELCO (49%)	Cathodes	73 000
Radomiro Tomic	Calama	1 251	CODELCO	Cathodes	326 000
Chuquicamata	Calama	3 935	CODELCO	Cathodes	319 000
Spence	Sierra Gorda	1 514	BHP Billiton	Cathodes	203 000
Sierra Gorda	Sierra Gorda	1 461	KGHM Chile SpA (55%) South32 Ltd. (45%),	Concentrates	198 000

Mine	Municipality(ies)	Number of workers	Owner(s)	Product	Production (tonnes)
Centinela Concentrados/Súlfuros (formerly Esperanza)	Sierra Gorda	7 170	Antofagasta Minerals S.A. (70%) Marubeni Copper Holdings Ltd. (30%)	Concentrates	185 000
Centinela Cátodos/Óxidos (formerly El Tesoro)				Cathodes	89 000
Ministro Hales	Calama	771	CODELCO	Concentrates	182 000
Gabriela Mistral	Sierra Gorda	4 575	CODELCO	Cathodes	101 000
Zaldívar	Antofagasta	1 841	Antofagasta Minerals S.A. (50%) Barrick Gold (50%)	Cathodes	87 000
Antucoya	María Elena and Mejillones	2 125	Antofagasta Minerals S.A. (70%) Marubeni Corp. (30%)	Cathodes	79 000
Lomas Bayas	Sierra Gorda	997	Glencore	Cathodes	64 000
Mantos Blancos	Antofagasta	Na	Capstone Copper Corp.	Cathodes and concentrates	45 000
Franke	Taltal	406	KGHM Chile SpA	Cathodes	11 000
Michilla	Mejillones	Na	Haldeman Mining Co. S.A.	Cathodes and concentrates	21 000
Taltal (formerly “Las Luces”)	Taltal	Na	Grupo Minero Las Cenizas S.A.	Concentrates	Na
Mantos de la Luna	Tocopilla	Na	Cía. Minera de Tocopilla S.A.	Cathodes	Na

Source: OECD elaboration, based on data from COCHILCO, CODELCO, Consejo Minero and SONAMI.

Under current forecasts, both the Chilean and regional copper production output is set to increase, reaching 6.6 Mt per year by 2033 (from today’s 5.7 Mt) at the national level and 3.26 Mt per year by the same year (from today’s 3 Mt) at the regional level (COCHILCO, 2022[8]).

To achieve these levels of production, large-scale investments will be needed both in greenfield (i.e. new mines) and brownfield (i.e. expansion and improvement of existing operations) projects.

On aggregate, the total amount of copper-related investment in Antofagasta in new projects and expansions is forecast at USD 20.7 billion through 2031, for a total of 14 projects (of which 10, amounting to USD 11.6 billion, are considered “highly likely to occur”) (COCHILCO, 2022[10]).

These numbers place Antofagasta as the main copper mining investment destination within Chile, with 34.1% of total projects and 31.8% of total investment amounts (in comparison, Atacama, Chile’s second-highest destination, amounts to 26.8% of expected projects and 24.3% of total investments).

Box 3.2. Copper production processes, trends in end products and the smelter outlook

The mining and processing of copper in Antofagasta include several stages. Some are common to all mines, while others depend on ore body characteristics. Typical processes include the following steps:

- Drilling and blasting to fracture and extract copper-bearing rocks.
- Loading the rock, using large shovels or front-end loaders, and hauling it by trucks to the crushers.

- Crushing the rock to a size of about 15 cm.
- Depending on whether the deposit is one of copper oxides or sulphides, the process will continue through different phases:
  - In the case of oxides, the crushed rock is progressively subject to: i) leaching (applying a solution of sulphuric acid and water); ii) solvent extraction; and iii) electrowinning phases to produce a cathode with a purity of 99.99% copper. This process is usually referred to as hydrometallurgical.
  - In the case of sulphides, the crushed rock is: i) ground to very fine diameters (approximately 0.2 mm); ii) treated with chemical reagents in a froth flotation stage; and iii) thickened to obtain a concentrate of approximately 28-30% copper content.
    - Concentrates, in turn, are either exported as such or: iv) smelted and refined to obtain copper blisters (96% copper purity) or anodes (99.5% copper purity). These blisters and anodes (in Chile referred to as refined or FURE products, after its Spanish acronym) can be: v) further purified through pyro- and electro-refining to, again, produce copper cathodes of 99.99% purity.

Export products and trends

Chile's copper production is largely exported, with very little in-country consumption (less than 1% of copper production (COCHILCO, 2022[15]). Copper produced in Antofagasta is mostly exported through one of the region's four deep water, mining-specialised ports (i.e. Angamos, Antofagasta, Coloso and Mejillones) (OECD, 2013[16]).

In 2021, national copper exports were split between concentrates (53.4%), cathodes (25.1%) and refined products (21.5%) (COCHILCO, 2022[17]). These proportions are gradually changing and concentrates are expected to reach as much as 78% of total exports by 2033, with Antofagasta more than leading the trend by shifting its regional copper production from 61.5% of concentrates in 2021 to over 90.6% by 2033 (COCHILCO, 2022[8]).

This shift in the productive matrix is mostly due to two factors: i) geological reasons, which place oxide copper deposits closer to the surface than sulphides, meaning the former have been mined for much longer and are already depleted or nearing depletion; and ii) the cost structure of the Chilean smelter and refining industry.

The smelter conundrum

Chile currently operates seven copper smelters (two private and five publicly owned), of which Glencore's Altonorte in La Negra industrial area and CODELCO's Chuquicamata in Calama are found in the region of Antofagasta.

In addition to copper blisters, anodes and electro-refined cathodes, these smelters/refiners produce anodic muds (a sub-product of anode refining rich in gold, silver and platinum-group metals) and sulphuric acid, essential to the leaching phase of hydrometallurgical processes.

However, the country's smelting industry is among the world's less cost-efficient, with an average of USD 211 per tonne of copper produced (USD/t). This compares poorly with the industry average of 114 USD/t and, especially, with China's 25 smelters, which operate at 59 USD/t on average (COCHILCO, 2022[17]).

In terms of business performance, at expected prices of copper concentrate refining of USD 160-200 per processed tonne, 2 of the country's 7 smelters break even, 3 operate at a loss, and only 2 are profitable (COCHILCO, 2022[17]).

Coupled with high financial costs, Chilean smelters are generally older than the industry average, employ dated technology (although efforts are being made to update the infrastructure) and have a track record of poor environmental performance, especially in connection with air quality matters (Pérez et al., 2021[18]).

This situation is a cause of concern to policy makers and industry participants who are wary of the nation's main export product being overly dependent on Asia's (especially China's) smelting capacity, which accounts for 91% and 67.8% respectively of Chile's total copper concentrate exports.

In addition to commercial strategic considerations, concerns also relate to the overall mining industry's carbon footprint (since the export of concentrates is approximately 45% more carbon-intensive than the shipping of anodes/cathodes) and to the limitations of developing a more circular economy mining sector when a key downstream component would be increasingly based overseas (Lagos et al., 2021[19]).

National mining policy has set out the goal of ensuring Chile retains its current smelting capacity by 2050, although it does not spell out how it will tackle the thorny issues explained above (Ministerio de Minería, 2020). Studies have shown that a new smelter in Chile, compliant with current environmental regulations, would be economically feasible (Lagos et al., 2020[20]; 2021[19])

Source: CNEP (2017[21]), *Productividad en la Gran Minería del Cobre [Productivity of Large-scale Copper Mining]*, https://cnep.cl/wp-content/uploads/2017/09/Productividad-_cobre_14_09_2017.pdf; Acosta Barriga, F. (2017[22]), *Chile: La Minería en el Siglo XXI [Chile: Mining in the 21st Century]*, Ocho Libros Editores, Santiago de Chile; Pérez, K. et al. (2021[18]), "Environmental, economic and technological factors affecting Chilean copper smelters: A critical review", https://doi.org/10.1016/j.jmrt.2021.08.007; Lagos, G. et al. (2020[20]), "Cobre refinado: Un buen negocio para Chile [Refined copper: A good deal for Chile]", http://www.cesco.cl/analisis-y-estudios/; Lagos, G. et al. (2021[19]), "Análisis económico de las cadenas globales de valor y suministro del cobre refinado en países de América Latina [Economic analysis of refined copper global supply and value chains in Latin America]", https://www.cepal.org/es/publicaciones/47451-analisis-economico-cadenas-globales-valor-suministro-cobre-refinado-paises; OECD (2013[16]), *OECD Territorial Reviews: Antofagasta, Chile 2013*, https://doi.org/10.1787/9789264203914-en; COCHILCO (2022[17]), *Informe Mercado de Fundiciones 2022 [Smelter Market Report 2022]*, http://www.cochilco.cl/Mercado%20de%20Metales/Informe%20Fundiciones%202022%20Versión%20Final%20RPI.pdf; COLCHICO (COCHILCO, 2022[15]), "Medición de encadenamientos productivos de la industria minera en Chile [Measurement of value chain linkages of the mining industry in Chile]", https://www.cochilco.cl/Listado%20Temtico/Encadenamientos%20en%20la%20miner%c3%ada.pdf; COLCHICO (2022[8]), "Proyección de la producción de cobre 2022-2033 [Forecast of copper production: 2022-2033]", http://www.cochilco.cl/Mercado%20de%20Metales/Proyección%20de%20la%20producción%20esperada%20de%20cobre%202022-2033.pdf.

In addition to large-scale mining operations (which are variously defined as those above a certain threshold of copper production – generally over 50 000 tonnes per year – or those employing more than 400 workers), Chile has several medium-sized, small and artisanal mining operations.[3]

In the national context, small- and medium-sized companies are marginal producers of copper, being responsible for 1% and 3% of all copper production in 2021 respectively. These figures are even smaller in Antofagasta, with small and medium-sized companies accounting for 0.4% and 0.94% of regional copper production respectively (SERNAGEOMIN, 2022[3]).

In sum, Antofagasta's copper industry is world-class in terms of assets and production and is largely composed of large-scale, mostly open-pit mines owned and operated by some of the world's leading mining companies.

Current operations, future projects and estimated global demand for copper are expected to keep Antofagasta at the forefront of world copper production for several decades, making this industry the largest single economic sector in the region for years to come.

Lithium: Global leader in reserves

Aside from copper, lithium is the largest mining value chain in Antofagasta. With approximately 123 000 tonnes per annum of LCE, Antofagasta's production makes Chile the second producer of lithium in the world after Australia (COCHILCO, 2021[9]; Ministerio de Minería, 2020[5]).

At 9.2 Mt, Chile is also the world leader in lithium reserves and, with 9.8 Mt, the world's third largest jurisdiction in terms of lithium resources (USGS, 2022[23]). Together with Argentina and Bolivia, Chile is part of the so-called Lithium Triangle, home to 52 Mt of lithium resources, equivalent to approximately 60% of known global lithium resources (USGS, 2022[23]).

Geologically abundant and present in many forms, lithium is, however, commercially produced from two sources: hard rock (mainly spodumene) and brine from salt flats or *salares*. A *salar* is a high-altitude, endorreic (drainage) basin that, over time, concentrates the soluble elements found in its catchment area through evaporation.

Salt flats hold lithium in their brine, which also contain other elements – in different proportions depending on the *salar's* chemical makeup – such as potash, boron, magnesium, sodium and sulphur. Some of these elements (chiefly potash and boron) are commercially important and sometimes produced in parallel to lithium, while others (especially magnesium and sulphur) are considered impurities and may present challenges to the production of high-grade lithium.

Lithium is a key component in lithium-ion batteries and has seen its global demand grow significantly in the past years, pushed by the energy transition, the increased adoption of electric vehicles (EVs) and the deployment of lithium-ion batteries in non-transportation energy storage (i.e. decentralised and grid-scale energy storage).

Under current technologies, future demand is expected to continue to increase in lockstep with the decarbonisation of the economy and the exponential growth in energy storage requirements. Under a 2 degrees Celsius (ºC) scenario,[4] utility-scale battery storage is expected to increase 25-fold between 2020 and 2040 (IEA, 2022[24]).

Lithium produced in Chilean *salars* is potentially the lowest cost lithium (especially if coupled with solar evaporation ponds) but gives manufacturers lower flexibility than in other jurisdictions in terms of the type of lithium compound produced (Box 3.3).

Chile has roughly 60 salt flats, all located in its 4 northernmost regions. Most notable for their lithium production potential are the La Isla, Maricunga and Pedernales *salars* in the Atacama region (all of which host projects in different stages of development) and – especially – the Salar de Atacama in Antofagasta, the only one currently in production.

Lithium production is expected to increase in the future both at the national and regional levels. Plans to develop other *salars* in neighbouring regions and expand current production from Antofagasta's Salar de Atacama are in place.

Box 3.3. Lithium production from brine – At the crossroads of the mining and chemical industries

The production of lithium from brine is a complex and sophisticated process that encompasses both mining and chemical knowledge and techniques.

Typical steps include the following:

- A wellfield is drilled in the salt flat and brine is pumped to solar evaporation ponds. The lithium content of untreated brine depends on the *salar* but at this stage is approximately 100-1 600 parts per million (PPM).
- Brine is then stored in a chain of ponds that, through successive stages of solar evaporation (and in some cases, the addition of chemicals), allow different elements to precipitate, concentrating the lithium for further processing.
- As a result of this, the brine's lithium content is gradually increased and impurities or subproducts separated. At the end of the solar concentration phase, the brine has a lithium concentration of 10 000-60 000 PPM.
- Once concentrated, the brine is sent to the chemical plant, where it is pumped to vats for a solvent extraction phase. This stage usually involves the addition of chemical reagents (e.g. hydrochloric acid, sulphuric acid, soda ash, etc.) to eliminate most of the boron and magnesium still present.
- Finally, the lithium-rich solution is treated with sodium carbonate to produce the lithium carbonate (LC), which, after filtering, drying and packing, is then shipped for export.
- It is possible to produce lithium hydroxide (LH) from LC, but this involves several processing stages at the chemical plants, involving additional time, energy and the use of chemical reagents (especially lime).

In recent times, in addition to the conventional solar concentration process, new lithium processing technologies have appeared, most notably "direct lithium extraction", or DLE, which seeks to bypass the solar concentration phase by heating the brine and enhancing the chemical aspects of the process.

Solar concentration and DLE are complex processes but, in general terms, it can be said that solar concentration uses less energy and freshwater than DLE, though requires larger volumes of brine and longer processing times than DLE. Both processes require large volumes of reagents, which are easily 2:1 ratio to the lithium produced.

Production processes are tailor-made to the specific chemical composition of the brine and usually require a significant period of adjustment to the *salar*'s hydrogeological and geographical conditions (including the basin's water replenishment rates and permeability, solar irradiation rates, etc.)

A word on "battery-grade" lithium

Batteries utilise lithium in one of two forms: lithium carbonate (LC) and lithium hydroxide (LH). Other compounds (such as lithium chloride, lithium sulphide, etc.) make up at present less than 5% of world demand (Jiménez and Sáez, 2022[25]).

For processing reasons, lithium extracted from brine is first produced as LC, whereas that coming from hard rock is produced as LH or LC. This means that Australia and other hard rock producers have greater flexibility in production over brine-based producers such as Antofagasta, which can have an impact depending on where the market moves in terms of LC or LH demand. In this sense, LH is forecast to grow in demand and potentially overtake LC in the next few years.

Currently, so-called "battery-grade" lithium is of a purity of 99.5% and higher, although the remaining 0.5% is oftentimes crucial in terms of its chemical composition and make.

Indeed, cathode manufacturers employ different technologies and formulae that require both: i) consistency in the chemical composition and purity of the lithium used; and ii) penalise the existence of certain elements in the non-lithium portion of the compound. This explains why LC and LH are not

considered commodities (in the sense that a standard product can be easily substituted) but rather specialised chemicals.

It is also the reason why many downstream users of LC or LH seek to establish and maintain long-term relationships and contracts with lithium producers that guarantee that the product will comply with their specific processing requirements (Obaya and Céspedes, 2021[26]).

In sum, the production of lithium from *salares* involves the complex processing of brine and the production of highly specific chemical compounds of a given and consistent quality. This implies sophisticated methods involving numerous steps and – in most cases – precise knowledge of the *salar* and its chemical fingerprint.

Source: Jiménez, D. and M. Sáez (2022[25]), "Agregación de valor en la producción de compuestos de litio en la región del triángulo del litio [Value-adding in the production of lithium compounds in the lithium triangle region]", www.cepal.org/es/publicaciones/48055-agregacion-valor-la-produccion-compuestos-litio-la-region-triangulo-litio; Obaya, M. and M. Céspedes (2021[26]), "Análisis de las redes globales de producción de baterías de ion de litio: implicaciones para los países del triángulo del litio [Analysis of global production networks of lithium-ion batteries: Implications for the countries of the lithium triangle]"

Having started production almost four decades ago, Antofagasta's two operations (Table 3.2) have placed the region as a world player in the production of lithium products, especially LC.

Table 3.2. Lithium operations and projects in the region of Antofagasta

Company	Operations		Production capacity	Number of workers (including non-lithium operations)	Projects
	Mine	Plant			
Albemarle	Salar de Atacama (Municipality of S.P. de Atacama)	La Negra (Municipality of Antofagasta)	• 85 000 tpa of LC • N/A tpa of lithium chloride	1 100	• Expansion of La Negra plant, with the construction of plant IV (in commission)
SQM	San Pedro de Atacama (Municipality of S.P. de Atacama)	Salar del Carmen (Municipality of Antofagasta)	• 150 000 tonnes per annum (tpa) of LC • 60 000 tpa of LH • 980 000 tpa of potassium chloride	3 900	• Expansion and optimisation of Salar del Carmen plant to 180 000 tpa of LC and 30 000 tpa of LH (in construction) • Further expansion of Salar del Carmen plant to 210 000 tpa of LC (permit pending) • New dual plant with a capacity of 60 000 tpa of LC or LH (permit pending)

Source: OECD elaboration, based on data from Albemarle, COCHILCO and SQM.

Both companies are among the world's top lithium producers (including production from their non-Chilean assets) (COCHILCO, 2021[9]); they have a long history in the region (Albemarle's – then Foote Mineral Company – first production started in 1984 and SQM's in 1994) and, in addition to LC, LH and related products, produce other industrial minerals from their Antofagasta assets (see next section).

Following expected market growth dynamics and specific contractual terms agreed in 2016 (Albemarle) and 2018 (SQM) in renegotiations with the Chilean public Production Promotional Corporation (CORFO) (see Box 3.4), both companies seek to increase production.

Of special note in this regard is the recent announcement of the National Lithium Strategy which, among its goals: i) seeks to provide the Chilean government with a majority participation in the ownership of lithium companies (to this end, CODELCO is to enter into negotiations with Albemarle and SQM for the transfer of a controlling stake in both Salar de Atacama operations); ii) proposes the creation of a national lithium company to participate in downstream transformation of lithium into lithium-ion cells and batteries; iii) looks to accelerate projects in some of Chile's numerous and as of yet non-productive *salars*; and iv) promotes research and development (R&D) activities through the establishment of a public technological institute for the research of lithium and *salars*, to be based in the region of Antofagasta (Gobierno de Chile, 2023[27]).

Box 3.4. Legal framework of lithium production in Chile

In Chile, lithium is not subject to the general mining regulations, being instead governed by its own specific framework dating back to the 1970s.

In 1979, potential military uses of lithium moved Chile to declare it of national importance, reserve it in property for the state and proclaim it not subject to concession to private persons. The Chilean Nuclear Energy Commission was entrusted with the administration of all lithium-related contracts and assets, with the sole exception of those pertaining to mining properties requested or granted before the above declaration of public interest.

Such exempted properties were held by: i) CORFO, with rights to 55% of the Salar de Atacama; ii) CODELCO (100% of the Pedernales and 18% of the Maricunga *salars*); iii) Chile's National Mining Company (ENAMI) that owns 4% of Salar de Aguilar; and iv) 3 private companies owning 25% of the Maricunga *salar*.

All other lithium-bearing *salars* and deposits are to remain state property and can only be put into production: i) directly by the state or through CODELCO and ENAMI, its state-owned companies; ii) through an administrative concession, not governed by the Mining Code; or iii) by a special operation agreement (CEOL), granted by the Ministry of Mines.

In 1980, CORFO and Albemarle's predecessor Foote Mineral entered into an agreement to jointly produce lithium from the Salar de Atacama. This agreement was followed in 1986 by another between CORFO and SQM's predecessor Minsal Minera. These contracts included clauses which, in modified form, remain applicable to this day (e.g. maximum extraction quotas, special royalties payable to CORFO, fixed term, etc.).

Following the radical increase of lithium demand and prices sparked in 2010-15 by the battery and energy storage exponential growth (driven in turn by the global move for a decarbonised economy) and a 2012 failed attempt to incorporate new lithium producers through a somewhat scandalous CEOL process, the more accessible avenue to expand production was the renegotiation of existing agreements with Albemarle and SQM.

This process resulted in amended versions of Albemarle's (in 2016) and SQM's (in 2018) agreements. The renewed agreements include, among other things:

- Larger extraction quotas, subject to the commissioning by each company of new plants or facilities by a certain date for specific additional production volumes (e.g. 24 000 tpa of LC for Albemarle and 50 000 tpa of LC for SQM).

- Up to 25% of production being sold at preferential prices to Chilean companies engaged in downstream value-adding activities.
- Monetary contributions to local communities and to R&D institutions engaged in certain types of research (e.g. solar energy, lithium products, etc.).
- A ban on the sale of brine and lithium concentrates.
- Greater access to information and oversight of operations and processes by government authorities and local communities.

The agreements are operational and have spurred the intended expansion of lithium production. Questions remain, however, as to whether Chile will be able to generate the conditions to attract new producers and projects to its lithium assets, key to achieving the national mining policy goal of producing 380 000 tpa of LC equivalent by 2030 (Ministerio de Minería, 2020[5]).

Source: Poveda Bonilla (2020[28]), "Estudio de caso sobre la gobernanza del litio en Chile [Case study on the governance of lithium in Chile]"; Cademartori Dujisin, J. et al. (2018[29]), "La economía política de la explotación de litio en Chile : 1980-2018", *Revista de ciencias sociales*, Vol. 10/34, pp. 83-100; Ministerio de Minería (2020[5]), *Política Nacional Minera 2050 [National Mining Policy 2050]*, www.doe.cl/alerta/28012023/2262175.

Another challenge for the continuing viability of lithium extraction from *salars* (potentially intensified by the planned expansion of production) is the social pressure regarding the long-term environmental impact of water use in a dry environment.

Companies are already taking steps in this direction, including modifying processes to be less water-intensive and rethinking their product mix (i.e. prioritising lithium over water-demanding potash) but further efforts and investments in technology will likely be required (see Table 3.3).

Finally, potentially disruptive technologies and developments should also be considered in the mid- and long-term scenarios. Indeed, sodium-ion batteries, hydrogen cells and similar breakthroughs could adversely impact the demand for lithium (World Bank, 2020[30]) and will require foresight and advance planning to ensure such disruptions, if they are to occur, are adequately managed.

Other mineral products

As indicated above, Antofagasta's mineral endowment is not limited to copper and lithium.

The region has also been singled out as having potential for the development of metallic and non-metallic minerals such as gold, silver, lead, zinc, molybdenum, iodine, natural nitrates, boron and rare earth elements.

Of the above-mentioned minerals, Antofagasta currently produces: i) gold from Yamana's El Peñon and Austral Gold's Guanaco mines; ii) iodine and natural nitrates from SQM's Coya Sur, María Elena and Pedro de Valdivia operations; iii) potash from Albemarle's and SQM's Salar de Atacama operations; and iv) boron, from Quiborax's Ascotan mine.

In addition to those stand-alone operations, the region obtains gold, silver and molybdenum as sub-products of their copper mining (in Antofagasta Minerals' Centinela and KGHM's Sierra Gorda mines).

Finally, since 2011, CODELCO has operated Molyb, a molybdenum concentrate plant in the municipality of Mejillones with an annual production capacity of 17 000 tonnes of molybdenum trioxide.

In terms of future developments, Antofagasta is the third most prospective region within Chile for the development of non-copper-related projects, with a total of 48 potential targets for silver (26 projects), molybdenum (8), zinc (6), iron ore (5) and lead (3). Of these, three projects in different stages of

development (Cachinal, El Inca and Nuevo Juncal) appear to be especially promising (Muñoz López, Escobar and Quintanilla, 2021[31]).

Innovative approaches to obtaining valuable minerals from less-traditional sources, including tailings, smelter waste and even the seafloor is under study, with CODELCO taking the lead in initiatives to reprocess copper anode mud at its Planta Recuperadora de Metales SpA (a joint venture with Korean LS-Nikko) in operation in Mejillones, Antofagasta, since 2016.

Seabed mining, in turn, is being explored, with the Mejillones peninsula having been identified as one of the prospective areas for nodules containing rare earth elements (Muñoz López, Escobar and Quintanilla, 2021[31]).

In future, as more former mining and smelter waste streams are re-treated and other sources of valuable minerals are tapped, production of non-copper and lithium products is likely to increase.

This would be in line with the goals stated in the national mining policy (Ministerio de Minería, 2020[5]), which seeks to diversify the Chilean mineral portfolio through the production of products other than copper and lithium.[5]

Antofagasta's METS sector

A key component of any mining business ecosystem is that of the industry's supply base, comprised of those companies providing "specialised products and solutions for mineral exploration, extraction and mining supply chains" (METS Ignited, 2016[32]).

From explosives, chemical reagents, mill balls, fuel and off-road tires to construction, financial, commercial and legal services, mining functions everywhere as a catalyst of economic activity and development (COCHILCO, 2022[15]; Corporación Alta Ley, 2019[33]).

At the national level, Chile has long identified mining suppliers as a relevant sector for development and, starting in the 1990s, has put in place successive public policies to this effect, setting ambitious goals in terms of number of companies and export values (Ministerio de Minería, 2020[5])((CNEP, 2017[21])).

In Antofagasta, this impulse was mirrored by the creation of the *Cluster Minero de la Región de Antofagasta* (CMRA), an initiative adopted in 2019 by CORFO, the regional government, the Antofagasta Association Industrial Association, the Chilean Chamber of Construction, the Association of Antofagasta Municipalities and the University of Antofagasta and the Catholic University of the North.

This agglomeration of relevant industry players is showcased every two years in Exponor, one of South America's largest trade fairs (Box 3.5).

Box 3.5. Exponor – A leading industry event

Exponor is a mining trade fair organised by the Antofagasta Industrial Association (AIA) and, together with Expomin (also in Chile) and Perumin in Peru, is considered one of the most important trade shows in the mining industry in Latin America.

The event brings together key players in the industry, including mining companies, suppliers, government representatives and industry experts. The fair provides a platform for participants to present their latest products, services and technology while also facilitating networking opportunities and promoting business relationships.

With a focus on sustainability and innovation, Exponor has become an important forum for discussing and sharing ideas about the future of the mining industry, as well as discussing best practices, sharing knowledge and identifying opportunities for collaboration.

The latest edition of Exponor was held from 13 to 16 June 2022 and featured over 730 exhibitors showcasing their products and services across a variety of categories, including mining equipment, technology and services. More than 40 500 visitors from around the world attended the fair to learn about the latest trends and innovations in the mining industry.

Source: Exponor (n.d.[34]), *Homepage*, https://exponor.cl.

Together with other public-private collaborations – such as the World Class Suppliers Program, co-financed in 2009 by BHP Billiton and Fundación Chile, and since joined by CODELCO – the CMRA has sought to capitalise on regional mining activity to develop a strong set of local suppliers capable of devising solutions to the industry's challenges and, eventually, able to export know-how and products.

Antofagasta boasts the largest concentration of mining supply companies of all of the Chilean regions (with the exception of the Metropolitan region),[6] accounting for 6% of large, 10% of medium-sized and 18% of small supply companies (Expande, 2019[35]). It has managed to attract multinational companies (including Cummins, Caterpillar, Komatsu and 3M, among others) and develop its own number of local suppliers (such as Complejo Metalúrgico Altonorte, Inacal, Mabortex and Sales de Magnesio, all companies with annual sales between USD 50-100 million).

However, the fact remains that the METS sector in Antofagasta still shows a lot of room for improvement if it is to attain the same relative importance of mining compared to national totals. Indeed, Antofagasta accounts for 50% of total copper production and 100% of total lithium production but only for 26-12% of total mining industry suppliers (Atienza, M. et al., 2015[36])

Challenges and strengths of Antofagasta's mining industry in fostering sustainable regional development

Antofagasta is in many ways uniquely positioned to become one of the world's leading producers of responsibly sourced minerals, key for a low-carbon future.

The transition towards clean energy will be more resource-intensive than energy generation from fossil fuels, and both copper and lithium are minerals whose demand will significantly increase in this context (World Bank, 2020[30]). This additional mineral production – although a fraction of fossil fuels' carbon intensity – will also have to be mined in climate-responsible ways.

Antofagasta's large endowment of energy transition minerals and the low-carbon footprint with which these minerals can be mined (given the region's superb renewable energy potential) provide Antofagasta with the opportunity to play a key role in the global push towards a decarbonised future. A future that, in turn, will further boost Antofagasta's development by providing long-term demand for its METS.

World-class geological resources, a long-established mining presence and a strong mining value chain provide the region with a great head start. There remain, however, important challenges to address, including progressively diminishing mineral grades, productivity gaps and human skills (Table 3.3).

Table 3.3. Main strengths and challenges of Antofagasta's mining industry

Strengths
Long history, established players, societal support
• A mining jurisdiction for more than a century, with uninterrupted relevance as a key global player (especially in copper and lithium) since the 1990s. • Strong business environment with some of the world's leading companies (both producers and suppliers, see section above) and established industry-wide bodies for many decades. Home to Exponor, one of the two main industry trade fairs in Chile and among the largest in Latin America (Box 3.5). • Cultural identification and familiarity with the industry enhance the sector's overall acceptability (Moffat et al., 2014[37])
Institutional and academic support
• Consistent and long-term focus by the regional government on leveraging mining as a catalyst for regional sustainable development (examples include the Regional Development Strategy (RDS) 2001-2006, the RDS 2009-2020 and, more recently, the Regional Innovation Strategy 2022-2028). This is likely to be enhanced in response to the "devolution" of competencies to the regional government as a result of the significantly enhanced decentralisation of the public sector (see Chapter 4). • Strong presence and support of universities and research institutions, which provide traditional education (e.g. engineering, metallurgy and geology) and specific and innovative programmes, including the Catholic University of the North *Instituto de Políticas Públicas* (Public Policies Institute) and *Escuela de Negocios Mineros* (School of Mining Business), the University of Antofagasta's *Economía Minera* (Mining Economy) group and congress, and the Hackamine challenges sponsored by BHP, Consorcio Heuma and Fundación Chile (joint endeavour between the engineering schools of the Catholic University of the North and the University of Antofagasta).
Geographical location and infrastructure
• Unique geographic location, between the Pacific Ocean and the Andes Mountains, at the crossroads of significant existing and potential mining projects and regions, including in Argentina, Bolivia and Peru, as well as those occurring in the central regions of Chile (where future copper production is expected to grow (CNEP, 2017[21]). Opportunity to become a regional hub for development, innovation and value-added services. • Deep water and reliable ports (OECD, 2013[16]), road and railroad networks and Cerro Moro international airport offer easy access to markets, as well as a gateway to the Pacific Rim, one of the largest and fastest-growing markets for minerals and metals in the world. The regional government has long identified this geographical advantage as an opportunity for development, diversification and growth (GORE, 2009[38]).
Innovative approach to mining sustainability
• The region has led the push towards innovation of the mining sector, including through initiatives such as: i) seawater utilisation and desalination (COCHILCO, 2021[9]; Corporación Alta Ley, 2021[39]); ii) decarbonisation of operations through renewable energy (COCHILCO, 2022[40]) and the electrification of mining trucks and equipment (Ministerio de Energía, 2021[41]); iii) green hydrogen adoption (Corporación Alta Ley/SAMMI Cluster Minero Andino, 2023[42]); and iv) automation, digitalisation and 5th generation cellular network technology (5G) deployment. • Mining operations in the region are also part of a national network of test bench sites, while the METS sector is an active player in piloting innovative technologies (Centro Nacional de Pilotaje, 2021[43]).
Challenges
Productivity and diminishing ore grades
• Productivity of mining in Chile and Antofagasta has been in decline, with mining becoming a drag on productivity at the national level for the past 20 years ((De La Huerta, C. y J. Luttini, 2018[44]) (OECD, 2022[2]). The following factors mainly explain this fall in productivity: o Between 2000 and 2014, overall copper production increased in Chile by 19%, energy requirements grew by 79%, labour by 157% and capital investment by 178% (CNEP, 2017[21])This sharp decoupling of production and inputs (with the latter far outpacing the former) resulted in a significant deterioration of total factor productivity (OECD/UN, 2018[45]). o The deterioration of ore grade, from an average copper content of 1.4% in 1991 to 0.65% in recent years (CNEP, 2017[21])Extraction shifts to greater depths, resulting in longer processing and internal transportation times and higher energy and water consumption (OECD/UN, 2018[45]). o Overall regional water scarcity means the sector needs to procure its water in ways that affect overall productivity (OECD/UN, 2018[45]).
Skills
• Although Chile ranks high as compared to its regional peers in terms of educational achievement, it still has a long way to go when matched to OECD members. • In mining-specific skills, there is a significant deficit both in terms of employees and competencies needed. For the period 2021-30, a 25 000-employee gap is foreseen due to the compound effects of the retirement of current workers and the expected creation of new jobs resulting from the increased sophistication of mining operations and processes (CCM/Programa Eleva, 2020[46]; CCM, 2018[47]).
Land availability
• Two issues adversely impact Antofagasta's development: i) an excessively centralised public land administration and management system which, under Chilean law, makes cession of public lands expensive, burdensome and bureaucratic; and ii) widespread mining property speculation (Martorell Awad, 2020[48]; Palma-Behnke et al., 2021[49]). • The high proportion of public lands in Antofagasta and the large number of mining properties owned in the region combine to make land scarce and difficult to obtain to put to useful purposes.

Environmental and social matters
• Environmental challenges include: i) dispelling doubts about the long-term effects of marine water capture and desalinisation; ii) the region's significant carbon footprint (derived from a combination of intensive use of energy and reliance on fossil fuels (especially coal) for energy generation); and iii) geological and environmental constraints regarding production, both in terms of diminishing copper-to-sterile ratios, as well as issues regarding lithium extraction in the region's high-altitude salt flats. • The equitable allocation of benefits from the industry (both regionally and at the local community level) is also likely to prove challenging going forward, especially in the face of the mentioned changes that digitalisation is already causing in mining's traditional shared-value proposition. • A factor to be considered includes a heightened perception and demand for ESG-compliant and sustainably mined minerals by consumers and public authorities around the world. Companies operating in the region will have to ensure their operations and practices adhere to international ESG standards.

The adequate balancing of these – and other – factors place Antofagasta in a prime position to benefit from current global trends, which include a focus on energy transition requirements, a changing global value chain and supply context, heightened international competition for natural resources, a renewed interest in the region's mineral portfolio and an expectation of sustainably mined minerals (Box 3.6).

Sustainability requires the region to mobilise its mining assets and effectively manage its challenges to achieve the environmentally adequate use of its geological endowment while ensuring the mining industry's impacts and benefits are equitably spread among all relevant stakeholders, including the region's future generations.

In terms of regional development, long-term sustainability will depend on Antofagasta's mining sector being harnessed to achieve three simultaneous goals:

1. Maximise the opportunities presented by the energy transition to enhance the industry's positive impact on the region's economic and social fabrics while minimising potential adverse effects on the environment.
2. Develop a strong, innovative and inclusive value chain capable of providing equipment, technology and services to Antofagasta, as well as other South American and global mining regions.
3. Progressively decouple Antofagasta's regional growth from the production of minerals by fostering alternative uses of the region's natural capital and the development of non-mining-related economic sectors.

Box 3.6. Green mining: A key concept in the Chilean context

The concept of "green mining" was originally developed in Finland and revolves around five pillars:

1. Promoting materials and energy efficiency by reducing the environmental footprint of mineral-based product life cycles.
2. Ensuring the availability of mineral resources for the future (e.g. addressing the intergenerational "mineral debt") through geoscientific mapping and research, and mineral exploration.
3. Minimising adverse environmental and social impacts in all stages of mining operations while maximising social and local benefits
4. Improving work and organisational practices, with a view of ensuring mining is safe and meaningful for its employees, for local residents and for the environment.
5. Ensuring sustainable land use following mine closure by conceiving mining as a transitional use of the land.

A recent book published by the Future Challenges, Science, Technology and Innovation Committee of the Senate of Chile (2022[50]) further defined the green mining concept, as applicable to Chile, as mining that is:

- Low in local and global emissions and adaptable to climate change.
- Low in waste, minimising its generation and integrating into circular production systems.
- Caring for biodiversity in the ecosystems where it operates.
- Efficient in the use of water.
- Efficient in the use of energy and intensive use of low-emission renewable energy.
- Promoting the development of productive chains or clusters.
- Integrated into territories, opening spaces for the participation of local capabilities in the processes of creating value for sustainable mining.

These features will have to be adequately addressed by Antofagasta to develop a mining strategy that is well-suited to the long-term development of the region. In this regard, both lithium-producing companies in the region have initiated certification steps towards the Initiative for Responsible Mining Assurance, a step that will likely have to be followed by copper miners in the short term.

Source: Nurmi, P. (2017[51]), *Green Mining – A Holistic Concept for Sustainable and Acceptable Mineral Production*; Comisión Desafíos del Futuro, Ciencia, Tecnología e Innovación (2022[50]), *Chile tiene futuro desde sus territorios*. Comisión Desafíos del Futuro, Ciencia, Tecnología e Innovación 2018-2022 del Senado de la República de Chile (2022), "Chile Tiene Futuro Desde Sus Territorios" [Chile has a Future From Its Territories], Ediciones Biblioteca del Congreso Nacional de Chile, Santiago de Chile, http://repositoriobibliotecas.uv.cl/bitstream/handle/uvscl/3817/CHILE%20TIENE%20FUTURO%20-.pdf?sequence=1&isAllowed=y (accessed on 12 April 2023).

Accelerating the transition towards more environmentally sustainable mining

Environmentally, the region must make the most of its advantages to enhance sustainability in extracting and processing its mineral products. This includes implementing circular practices in the use of key industry inputs (especially energy and water), minimising the use of those resources and the generation of waste streams (Krausmann et al., 2018[52]).

Success in this area would ensure the mining industry remains an essential player in the sustainable development of the region while also providing an instant advantage to Antofagasta by allowing it to comply with the progressively more demanding requirements of natural resource-based development. These include both consumer preferences for traceable, "green" minerals and products (van den Brink et al., 2019[53]) and a gradually more exacting regulatory landscape, such as the one embodied in European Union Regulation 2017/821 (Conflict minerals) or in the *OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas* (OECD, 2016[54]).

Antofagasta's already significant head start towards less water- and carbon-intense mining also creates opportunities down the line for the region to contribute – by exporting its technology and know-how to other mining regions in the world – to the sustainable future of mining and to the region's economic diversification development. To do so, several challenges remain. Among these, the following three stand out.

Energy

Nationally, the mining industry is responsible for 15.3% of Chile's overall energy consumption, which translates into 34.1% of total electricity and 21.1% of total diesel consumption (COCHILCO, 2022[40]; 2022[55]; 2022[56]).

Some of the mining industry's processes carried out in Antofagasta (including comminution, concentration and cathode production for copper and brine processing for lithium) are energy intensive. In copper mines, especially, energy is also required to power the machinery and heavy trucks essential for the extraction and in-site transport of the ore.

Throughout the north of the country, but especially in the case of Antofagasta, energy consumption is also high in relation to the provision of sea and/or de-salinised water, which must be extracted, processed and transported from the coast to altitudes of up to 3 000 metres above sea level and higher.

Energy generation and transportation provide an obvious avenue for enhancing the mining industry's environmental profile while, at the same time, fostering the diversification of the local economy and creating innovation and learning opportunities.

Fortunately, the region enjoys one of the world's highest potentials for renewable energy generation (Ministerio de Energía/GIZ, 2014[57]; Ministerio de Energía, 2021[41]), with the Atacama Desert scoring the highest solar incidence in the world at 3 500 kilowatt hour per square metre (kWh/m^2) direct normal irradiance and UV-B radiation 65% above the European average (OECD/UN, 2018[45]).

In recent years, there has been a progressive increase in the use of renewable energy in the Chilean mining sector. This has been done by integrating these energies into mining operations in one of three different ways: i) direct use of renewable energy in some process; ii) through power purchase agreements (PPAs) in which the mining company participates in the investment of the renewable energy project; and iii) through PPAs in which the mining company, as a customer, requests its generator to supply renewable energy[7] (COCHILCO, 2022[56]). In Antofagasta, all large-scale copper operations, both lithium producers and even some industrial mineral producers, have either PPAs or self-built renewable energy projects (COCHILCO, 2022[58]).

This trend has been especially strong in Antofagasta, with as many as 13 renewable energy projects in place as of 2022 (COCHILCO, 2022[56]) and more to come (Vyhmeister et al., 2017[59]). Antofagasta is also home to some of the country's leading scientific research initiatives in the development of solar generation technology, with the Atamostec Solar Energy Research Center (SERC) project – a network of researchers and institutions focusing on solar energy – as a prime example (OECD/UN, 2018[45]).

Finally, Chile's National Green Hydrogen Strategy (Ministerio de Energía, 2020[60]) is also being reflected in Antofagasta, both with several projects vying to produce green hydrogen in the region and through the piloting of green hydrogen as a fuel for mining projects and operations, especially as a replacement of diesel for heavy trucks (COCHILCO, 2022[56]). Challenges remain, however, as the technology – although promising – is still in the early stages of adoption (COCHILCO, 2022[58]).

Water

The mining industry is already an important user of water in the country, accountable for a total of 17.6 cubic metres per second (m^3/s) for copper mining, of which two-thirds (11.8 m^3/s) are "continental" waters (including surface and underground water sources). The remaining 5.7 m^3/s are seawater[8] (COCHILCO, 2022[61]).

Nationally, water intensity is expected to grow over time in response to several factors, including: i) an increase in total copper production; ii) diminishing copper contents (which require the processing of larger quantities of material); and iii) a shift towards the more abundant copper sulphurs – whose flotation process requires more water per unit of production – from the rarer and progressively depleting copper oxides (COCHILCO, 2021[62]).

In response to the above factors, copper mining water use is forecast to achieve by 2032 a total of 20.9 m^3/s, of which 68% (14.2 m^3/s) will be seawater and 32% (6.7 m^3/s) will be continental water, reversing the current proportion (COCHILCO, 2021[62]).

The advent of green hydrogen projects would also likely add to water demand since, under current technology, 9 litres of water are required for every kilogram of hydrogen produced (Beswick, Oliveira and Yan, 2021[63]), although an integrated approach between green hydrogen production and water policies may result in a net-positive effect (see next section).

This increase in water demand will take place against a backdrop of climate change that is expected to diminish rainfall in Antofagasta – already one of the world's driest regions – by as much as 60% before the turn of the century (COCHILCO, 2021[62]).

Regionally, water presents a significant challenge given; i) the dryness of Antofagasta (together with the rest of the Chilean northern regions subject to "very high" risk of hydric stress (Ministerio de Minería, 2020[5]); ii) the volumes of water used by mining operations in the region (53% of national mining water use, dwarfing the second-highest region, O'Higgins, at 13%); and iii) the importance of mining relative to other regional water uses, which stands at 57% of regional water use (again, the highest of all Chilean regions (COCHILCO, 2022[61]). Contrary to every other Chilean region, mining, and not agriculture, is the main consumer of water in Antofagasta, although the Agricultural sector still accounts for 15% of total water use (Aitken et al., 2016[64]). Starting in the last decade, the mining industry began using desalinised seawater, which is obtained and processed at sea level and pumped for its use at the mines. Currently, 9 large and mid-sized operations use seawater in Antofagasta (out of a national total of 14 seawater capture plants in operation) and this number is expected to grow over time (Corporación Alta Ley, 2021[65]). In fact, Antofagasta is expected to be the region with the highest proportion of seawater utilisation, with as much as 63% of national seawater used by the region. Conversely, continental water use will diminish by as much as 74% in Antofagasta, freeing these resources for other uses (COCHILCO, 2021[62]).

Despite the significant progress reflected by these numbers, they would still fall short of the national mining policy target, which mandates a maximum of 10% of continental water use by 2030 and 5% by 2040 (Ministerio de Minería, 2020[5]). In addition to obtaining water from non-continental sources, the industry will have to improve its efficiency in the use of water, reducing consumption through recirculation, a circular economy approach and deploying novel technological processes in matters such as dust removal, tailings, etc. (Aitken et al., 2016[64]; Stella, Budinich and Botov, 2023[66]).

Waste streams

Nationally, the copper mining industry is responsible for 15.6% of total Scope 1 and 2 greenhouse gas (GHG) emissions,[9] with Antofagasta accounting for 58% of total copper-related Scope 1 and 2 GHG emissions in Chile (COCHILCO, 2022[56]).

National mining policy vows to attain carbon-neutrality for the whole of Chile's mining industry by 2040 (Ministerio de Minería, 2020[5]), in line with the Government's 2050 Net Zero goal, as stated in the June 2022 Climate Change Law. To achieve this, a combination of green hydrogen adoption and heavy truck fleet electrification is proposed, with initiatives already being put in place in several of Antofagasta's mining operations. This follows a broader trend where many of the major mining companies operating in the region (including the operators of Antofagasta's largest copper mines) have pledged to curtail emissions and are taking concrete steps in this direction.

The same goes with regard to particulate emission reduction programmes, which are being developed and implemented following the International Council on Mining and Metals *(ICMM)* Innovation for Cleaner, Safer Vehicles initiative.

Another significant waste stream of mining is that of sterile rock deposits and tailings (i.e. massive deposits of liquid slurry made of fine metal or mineral particles and water created when mined ore is crushed and finely ground as part of the extraction of metals and minerals).

Antofagasta has 51 tailing deposits, which amount to a surprisingly low percentage (6.9%) of Chile's totals (Ministerio de Minería, 2019[67]). These are, however, generally massive in nature, contain important volumes of water and require long-term geophysical and geochemical stability monitoring.

Several initiatives are being studied and put in place to enhance the circularity of massive sterile rock and tailing deposits, through the reprocessing of material to extract valuable elements, the extraction of water from tailings to be reused in mining processes and the development of new technologies and processes that are more efficient and environmentally sustainable (Ministerio de Minería, 2019[67]; Corporación Alta Ley, 2019[33]; 2021[65]).

As is the case with energy and water, innovative approaches and solutions developed in Antofagasta would not only further enhance the region's environmental profile but also constitute potential opportunities for economic diversification and development.

In sum, more sustainable mining as a regional opportunity

Accelerating the implementation of an environmentally sustainable mining process presents both challenges and significant opportunities. A strong ESG-driven mining sector and policy (ideally striving for a "first in class" position), would allow the region to maintain its global relevance in years to come, ensuring long-term global acceptability of – and consequent premium for – its mineral products.

Greater use of renewable energy, lower reliance on continental water and valorisation of mining waste streams all present ideal potential targets for prioritisation.

To do this, the regional government must foster a collaborative approach with the national government, industry players and academia, whose role would be of special importance given the innovative nature of most of the actions needed in this area.

Initiatives may include, among others:

- Publicly show the level of renewable energy sources used in each mine in the region.
- Incentivise the use of shared desalinisation facilities and more efficiency in water uses.
- Provide tax credit incentives to attract investments for reusing mining tailings.
- Ensure that the national government company CODELCO leads by example in the use of renewables and desalinated water.

Adoption and maintenance of ESG-compliant practices and credentials for the sector should thus be made a top regional priority. This includes promoting a common use of certificates that also include civil society validation, such as the Initiative for Responsible Mining Assurance – commonly referred to as IRMA – for which a number of mining companies in the region are already applying. The implementation of a robust circular economy approach would also work in the same direction. By ensuring that mining is conducted under the tenets of the circular economy, Antofagasta would capture the benefits of a more sustainable mining industry, which is also purposefully designed to prolong the viability of the sector over long periods of time.

By designing mining sites and operations with circularity in mind, the region could position itself to obtain significant benefits and savings in terms of life-of-mine extensions, smaller input volumes (especially in energy and water), minimised waste streams and more efficient and resilient equipment and processes.

As is the case with ESG standards, championing circularity would also generate know-how that could easily be exported to other mining regions and across productive sectors, thereby generating an independent side-industry and revenue stream which would exist beyond the mining industry itself. In this sense, the Regional Innovation Strategy 2022-2028 identifies the existence of a green, sustainable and technologically advanced mining industry as one of the pillars of future regional development (GORE, 2022[68]).

Leveraging Antofagasta's mining sector to promote regional economic diversification

Previous OECD reports have identified diversifying the national and regional economies as a fundamental challenge to lessen the dependence on natural resources (subject to cyclicality) and generate opportunities for sustaining continuous long-term growth (OECD, 2013[16]; 2018[1]; 2022[2]). Studies have also shown a strong correlation between economic diversification and sustained growth for low- and middle-income countries, with higher GDP per capita, lower volatility and job creation resulting from a more diverse economy (IMF, 2014[69]).

As mentioned in previous paragraphs, Antofagasta's mining industry presents a number of assets and challenges that, if properly addressed, will allow the region to develop a more diversified and resilient economic profile. This would have the benefit of further enhancing Antofagasta's mining industry's social acceptability, as well as providing long-term sustainability and prosperity, by generating development opportunities that are decoupled from the extraction of natural resources.

Three main avenues of regional economic diversification may stem from Antofagasta's vibrant mining industry:

1. Downstream diversification, by adding value to mining products.
2. Upstream diversification by developing the METS sector.
3. Diversification beyond the mining value chain by taking advantage of synergies with non-mining sectors.

Diversification throughout the mining value chain

Globally, mining is known to generate economic linkages throughout the value chain.

At the national level, the multiplier effect of the mining activity over other related value chain sectors has been estimated to be 1.96 in 2019 (growing from 1.4 in 2008), which is doubly significant since, in 2008, the mining share of total national GDP was 20%, while it only amounted to 16% in 2019 (COCHILCO, 2022[15]).

This trend has been shown to deepen, with the mining sector shifting from those considered "independent sectors" (i.e. not linked to other sectors) to that of "driving sectors". In other words, the mining industry has strengthened its multiplier effect, becoming a driving force of the economy from 2015 onwards (COCHILCO, 2022[15]).

Despite the challenges, there is significant potential for beneficial outcomes stemming from a thriving mining sector, especially in terms of local sourcing and value-added processing.

Although downstream diversification is more apparent, the greater benefits in terms of job creation, skill development and experiential learning are likely to be realised through local sourcing or upstream diversification. This is because many of the competencies required by enterprises that supply products and services to mining firms (such as equipment maintenance and repair, construction, specialised apparel, catering and so on) can be seamlessly transferred to other industries (McMahon and Moreira, 2014[70]).

Downstream transformation and value-adding

Downstream diversification opportunities arise from: i) the transformation of mineral products into intermediate goods; and ii) other forms of value-adding to those mineral products (such as, for example, the production of a purer form of lithium products).

In the Antofagasta region context, this would in essence involve the manufacture of products from, or the addition of value to, any of the region's main mineral products, namely copper concentrates or cathodes, and LC or LH.[10]

Downstream diversification from the transformation perspective requires a deep understanding of the respective value chains of copper and lithium in order to better identify the opportunities available to the region. The challenges regarding this type of diversification are, however, significant as, in many cases, the economic rationale for the efficient and competitive production of a given product is strikingly different from other products in prior stages of its value chain (IMF, 2014[69]). As will be explained below, a clear example of this dynamic can be seen in the case of lithium battery components and similar products.

In terms of copper, downstream transformative diversification would entail, in the first instance, the manufacture of copper-made products such as wire rods, wire, cable, tubes and copper and copper alloy semi-manufactured products. From there, any number of copper-bearing products could theoretically follow, with copper foil being promoted as a potential high-value-added product (Corporación Alta Ley, 2019[33]).

Similarly, in the case of lithium, a potential avenue for downstream diversification would be the lithium battery and electric vehicle (EV) value chains. These comprise several different steps, namely: i) lithium extraction; ii) production of battery materials (chiefly, "battery-grade" LC or LH); iii) battery components (cathodes); iv) cell production; v) module production; vi) battery pack assembly; and v) integration into the vehicle (Clean Energy Canada, 2021[71]).

To date, a combination of long-term investment, skilled labour, manufacturing capabilities and technological development has enabled Asia to become the dominant producer of lithium battery cathodes, cells and battery packs. While other regions, such as Europe and North America, are working to develop their own battery supply chains, it will likely take time for them to catch up with the established infrastructure and expertise of Asian manufacturers. And the same holds true for Antofagasta.

In this regard, the recently announced public technological institute for the research of lithium and *salars* – a part of the National Lithium Strategy – to be based in the region of Antofagasta (Gobierno de Chile, 2023[27]) could play a relevant role in the development of downstream applications and lithium products. However, a long-term incentive policy will likely have to be adopted to ensure conditions are present to foster innovation and adequate investment.

In sum, although there are opportunities for downstream diversification, these should be explored with caution and with the view of prioritising those areas where Antofagasta is better suited for competitive advantages. Areas of potential development include obtaining speciality chemicals from lithium (with specific levels of purity and non-lithium contents) and, in the case of copper, the installation of a smelter/refinery that, taking advantage of abundant renewable energy sources, is able to produce copper cathodes with a low-carbon footprint (see, however Box 3.2, trends in end products and the smelter outlook for the potential challenges involved).

Downstream diversification in the form of value-adding processes and methods of production is a different proposition, with greater potential. These would include development such as processes related to the more sustainable extraction and processing of copper and lithium (by, for example, reducing inputs, waste streams, r time involved), greater traceability and environmental monitoring of production processes and the development of more inclusive social and labour practices that foster greater acceptability of the industry as a whole (Corporación Alta Ley, 2019[33]; 2022[72]).

To achieve these results, policies should focus on promoting innovation – an area where Chile lags behind other mining jurisdictions (OECD/UN, 2018[45]; Poveda Bonilla, 2020[73]) – and on creating the adequate conditions for these developments to occur, including the fostering of necessary skills (CCM/Programa Eleva, 2020[46]).

Upstream diversification: Leveraging the METS sector

The mining equipment, technology and services (METS) sector plays an important role in the development of a resilient and sustainable mining industry in many jurisdictions (including Australia, Canada, Finland and Sweden), through the creation of employment and business opportunities.

The METS positive influence is twofold: i) by providing competitively sourced services and equipment to local miners (which enables efficient mining operations to thrive); and ii) by capturing and transforming the benefits from mineral extraction into long-term business propositions that transcend the eventual depletion of local mineral deposits.

The development of "world-class exporting suppliers" (with a view of achieving exports worth USD 4 billion annually) was made a central tenet of the country's future development (Corporación Alta Ley, 2015[74]). However, there is still work to do.

There are now more than 8 500 mining suppliers in Chile, responsible for 1.16 million jobs, or 13% of total national employment (Corporación Alta Ley, 2021[39]). Chilean METS represent, in turn, 60% of the operational costs of mining companies through purchases of goods and services (Meller and Gana, 2015[75]). Although these numbers compare favourably to other mining jurisdictions, in export value, Chilean METS underperform significantly with just USD 500 million in exports in 2020 (vs. USD 3.7 billion in Canada, USD 6.7 billion in Finland, USD 13.3 billion in Sweden and USD 20.2 billion in Australia (Corporación Alta Ley, 2021[39])).

Also, as pointed out in prior reports (OECD, 2013[16]; OECD/UN, 2018[45]), Chile could benefit from further promoting innovation in its METS sector, both areas where Chilean metrics significantly underperform other jurisdictions (OECD/UN, 2018[45]) (CNEP, 2017[21])In terms of innovation, Chile's R&D expenditure for 2019 was 0.35% of its GDP, significantly below Canada (1.5% of GDP), Australia (1.9% of GDP), Finland (2.8% of GDP) or Sweden (3.4% of GDP) (Corporación Alta Ley, 2021[39]).

Finally, despite being supportive of METS development and having long identified the sector as an important contributor to the prosperity of the country, Chile spends just 0.02% of GDP in public subsidies or initiatives related to METS development, whereas Australia devotes 10 times more and Canada 56 times more (Corporación Alta Ley, 2021[39]).

Antofagasta is home to the Mining Cluster initiative set up in late 2019, with the view of promoting the development of METS at the regional level. This initiative can be coupled with the profound transformations reshaping the mining industry – including digitalisation, automation, artificial intelligence, remote operations and the manifold changes related to green mining – to develop a vibrant METS sector at the forefront of this new mining industry (OECD/UN, 2018[45]).

Sustainability solutions designed and tested in Antofagasta will be in high demand elsewhere, especially in a region that is already mining-intensive and will likely be more so in future. Brazil, Colombia, Ecuador and Peru already have significant mining sectors. Argentina and Bolivia are also looking to expand their mining industries. The fact that they share many geological, climatological and geographical features with Antofagasta means that techniques and solutions developed in Antofagasta could be easily transferred to them.

However, a proper environment between mining companies and METS should be created and sustained to achieve these results. As raised by various companies in the OECD mining regions initiative, the main source of innovation in mining comes from the interaction between miners and suppliers. The main challenge is to facilitate mining companies in presenting their production challenges to their base of national suppliers, so that they can develop and scale solutions without affecting the operational continuity of the mining process.

Box 3.7. Increasing participation of local communities in the mining value chain: Fostering development of Indigenous communities

Mining's positive effects on the socio-economic and human development of its host jurisdictions have been shown to be greater when strong local economic linkages are at play (McMahon and Moreira, 2014[70]).

These linkages can deliver win-win results for the community (in the form of jobs, economic and human development opportunities) and for the mining sector (which will see its approval ratings raise), helping cement the overall "social license to operate" of the industry.

A particular case can be made regarding the development of Indigenous communities and their integration into extractive and mining value chains. Indeed, positive examples of natural resource-led development led by Indigenous peoples include the Frog Lake Energy Resources Corporation in Canada, the NANA Regional Corporation in Alaska, United States and the Gumatj Corporation in Australia's Norther Territory (OECD, 2019[76]). All of the above participate in different stages of the mining process and value chain (from passive landowners to more active mining services providers and mine operators) and have managed to reap significant community benefits from their industry participation.

In Antofagasta, steps in this direction have been taken in connection with the Indigenous communities located in the vicinity of the Salar de Atacama lithium operations though – mostly – agreements between certain community groups and mining companies. However, it appears that a more co-ordinated approach with public sector oversight would perhaps generate greater benefits with less community friction.

Source: McMahon, G. and S. Moreira (2014[70]), *The Contribution of the Mining Sector to Socioeconomic and Human Development*, https://documents1.worldbank.org/curated/en/713161468184136844/pdf; OECD (2019[76]), *Linking Indigenous Communities with Regional Development*, https://doi.org/10.1787/3203c082-en.

Diversification beyond the mining value chain: Leveraging synergies

Aside from diversification through the value chain, mining and the economic environment that follows from it provide the possibility of diversifying the productive matrix of a region by harnessing its potential synergies.

As mentioned above, Antofagasta is centrally located within an area of intense present and future mining activity, both within Chile and internationally. In this regard, the region can act as a fulcrum for the development of other mining regions, providing Antofagasta with opportunities for diversification of its own productive fabric. Mining equipment, technology, services and know-how – especially if carried out in compliance with ESG and circular economy standards – can easily be exported elsewhere. In this sense, the Mining Integration and Complementation Treaty signed with Argentina can facilitate the flow of mining inputs and technology between these two neighbours (Bauni, 2005[77]).

Mining also requires inputs (especially power and water) and presupposes (or generates) significant infrastructure that other economic sectors can utilise. Railroads, roads, ports and airports, power generation and transportation, seawater desalinisation plants and pipes, and the transition towards a decarbonised mining industry are all factors that can mobilise other areas of the economy.

Potential areas where mining can act as a catalyst of synergistic development are listed in the following.

Renewable energies and hydrogen

Antofagasta's potential for renewable energy generation (especially solar photovoltaic and thermal) is, literally, second to none (Ministerio de Energía/GIZ, 2014[57]). This, coupled with the progressive but relentless decarbonisation of the mining industry, provides the region with a clear avenue for diversification. Indeed, locally generated know-how, technology and solutions can be applied elsewhere while – at the same time – generating a strong independent renewable energy industry.

And the same holds true for hydrogen generation (Ministerio de Energía, 2020[60]), which is expected to play a significant role in the decarbonisation of the mining industry (IEA, 2021[78]).

Antofagasta is therefore poised to develop as an innovative, competitive and world-class renewable energy and hydrogen hub, both to supply the region's mining sector and to generate an independent industry that is called to transcend the eventual depletion of the region's mining assets (OECD, 2012[79]). In terms of future investment, Antofagasta is home to 13 new renewable energy projects (including solar, wind and hydrogen), for a total of 6 982 megawatts (MW), leading among all Chilean regions which, in aggregate account for 1 368 MW (Ministerio de Energía, 2022[80]).

Adequate planning and incentives should be put in place to ensure that the energy transition – spearheaded by the mining industry – is properly captured regionally in terms of knowledge generation and economic diversification. Also, an integrated approach between renewable energies, net zero policies and water use may in fact yield positive effects in terms of water availability for the region (Newborough, 2021[81]).

Tourism

The Atacama Desert is a place of great natural beauty and significant cultural heritage value (San Pedro de Atacama was submitted to the United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage Convention by Chile in 1998). It is a thriving tourism destination with natural preservation areas, archaeological and cultural heritage and astronomical tourism of international fame.

This area accounts for 8.7% of total regional employment (amounting to 27 000 employees) (Subsecretaría de Turismo, 2021[82]) but can still be further developed. Most of the activity focuses on San Pedro de Atacama and tourists fly into Calama rather than Antofagasta in order to reach the area (OECD, 2013[16]). Most of Antofagasta's tourism is "business tourism" linked to the mining industry and focused on conferences, mining events (such as Exponor) and business with mining companies.

The possibility of enhancing tourism has long been identified as an important component of regional development and innovation strategies (GORE, 2009[38]; 2022[68]). These policies describe a number of actions to foster tourism as one of the region's key economic activities, chiefly developing "special interest tourism" (including astronomy and experience-based tourism) as well as setting forth the conditions for the tourist industry to thrive (including the digitalisation of tourist services).

Desert-based agriculture

Desert-based agriculture (DBA) stands out among the other potential avenues for diversifying the region's economic fabric. Although small – agriculture represented barely 0.5% of regional GDP at the time of the latest territorial review (OECD, 2013[16]) – DBA has a long history in the region and strong cultural bonds with local and Indigenous communities.

The regional government has long promoted this activity as a means of diversifying the local economy and, more recently, as a potential competitive advantage in the face of climate change, worsening conditions for agriculture and a particularly long drought in Chile (GORE, 2022[68]).

CORFO has also supported several programmes with a view of developing DBA, including an R&D initiative called *Consorcio del Desierto* launched in 2022, together with several other institutions such as Fraunhofer Chile Research, the Catholic University of the North, Arturo Prat University, UC Davis Chile Life Sciences Innovation Center and the Corporación de Desarrollo Social del Sector Rural (Rural Sector's Social Development Corporation).

Aside from providing agricultural products to the region, experiences gained, and technology developed in Antofagasta's unique desert environment could potentially be exported elsewhere, with the attendant benefits for the region.

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Notes

[1] In Chile, it is estimated that for every direct job, mining is responsible for as much as two indirect employees (CNEP, 2017[21]).

[2] The capital expenditure of a greenfield copper mine typically runs to several billion dollars and is increasing over time.

[3] Definitions vary as well; however, SERNAGEOMIN considers a company: i) mid-sized if it employs more than 80 but fewer than 400 employees; ii) small-sized, if it employs more than 12 but fewer than 80; and iii) artisanal, if it employs fewer than 12 people.

[4] The "2°C scenario" refers to the technology-based climate change mitigation scenarios developed by the International Energy Agency (IEA) and, specifically, to a scenario with at least a 50% chance of limiting the average global temperature increase to 2°C by 2100. See IEA, *Energy Technology Perspectives 2017*.

[5] Of note in this sense is the Chile Polimetálico project, co-financed by COCHILCO, CORFO and Corporación Alta Ley ((ChilePolimetálico, nd[84])).

[6] Reasons for this unusual concentration of METS companies are multiple and include a low level of decentralisation in Chile, lack of adequate supply chains and skills in other regions and the high cost of access to land in the northern regions of the country (including Antofagasta) (CNEP, 2017[21]).

[7] The National Mining Strategy sets out a target of 90% of PPAs from renewable resources by 2030 and 100% from 2050 onwards (Ministerio de Minería, 2020[5]).

[8] A major industry breakthrough, seawater can in turn be used after being desalinised (accounting for 63% of total seawater used) or "raw"/direct seawater (37% of seawater used) (COCHILCO, 2022[61]).

[9] Scope 1, 2, and 3 are categories of carbon emissions created by a company's operations and in the wider value chain. Scope 1 emissions are Green House Gas (GHG) directly made by the company. Scope 2 emissions are indirectly made by the company. See: https://ghgprotocol.org/sites/default/files/standards_supporting/FAQ.pdf

4 Towards a Mining Strategy of Well-being for the Region of Antofagasta

This chapter presents the rationale and building blocks for the Mining Strategy of Well-being for the Region of Antofagasta 2023-2050, which aims to address mining-specific challenges and opportunities in the region and support higher well-being standards for all people living in the Antofagasta region. The chapter first outlines the relevance of developing a regional mining strategy, especially with the ongoing decentralisation process in Chile. Second, it summarises the process of developing this strategy, its objectives and the timeframe of strategic projects. Finally, it provides guidance on a governance mechanism for the long-term continuity and monitoring of the strategy and describes the allocation of roles for regional stakeholders and funding sources.

Policy takeaways

Assessment

- Mining development has generated important wealth for Antofagasta and the country but these benefits have not been equally distributed across the region, leaving many communities behind across a wide range of well-being indicators (see Chapters 2 and 3). Despite public and private initiatives to better translate mining wealth into benefits for the communities, the region has lacked an integrated co-ordination mechanism to align efforts and policies among levels of governments and companies and produce long-lasting changes in well-being standards. This has negatively impacted the region's attractiveness for businesses and people raising families.
- The ongoing decentralisation process in Chile provides a new opportunity for the region to attain a more sustainable and inclusive future. For the first time, the region benefits from a newly elected regional governor with new administrative and planning tools, whose responsibilities and mandate are to support the interests and aspirations of citizens from the region. In parallel, Indigenous and non-Indigenous communities in the region have strengthened their voices and governance for more decision-making power and accountability. Against this backdrop, the mining sector is increasingly under international and local pressure to adapt to societal demands and global climate agreements to reduce its impact on the environment and improve local outcomes.
- A long-term plan with formal co-ordination and monitoring is needed to ensure that the region can materialise future investments in minerals and energy in a sustainable manner while ensuring greater well-being standards along social and environmental dimensions. The Mining Strategy of Well-being for the Region of Antofagasta 2023-2050 (hereafter the Mining Strategy) embodies this coherent long-term plan. For its elaboration, different parts of society were involved to reach common agreements and identify strategic objectives and projects. A multi-stakeholder governance mechanism is warranted to help monitor the implementation of this strategy and ensure its continuity beyond political cycles. Likewise, the national government and its national agencies in the region need to support the institutional capacity to implement this strategy successfully, in alignment with the national mining strategy and the sustainable development of Chile.

Takeaways

The recommendations below provide the building blocks of the Mining Strategy, with suggested long-term objectives and governance mechanisms. The construction of the strategy benefitted from more than 80 meetings with stakeholders in the region, including representatives from the private and public sectors, civil society and Indigenous communities, academia and local businesses, who provided their development priorities and feedback on the objectives, structure and governance of the Mining Strategy for the region of Antofagasta.

To improve the economic, social and environmental well-being standards in Antofagasta while promoting a more competitive and environmentally responsible mining sector, the regional government of Antofagasta needs to:

- **Formalise and implement the Mining Strategy with concrete objectives and a timeframe of strategic projects** that involve and consider the needs of different regional stakeholders. To this end, the regional government should:
  - Recognise in the Mining Strategy the need for a new pact among communities and the private sector in the region of Antofagasta, to rebuild trust within the region and reach common agreements for improved development. This new pact would benefit from the recognition that

more needs to be done to improve well-being standards in the communities where mining takes place but also that the mining sector plays a strategic role in the development of the region of Antofagasta.

- Ensure the Mining Strategy is a regional government strategy with a long-term vision, common objectives and a clear timeframe for strategic projects. All of these elements should be based on the priorities provided by regional stakeholders. This involves:
  - Adopting a vision that sets the long-term and aspirational goal for the region with the aim of increasing well-being standards in economic, social and environmental dimensions. The vision can be accompanied by common agreements to reach compromises and align regional efforts.
  - Setting strategic objectives to address the main priorities identified across the region and reach the vision for the region in 2050. These objectives could be set across the five following areas:
    - Improve the well-being of local communities and Indigenous peoples.
    - Increase the participation of regional businesses in the mining value chain.
    - Strengthen skills and the regional knowledge ecosystem.
    - Improve governance for a more productive mining sector.
    - Rehabilitate the environment.
  - Implement short- and medium/long-term strategic projects to attain each of the objectives of the strategy. Several strategic projects have been identified throughout different multi-stakeholder meetings in the region.

- **Establish a governance mechanism to monitor progress and ensure the sustainability of the Mining Strategy over the long run and beyond government cycles**. This mechanism could benefit from the following elements:
  - A formal public official in the government co-ordinating the strategy and ensuring its implementation and continuity, with a defined budget and a team for operation and co-ordination.
  - A steering committee in charge of prioritising projects, rendering accounts of monitoring and evaluation, and proposing new orientations to the strategy. It should be composed of representatives of relevant actors in the region (private and public sector, civil society and Indigenous communities), with periodic rotation to expand possibilities of participation and representation (e.g. two years) and a consensus-based decision process.
  - A technical committee in charge of overseeing the projects, providing updates on the progress of the project and budget, and responding to other requests from the steering committee. This technical committee is made up of an executive secretary and a team of professionals in collaboration with personnel from academia and the private sector.
  - Ensure the Mining Strategy upholds Indigenous peoples' rights and promotes meaningful participation in decision making and prior and informed consent in designing and implementing relevant strategic projects for these communities.
- **Define a monitoring framework with impact indicators to monitor the long-term policy impact of the Mining Strategy as well as outcome indicators to measure the attainment of objectives and output indicators to measure the implementation**. This monitoring framework could also include horizontal performance indicators that can account for complementarity effects to co-ordinate actions across different parts of the regional government and national agencies in the region.

- **Ensure a formal channel of communication and involvement of regional stakeholders** on the construction, progress and changes of the Mining Strategy. This involves:
  - Including on the Mining Strategy webpage a summary of the process with different parts of society, agreed-upon objectives and strategic projects, with clear visualisation tools to show the progress of these projects.
  - Mapping and publicly reporting concrete information on the different environmental, social and corporate governance (ESG) initiatives of mining companies in the region to improve transparency and co-ordination.
  - Establishing annual public reports on the progress of the strategy via social media or public gatherings to reach the entire population.
- **Support the institutional modernisation and capacity of the national agencies operating at the regional level**. The national government is crucial to help ensure the successful implementation of the regional Mining Strategy and maintain a competitive and sustainable mining sector that keeps contributing to national fiscal income and growth and helps attain national climate goals. To this end, the national government should:
- Co-ordinate with the regional government of Antofagasta to identify institutional needs in the region and define methods to increase the capacity and upgrade the Regional Ministerial Secretaries (SEREMIs) – especially the SEREMI of the Environment and the SEREMI of National Goods – and the Superintendence of the Environment.

Introduction

As depicted in the previous chapters, Antofagasta is a global player in the mining industry, especially in copper and lithium. Its traditional know-how in mining operations, presence of rich geological resources, a mature mining ecosystem composed of leading mining companies, suppliers, universities with mining expertise, organised civil society actors and a recently strengthened regulatory framework with greater regional decentralisation make Antofagasta highly attractive for ongoing and future mining activities.

The mining sector contributes to the bulk of Antofagasta's gross domestic product (GDP, 72% in 2022), representing 90% of its exports. This sector has contributed to placing Antofagasta as the second Chilean region with the highest income per capita and highest foreign direct investment. The region is also a significant contributor to the national economy, accounting for 39.4% of Chile's total exports and contributing to 8.8% of the national GDP despite its population representing only 2.2%.

This prosperity, however, has not reached everybody in the region and has not fully translated into greater quality of life for its inhabitants. There are a number of challenges that remain across various dimensions of well-being (Table 4.1).

Table 4.1 Well-being challenges in the Antofagasta region

Economy	Higher unemployment rate (9.6% in 2021) than the national average (9.1%) and the OECD benchmark of mining regions (7%)
	Higher income inequality (Gini coefficient of 0.51 in 2019) than the national average (0.46)
Social	The lowest life expectancy (79.2 years) among Chile's 16 regions
	The fifth lowest life satisfaction among Chilean regions and in the bottom 22% across all OECD regions
	Lack of parks and green areas for recreation and leisure activities
Environment	38% more greenhouse gas (GHG) emissions per unit of electricity generated than the OECD benchmark of mining regions
	Concerns and lack of information about mining impacts on inland water, air pollution and biodiversity

The region of Antofagasta is currently undergoing a number of transitions that can reshape the effect of mining on regional development. First, the region is on the verge of a significant flow and interest of investment to modernise and expand existing mining operations, mainly copper, and to increase exploration and production of non-traditional minerals, such as lithium. Second, mining companies are increasingly adapting to the green and digital transitions, with projects to increase the use of renewable energy sources (solar and wind), desalinated water and automation for mining operations. Finally, the ongoing decentralisation process in Chile has allowed, for the first time in history, the democratic election of a regional governor with new administrative and strategic capabilities.

These transitions can bring new opportunities for local businesses and workers to participate and benefit from a more sustainable value chain. Nevertheless, without proactive planning, new developments and green mining initiatives can lead to few benefits locally, creating additional challenges, for example, in the co-ordination of water desalination plans and land use for solar and wind energy projects.

A long-term plan with formal co-ordination and monitoring is needed to ensure that the investments in the minerals and energy mining sector can materialise in a sustainable manner while ensuring greater well-being standards along social and environmental dimensions. This chapter presents the rationale and the building blocks for the development of that long-term plan set up by the regional government, namely the Mining Strategy of Well-being for the Region of Antofagasta 2023-2050 (hereafter the Mining Strategy).

Why a Mining Strategy of Well-being for the region of Antofagasta?

Across other OECD mining regions, mining strategies are developed to meet multiple objectives, which go beyond improving the competitiveness of the mining sector itself and also look at improving the liveability of people in the region.

The region of Antofagasta has a particular opportunity to mobilise its mineral wealth and industrial base to benefit from the increasing global demand for minerals and support the development of renewable energy technologies in the next decades.

However, the expected development of the mining sector driven by the global demand for minerals in the coming years must ensure more sustained benefits to the people and economy in the region. This requires a different way of governing mining, with a guiding framework that supports the competitiveness of the regional mining sector but also ensures that the wealth of this industry generates jobs and new local businesses and – above all – improves the attractiveness of living in the communities of Antofagasta.

The Mining Strategy can be the roadmap to mobilise the regional assets and improve the competitiveness of the mining sector to make the most of the digital and green trasitions with the aim to deliver greater well-being standards to its inhabitants. With this in mind, the following are the main reasons for developing a mining strategy for the region of Antofagasta.

Making the most of global megatrends and transformations affecting the mining sector

Global megatrends, including demographic change, climate change and the transition to a low-carbon economy, as well as digitalisation and automation, are bringing new challenges and opportunities to the development of mining regions (Table 4.2). For example, technological change and digitalisation can increase productivity and sustainability in mining activities but might also affect demand for local workforce.

Table 4.2. Opportunities and challenges of megatrends for the mining industry and regions

	Opportunities	Challenges
Changes in demographic trends (population ageing and migration)	• Successful integration of migrants may enhance labour supply • Lifelong learning can enable the old workforce to keep adding value	• Ageing population/local demographic decline leads to a shortage of labour • Unsuccessful migrant integration may lead to social problems • Many migrants tend to reside only temporarily and eventually move south to larger cities
Climate change and environmental pressures	• High standard of environmental performance and requirements will soon be a competitive advantage for regions that have transitioned to fossil-free, low-electrified mining and the development of environmentally friendly technologies to reduce carbon emissions in mineral and metal processes	• Pressures for the mining industry to improve its performance and reduce its environmental footprint • Harder policies and regulation to issue permits to operate in the future • Higher public reticence to accept mining explorations and openings
Technological innovation (e.g. digitalisation, automation, decentralised energy)	• Digitalisation/automation may compensate for shortages of labour in some sectors • Can make mining regions more attractive to live in by providing quality public services, including remote healthcare solutions • Creation of new jobs by involving regional actors to develop new digital and automated solutions • Offer greater labour opportunities for women and various segments of the population	• Displace certain workers in the mining sector, mainly the ones that perform more repetitive tasks • If technological innovation is produced outside the region, it can affect the competitiveness of the region • Can reduce the need for certain minerals by replacing them with laboratory product or by extracting them from the recycling process

In this context, the mining sector itself is also undergoing transformations. On the one hand, the industry is under increased pressure to reduce its impact on the environment and GHG emissions to meet global climate agreements. On the other, mining companies face a context of increasing competition with decreasing qualities of ore that are more difficult to access. Facing both transitions requires mining companies to invest in new technologies and processes and collaborate with governments to agree on environmental plans.

Automation is advancing significantly in the region. For example, Antofagasta Minerals operates a mining pit at the Centinela mine with almost an entire fleet of autonomous trucks (11), for which it trained about 100 workers (e.g. former drivers) in tasks needed for the autonomous operation, including monitoring and maintenance of the trucks or Global Positioning System (GPS) site mapping. Likewise, BHP currently has 6 drilling rigs and 4 autonomous trucks in operation and expects to gradually incorporate 52 trucks with autonomous technology by 2025.

Antofagasta is uniquely positioned to emerge as a global leader in responsibly sourced minerals, crucial for a low-carbon future. The region benefits from abundant geological resources, with some of the critical minerals for the green transition such as copper and lithium, and a well-established mining ecosystem comprising top mining companies, knowledgeable suppliers, mining-focused universities and a young workforce.

While the demand for minerals like copper and lithium is set to skyrocket, consumers, civil society, governments and international organisations are increasingly asking for mineral production that is carried out in a more climate-responsible manner. Antofagasta can leverage its renewable energy potential and advance the infrastructure of water desalination to play a pivotal role in showing a more sustainable way to mine. This future, in turn, will contribute to Antofagasta's continued development by creating long-term demand for its mining products, technology and services.

However, the mining sector is facing increasing challenges in maintaining competitiveness and ensuring smooth operations. These challenges include:

- **Productivity and diminishing ore grades**: Mining productivity in Chile and Antofagasta has been in decline, with mining becoming the largest drag on productivity at the national level for the past 20 years (Chapter 3).
- **Availability of skills**: In mining-specific skills, there is a significant deficit both in terms of employees and competencies needed. For the period 2021-30, a 25 000-employee gap is foreseen due to the compound effects of the retirement of current workers and the expected creation of new jobs resulting from the increased sophistication of mining operations and processes (Chapter 3).
- **Complex and centralised land management system**: An excessively centralised public land administration and management system and widespread mining property speculation make land scarce and difficult to obtain, for example to put to useful purposes downstream activities in mining processes.
- **Environmental matters**: Concerns and doubt about the long-term effect of mining on the local environment are persistent and few coherent and systematic strategies have been put in place to clarify such concerns. These concerns include doubts about the long-term effects of marine water capture and desalinisation, the region's significant carbon footprint derived from a combination of intensive use of energy and reliance on fossil fuels for energy generation.
- **Social concerns**: The equitable allocation of benefits from the industry (both regionally and at the local community level) is also likely to prove challenging going forward, especially in the face of aforementioned changes that digitalisation is already causing in mining's traditional shared-value proposition.

A well-set strategy has the potential to prepare the region to make the most of these megatrends and mitigate negative impacts locally. The impact of these megatrends on mining municipalities in the Antofagasta will depend on the long-term policy strategy to address changes and prepare firms and communities for the future.

Ensuring a sustained improvement of people's well-being

As mentioned in the previous chapter, Antofagasta is the largest copper producer and among the top lithium producers in the world. The sector has historically represented most of Antofagasta's GDP (53% in 2018) and exports (90%). The region stands out as the country's second-largest recipient of foreign direct investment, only surpassed by Santiago Metropolitan Region (Atienza et al., 2015[1]).

This sector has also pivoted the Chilean economy in the last decade. During 2010-20, the sector represented almost 10% of the country's GDP, contributed up to 56% of the national exports and generated 9.3% of tax revenue (Ministerio de Minería, 2020[2]). The participation of mining in the national GDP has grown from 8.1% in 2016 to 14.6% in 2021, and the contribution in tax revenue has gone from 2% to 13% in this same period.

However, while this natural wealth has fuelled Chile's development and positioned it as one of the most developed countries in Latin American, it has not fully translated into a relatively greater quality of life for Antofagasta. This region faces important development bottlenecks across different dimensions of well-being, with greater stagnation in some areas relative to other Chilean regions that did not benefit from such historic wealth.

Economically, the region exhibits a relatively high unemployment rate (9.6% in 2022) compared to the OECD benchmark of mining regions (7%) and relatively high economic volatility (Chapter 2). Furthermore, there is low participation of local companies in the mining value chain (15% of companies in the region in the World Class Supplier Program), with few forward linkages of the mining process (e.g. most copper is exported without a refining process) (Chapter 3).

In the social dimension, mining communities lack accessibility to quality education, childcare and specialised health. Children's and public green parks are an existing concern in the communities.

In the environmental dimension, the region is one of the most arid in the world, the mining sector has increased the demand for continental water and some extraction process also augment the risk of pollution of water reservoirs. There is also a lack of assessment of the biodiversity of the region (e.g. fauna and flora), coupled with visual pollution and relatively high levels of air pollution (Chapter 2).

Materialising previous and current initiatives that aimed to translate mining wealth into greater well-being

Different polices and initiatives in Chile and Antofagasta have tried to better translate mining wealth into greater well-being locally. At the national level, mainly, the Ministry of Mines and the Production Development Corporation (CORFO) have encouraged policies and strategies to promote development in Antofagasta, mainly targeting the economic dimension in the region.

At the regional level, the Mining Cluster of Antofagasta was likely the first clear, coherent plan to sustainably improve the role and interaction of the local economy with the mining process. Private companies and state-owned copper mining company Codelco have also undertaken initiatives to improve the effect of mining in the local communities. Table 4.3 summarises a number of main initiatives that have aimed at improving the mining impact in Antofagasta's development.

Table 4.3. Selected initiatives that have aimed at improving the effect of mining in Antofagasta's development

Policy or initiative	National or regional initiative	Origin	Description	Main area of focus
Alta Ley Corporation	National	Created in 2015 as part of CORFO's Smart Specialization Strategic Program.	An organisation designed to articulate the existing capacities in public and private entities and organisations in the mining industry, with the purpose of promoting and fostering the development of the sector to improve the competitiveness and sustainability of the mining sector.	Economic
Mining Cluster of Antofagasta	Regional (public-private)	2019 alliance between Antofagasta Minerals, CORFO and the Antofagasta Regional Productive Development Committee.	Brings together mining companies, government agencies and educational institutions around two strategic objectives: training human capital in the region and developing innovative suppliers.	Economic
Mining Cluster Program	National-regional (public-private)	In 2002, CORFO spearheaded the programme.	Develops a mining cluster to increase territorial competitiveness through business synergy and integration.	Economic
World Class Supplier Program	Regional (private)	In 2015, private initiative of BHP, followed by Codelco.	Develops innovations in domestic suppliers to provide technological solutions to specific problems detected by large firms and to sell them at a larger scale in international markets.	Economic
Creo Antofagasta	Regional (public-private)	In 2013, BHP Escondida and the local government initiated the strategy of gathering 11 companies around the city of Antofagasta and 2 universities.	Establishes programme focused on seven areas of action: use of land and growth, transportation and mobility, public space and green areas, environmental sustainability, participation and civic society, economic diversification and identity and culture.	Comprehensive (economic, social and environmental)
Calama Plus	Regional (public-private)	In 2012, Codelco (main funder) together with the local and the regional government, established this initiative with a directive council. Another nine companies joint.	Establishes a sustainable urban development plan for Calama to raise the standard of quality of life.	Comprehensive (economic, social and environmental)

Source: Based on Navarro, L. (2018[3]), "The World Class Supplier Program for mining in Chile: Assessment and perspectives", https://doi.org/10.1016/j.resourpol.2017.10.008; Devenin, V. (2021[4]), "Collaborative community development in mining regions: The Calama Plus and Creo Antofagasta programs in Chile", https://doi.org/10.1016/j.resourpol.2018.10.009.

At the regional level, the idea of a mining cluster was likely the first clear, coherent plan to sustainably improve the role and interaction of the local economy with the mining process. In 2000-06, the regional government put in place its mining cluster strategy, acknowledging that the regional businesses showed marginal participation in mining companies' secondary activities and there was low interaction between large and medium/small mining companies. This strategy was initially created in the 1990s due to the impact of the large investments that began during that decade. In the 2000s, it was recognised as one of the axes of the regional strategy of development for 2000-06, reflecting the need to consolidate a "mining, industrial and services productive complex" to take advantage of all of the potential and synergy associated with mining, and to support the growth and development of all other sectors of the regional economy. This policy goal has helped strengthen the linkages of regional businesses as providers of mining companies.

Yet, the mining cluster initiative in its different forms has not fulfilled the expectations, as few local businesses or the mining equipment, technology and services have grown internationally with a local market that is still fragmented and limited vertical knowledge transfer (Devenin, 2021[4]; Atienza et al., 2015[1]). This policy alone is not enough to address the increasing outsourcing trend of mining activity, which, together with changes in information and transportation technologies, has given rise to a process of relocation of production chains outside the regions of origin of the activity, both nationally and internationally (Atienza et al., 2015[1]).

Social and environmental aspects have been overseen in the different polices aiming at translating the mining wealth into the community. In particular, a reduced of attention to the social needs of mining communities (green areas, children's parks, education linked to industrial needs or quality healthcare) has led to a enabling environment that struggles to retain and attract skilled workers and companies.

While different private companies and Codelco have individually issued programmes to improve liveability in local communities, those actions are dispersed, lacking co-ordination among each other and scalability to create long-term solutions for the region. For example, the World Class Supplier Program successfully achieved its goals of creating technological solutions for large firms and developing supplier capacities. However, the scaling-up and internationalisation effects of the programme seemed small, given the low incentive from mining companies to collaborate in the scaling-up and internationalisation of providers (Navarro, 2018[3]).

An initiative worth mentioning and from which lessons can be learnt is Calama Plus. The Calama Plus Consortium resulted from a joint effort between Calama's public and private sectors, with the aim of building a comprehensive vision to improve quality of life in the city (Box 4.1). Despite the thoughtful structure and process, the initiative did not manage to meet expectations and fell short in implementing most of the projects. This led Codelco and many other companies to withdraw as project funders. Part of the difficulty was to maintain trust throughout the project's structuring and implementation as well as balancing project prioritisation and problem solving. Also, the lack of capacity of the municipal government to structure and implement projects undermined trust in the outcomes of the initiative. In Chile, many projects require approval from national agencies – e.g. acquiring land needs the approval of the Ministry of National Goods – and the municipal government struggled to meet the requirements of the project proposal or present a proposal on time.

Box 4.1. Lessons from the Calama Plus initiative

In 2012, Codelco, together with the local government, established the Calama Plus Consortium to set up a sustainable urban development plan to improve the city's attractiveness and raise the standard of quality of life for its inhabitants. Codelco was the initial financer of the initiative, which gathered a total of ten private companies operating around the town, including the largest mining companies in Calama (e.g. Antofagasta Minerals, Freeport MacMoran, Glencore), mining suppliers (e.g. Komatsu) and retail companies (e.g. Sodimac Calama).

The initiative included a governance body made up of different local actors (mining companies, regional governments and municipalities) compiling a list of local priorities in various workshops and meetings with the participation of about 24 000 inhabitants. These meetings helped to identify main priorities and agree on a number of projects capable of improving the urban development of the city and, thus, quality of life.

However, from 2012 to 2019, few of the priority projects were implemented, which led to the community's discontent and some companies' decision to withdraw. By 2019, main funder Codelco also decided to leave the initiative and reallocate resources to other initiatives (e.g. mining cluster). Many factors were behind the difficulty in meeting expectations and outputs, including:

- A governance body which lacked the capacity to reach a consensus and change the course of action and an unequal representation of members where the funding provider had greater decision-making weight.
- Lack of capacity to come up with agreements and compromises across different levels of government (national and municipal) to speed up implementation of key projects.
- Lack of capacity (human and technical) in the municipal government to structure, present and implement projects.

Source: Devenin, V. (2021[4]), "Collaborative community development in mining regions: The Calama Plus and Creo Antofagasta programs in Chile", https://doi.org/10.1016/j.resourpol.2018.10.009; CALAMATV (2020[5]), *Pasado y futuro de Calama Plus*, https://www.youtube.com/watch?v=t4VycLVIvOI.

Different aspects might explain the challenges in producing structural well-being improvements in Antofagasta. They include a lack of long-term planning to support diversified economic activities, a historical market-oriented economic policy framework and a lack of co-ordination between local and national governments to prioritise relevant projects for the social and environmental well-being of local communities.

Links with Chile's National Mining Policy 2050

Most recently, in 2022, the Chilean Ministry of Mines, on behalf of the national government, issued the National Mining Policy 2050 (Ministerio de Minería, 2020[2]). This policy acknowledges that "the absence of a long-term national mining policy, with answers to the growing and complex transformations on a national and global scale, undermines the possibilities of sustainable development of the mining sector and of the country as a whole". This policy has national objectives at the economic, social, environmental and institutional levels with a main national vision of the effect. It serves as a navigation chart for industry and the state, which was elaborated with a wider participation of citizens across the different regions of Chile (Box 4.2).

Box 4.2. Chile's National Mining Policy 2050

The Ministry of Mining decided to develop a National Mining Policy 2050 in order to have effective governance, strengthen institutions, open opportunities for dialogue and collaboration, encourage competitiveness and promote innovation, safe and inclusive development and a state-of-the-art environmental management system.

The process of the policy involved the participation of more than 3 500 stakeholders in all elaboration phases, with 128 open roundtables that set up 128 initiatives throughout the country covering the challenges posed in the 9 transversal axes of the policy. This elaboration process included a territorial focus with 1 500 participants and 18 regional workshops.

The vision of this policy is to: "Maintain and strengthen our leadership by supplying the minerals the world needs by 2050 in the fight against global warming, addressing the consequences of climate change and generating value for the country" (Ministerio de Minería, 2020[2]).

The policy recognises different challenges related to the economic, social and environmental spheres, which are the basis for the main objectives.

Table 4.4. Objectives of the National Mining Policy 2050

Area	Strategic objectives	Particular goals (selected)
Economy	Become a world leader in the sustainable production of minerals, promoting a low-carbon economy and protecting the health of people and the environment.	• Achieve a production level of 7 million tonnes (Mt) by 2030, where small and medium-sized mining companies double their production. • Have traceability and reportability systems for 100% of the production of large and medium-sized mining. • Ensure 30% of total patents requested in Chile in the area of materials and metallurgy are national by 2030.
	Generate a chain industry at the forefront of innovation and development.	
	Increase the sustainable productivity and competitiveness of the mining industry.	
Social	Have quality, inclusive jobs with high safety standards.	• Reach female participation in the industry of 20% by 2030 and 35% by 2050. • Ensure 100% of small to medium-sized mining companies develop sharing agreement projects with local communities. • Ensure multi-dimensional poverty of mining communities is below the national average by 2030.
	Develop projects collaboratively with communities and Indigenous peoples.	
	Generate value by reducing multi-dimensional poverty and safeguarding heritage in the territories where it is inserted.	
Environment	Lead the circular economy model by reusing waste and efficiently using resources.	• Reduce the share of continental water used in the mining industry by less than 10% of the total water used by 2025. • Promote the publication of guides to understand the legal framework to develop seawater desalination plants by 2025. • Establish emission goals for PM10 and PM2.5 for the mining industry by 2025 and compliance by 2030. • Ensure 90% of electricity contracts in the mining sector come from renewable sources by 2030.
	Lead adaptation and mitigation to climate change, achieving carbon neutrality in the sector by 2040.	
	Minimise environmental effects by harmonising the development of mining activity with the environment.	
Institutionally	Have a modern, transparent institutional framework with efficient management, ensuring the industry benefits the country.	• Publish and make available geologic, geophysics and geochemical information. • Provide real-time information on the environmental monitoring of mining projects. • Develop a governance model for the lithium industry to protect the salt lands. • Reduce the processing time for environmental and sectoral permits by 25% by 2030
	Have a legal framework for the mining sector for sustainable development in the long term.	
	Promote the social acceptability of mining.	
	Strengthen the framework of the sustainability of small and medium-sized mining.	
	Strengthen Codelco and Enami as state companies and international benchmarks.	

Source: Ministerio de Minería (2020[6]), *Política Nacional Minera 2050 [National Mining Policy 2050]*, https://doi.org/www.doe.cl/alerta/28012023/2262175.

While this national policy set a good basis for the integration of mining and regional development, it fell short in adopting a place-based approach and conveying roles for regional and local governments in co-ordinating and implementing projects of strategic interest for mining communities. The national mining strategy did promote main regional priorities across the country but did not establish action lines or objectives per region despite regions having different assets and challenges. Furthermore, while the National Mining Policy 2050 sets a good roadmap to improve the mining sector as a whole and its impact on Chilean society, it does not set clear strategies to unlock specific regional assets or address particular challenges in the different regions.

Supporting upcoming investments in the mining and energy sector and ensuring their linkages with the local economy

As of January 2023, Antofagasta is the second region in Chile with the highest investment projection for the next 5 years (24% of the total national investment in projects) (Oficina de Grandes Proyectos, 2023[7]). These investments are mainly driven by the mining sector (51% of the total), followed closely by those in the energy sector (44%). In total, the investments are estimated to create about 29 563 jobs during the construction process (7% of the employed population) and 15 000 during the operation process. The nature of the investment from mining is mostly brownfield (replacement or expansion of current operations or change of the production process) (Comision Chilena de Cobre, 2022[8]), while renewable energy investments tend to be linked to new operations. According to the Chilean Copper Commission (Comision Chilena de Cobre, 2022[8]), most mining-related investments in Antofagasta (until 2031) are related to copper mining (93%).

These productive investments add up to corporate social responsibility (CSP) projects in Antofagasta. They include drinking water and sewerage programmes (Antofagasta Minerals and Codelco), programmes to improve urban and recreational infrastructure (Antofagasta Minerals, BHP and Codelco), to improve digital skills of students and the working force and provide tertiary education opportunities (Antofagasta Minerals, BHP, Codelco, Glencore Sierra Gorda) or initiatives to support economic diversification (Albemarle and SQM).

All of these initiatives and investments would benefit from greater co-ordination with each other and with public investments as well as visibility in the community. A government mining strategy should also help to maintain and scale up CSP projects, which are usually focused only on the communities surrounding the mines and prioritise initial investment rather than ongoing operations.

Capitalising on the ongoing decentralisation process in Chile

As well as the need for a coherent long-term vision for Antofagasta, a long-term strategy created at the regional level can benefit from the ongoing decentralisation process in Chile by relying on the new elected figure of regional governor, alongside regional government's greater strategy implementation tools and accountability.

Chile has undertaken decentralisation efforts that provide regional government with greater responsability. Since 2021, regional governors in Chile can be elected by popular vote, based on Laws No. 20.990/2017 and No. 21.073/2018 that transformed the "mixed" regional system (both deconcentrated and decentralised) – in place since 1992 – into a full self-government system, with direct election of the regional executive (governors) by popular vote every four years (Biblioteca del Congreso Nacional de Chile, 2021[9]). The regional government is constituted by a governor (the executive body of the region) and a regional council (the legislative body) that has the deliberative power. The members of the council have been directly elected every four years since 2014 (OECD/UCLG, 2022[10]).

Under this evolving framework, the governor has acquired new responsibilities, including developing investment strategies and land use planning (Box 4.3). This represents an important shift from the previous multilevel governance structure, where each region was governed by an *intendent*, a delegate appointed by the President of the Republic to administrate the resources and design the policies for the region.

These changes open up new opportunities for regional governors to design and define their regions' development strategies and target strategic investment programmes. Furthermore, it creates a figure elected by public vote accountable for addressing the regional priorities of the population and implementing the strategic plans for development.

Box 4.3. New responsibilities of regional governments in Chile in an ongoing decentralisation

Since the late 2000s, the Chilean government has pursued important decentralisation and regionalisation reforms. Laws No. 20.990/2017 and No. 21.073/2018 allow governors to be elected by popular vote. The first 16 elected regional governors took office in July 2021 for a period of 4 years and with the possibility of re-election. In parallel, Law No. 21.074/2018 transferred from the national government to the new self-governing regions responsibilities on land use planning, economic and social development and culture.

The Inter-ministerial Committee of Decentralisation supports and advises the President of the Republic on the competencies to be transferred, which can result from presidential initiative or upon request from the regional government. The newly elected governor is accompanied by a presidential delegate who is appointed by the President of the Republic for each region and is in charge of the exercise of matters concerning internal government, public security, emergencies and co-ordination, supervision and control of public services operating in each region.

The regional governor has, among others, the following duties:

- Formulates development policies for the region, considering the respective community policies and plans.
- Submits to the regional council the policies, strategies and projects of regional development plans and their modifications.
- Submits to the regional council the proposed budget of the respective regional government.
- Represents the regional government judicially and extrajudicially,
- Appoints and removes the public officials in the regional government that the law determines.
- Ensures compliance with the rules on administrative probity.
- Promulgates, with the prior agreement of the regional council, the regional land use plan, the metropolitan, intercommunal, communal and sectional regulatory plans and the detailed plans of intercommunal regulatory plans.
- Chairs the regional council.

Law No. 21.074/2018 also created a mechanism through which regions can ask for further competencies to be transferred to them, which is under discussion.

Source: OECD/UCLG (2022[10]), *2022 Country Profiles of the World Observatory on Subnational Government Finance and Investment*, https://www.sng-wofi.org/country-profiles/; Biblioteca del Congreso Nacional de Chile (2021[9]), *Elección democrática de gobernadores regionals*, https://www.bcn.cl/portal/leyfacil/recurso/eleccion-democratica-de-gobernadores-regionales.

However, the match of responsibilities and resources for regional governments is still unclear. By 2020, grants and subsidies represented a significant (56.1%) and growing share of subnational revenues, slightly above the OECD average when only considering local governments (53.3%), reflecting the high level of dependency of municipalities with regard to the central government (OECD/UCLG, 2022[10]). The national government has a strategic role in implementing regional development plans.

The Ministerial Regional Secretaries (SEREMIs) – deconcentrated entities representing each ministry at the regional level – have responsibilities in environmental, land use or education policies, among others. Furthermore, auditing bodies like the Superintendence of the Environment are of particular importance to ensure mining activities do not affect the environment. In fact, meetings with regional stakeholders often referred to the low capacity of the Superintendence of the Environment (SMA) as one of the main bottlenecks to ensuring efficient environmental protection from mining and other activities in the region. For example, the SMA's staff is relatively small compared to the number of mining operations and companies to monitor.

Furthermore, there is an imperative to streamline the approval process for local public projects by the SEREMIs in order to expedite actions that address the needs of local communities. For instance, the execution of local projects related to community or economic infrastructure in mining municipalities of Antofagasta, such as expanding health centres or creating parks, green spaces or industrial areas, need approval from the SEREMI of National Goods to access public land. This process is often characterised by bureaucracy and lacks flexibility, further complicating matters for local governments with limited institutional capacity and constrained by the four-year political cycle.

Likewise, local governments also find it difficult to propose projects that need to be accepted by the SEREMI of National Goods, e.g. developing or expanding health centres, a park, a green or an industrial area. This process is often characterised by bureaucracy and lacks flexibility, further complicating matters for local governments with limited institutional capacity and constrained by the four-year political cycle. Therefore, the national government should strengthen the SEREMI of National Goods to allow it to prioritise strategic projects for the well-being of mining communities in Antofagasta that have to deal with a high proportion of public lands and the large number of mining properties owned in the region. This could include improving the technical and human capacity of national institutions, with a particular focus on easing the public land administration and management system.

The definition of responsibilities and financial autonomy for regions is still under discussion in Chile and discussions on a mechanism through which regions can ask for further competencies and resources to be transferred to them are still ongoing. In fact, during the development of this study, the national government announced the entry of a draft law, known as Stronger Regions, for approval by congress, a bill whose objective is to provide greater regional autonomy and financial flexibility and establish better inter-territorial compensation mechanisms and safeguard sustainability and fiscal responsibility. This draft law goes in the right direction as it aims to guarantee better correspondence between the responsibilities and attributions that the law gives to the regional governments and the resources they have for their exercise.

It is worth noting that these discussions of devolving regional powers have occurred in the midst of political unrest that led in 2020 to a plebiscite in which Chileans voted in favour of a new constitution. While the final drafting proposal for the new constitution, presented on 5 July 2022, was rejected, discussions are ongoing to reach agreement on a new constitution.

Therefore, a regional mining strategy for Antofagasta can be that roadmap to strengthen Antofagasta's mining sector and ensure that the mineral wealth provides a long-lasting increase in regional well-being. It will leverage a number of opportunities:

- Improving well-being of communities and Indigenous peoples in the region of Antofagasta by helping address the main development priorities for the region.
- Ensuring mining sector competitiveness and co-ordinating its investments to ensure its role as an economic engine for the region/
- Unifying regional actors around a single vision of the role of mining in regional development.
- Making the most of the ongoing decentralisation process in Chile to improve the regional government capacity and raise the strategic capacity of SEREMIs for the region.

- Improving co-ordination with Chile's national mining strategy to attain efficiencies in investment and programmes, and with other regional development policies, to unlock cross-sectoral synergies in the economy.

The Mining Strategy of Well-being for the Region of Antofagasta

Based on the potential benefits of an Antofagasta regional mining strategy, the next sub-sections describe the main components of this regional strategy, drawing from some best practice examples of national and regional mining strategies across the OECD.

Building the mining strategy for the well-being of Antofagasta

The experience across several OECD countries and regions has shown that strategic planning for extractive sectors is an important tool for economic growth, environmental protection and regional social improvements (reducing inequality and access to opportunities). A mining strategy connects the different actors across the mining value chain and promotes external networks by clarifying the role of mining for regional and national development. In a context where mining faces concerns from some parts of society, a well-designed strategy can help raise awareness among local communities of the opportunities and challenges involved in mining development and outline ways to better share the mining benefits.

A participatory process to legitimise and ensure alignment with local needs

Since October 2022, conducted as part of this study, the construction process of this regional strategy has involved more than 80 in-person meetings and focus groups, either with OECD representatives and peer reviewers of other member countries or organised directly by the regional government and the Catholic University of the North. Some of these meetings combined private and public sector representatives along with academia and civil society in an open discussion about the future of the region and the role of mining. Other meetings gathered specific groups of society to dive deeper into the main priorities and challenges for development. The regional government hast complemented these meetings by identifying ESG initiatives implemented by the different mining companies across the region and priorities informed by the different communities. This process is in line with other mining strategy construction processes in OECD countries (Box 4.4)

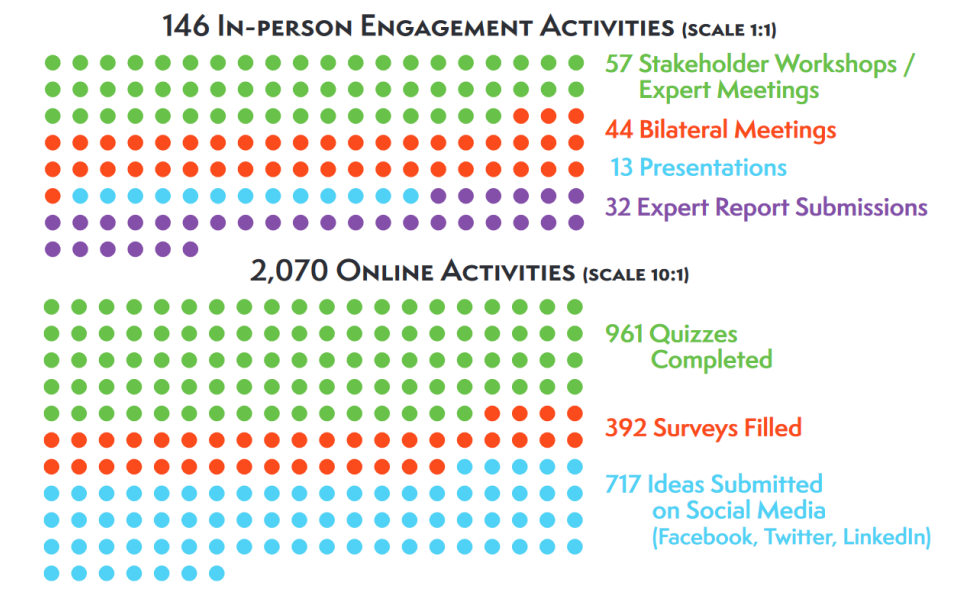
Box 4.4. Engagement strategy in the Canadian Minerals and Metals Plan

The Canadian Minerals and Metals Plan includes a vision, principles and strategic directions that governments, industry and stakeholders can pursue to drive industry competitiveness and long-term success. This generational initiative aims to raise Canadians' awareness of the importance of the minerals and metals sector, respond to ongoing and emerging challenges and help position Canada for opportunities offered by an evolving economy.

This plan was informed by engaging with Indigenous peoples, innovation experts, private companies, industry associations, non-governmental organisations, young people, other stakeholders and partners, as well as Canadians from across the country.

The government consulted with civil society to gather main concerns, ideas and suggestions to inform the plan. This engagement process included in-person activities with workshops, bilateral meetings and expert report submissions. It also adopted online activities through quizzes, surveys and ideas submitted through social media (Figure 4.1).

Figure 4.1. Analytics of the engagement strategy in the Canadian Minerals and Metals Plan



Source: Government of Canada (2019[11]), *The Canadian Minerals and Metals Plan*, https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/CMMP/CMMP_The_Plan-EN.pdf.

This strategy, its objectives and its implementation respect the the Indigenous and Tribal Peoples Convention No. 169 adopted by the International Labour Organization (ILO) (ILO, 1989[12]) and approved by the Chilean congress on 15 September 2009 as part of Chilean legislation. In virtue of this agreement, the implementation of the actions emerging from this strategy needs to consider the active participation of Indigenous peoples by guaranteeing respect for its integrity.

This process can be continued, especially during the phases of monitoring and rebalancing of priorities. Priorities today may not be the same as those in the future and a continuous participation channel to identify priorities is needed to account for changes in local conditions. Building on the efforts already made, the continuous engagement process can go further and involve expert reports in thematic areas and differentiated strategies to reach various types of populations, like social media for youth or radio and mail surveys for the older population.

A long-term vision that moves from past and current concerns towards a path for the future

Setting a clear and ambitious goal in the strategy is useful to align efforts across different levels of government and other regional stakeholders to meet common goals, attract skilled workers and new investors and create partnerships with international actors that support the long-term plan of the region (OECD, 2020[13]). A region with clarity in its long-term goals and certainty in the actions needed to get there becomes attractive for investment and public support.

In Antofagasta, as in other mining regions, discussing the effects of mining on local well-being often times leads to extreme positions across the regional stakeholders. The mining sector benefits and uses the territory's endemic natural resources, which disturb natural ecosystems, require natural resources like water and land and create visual, noise and air pollution. In Antofagasta, many mining operations occur in

lands of Indigenous populations whose beliefs and ways of life can be disturbed by the mining activity. Moreover, in Antofagasta, there is a lack of information on the past and current impacts of mining on the environment and human health.

The strategy's preparation and final output have been a catalyst to contrast the different views of development in the region, conveying main concerns from different parts of the population and reaching common priorities for future development. On the one hand, interviews with regional stakeholders underlined the need to recognise that mining governance in Antofagasta has not addressed the welfare needs of the communities where mining occurs. On the other, mining companies and businesses linked to them require institutional certainty for long-term investments in a sector that is increasingly competitive worldwide.

Despite these apparently different needs, meetings and survey responses from different regional stakeholders indicated that mining is perceived to be one of the engines of the region's future development (Box 4.5). This common understating provides a good basis to build from, as in mining regions – where one single sector represents most of the economic growth – development strategies that are designed at the margin of this sector risk missing the core actors and dynamics for regional development. Therefore, the strategy's vision needs to leverage regional mining assets, to attain greater objectives, such an improved well-being, that meet the expectations of other stakeholders and sectors in the region.

Box 4.5. A recent survey on the perception of mining in the development of Antofagasta

According to a survey of 700 inhabitants of Antofagasta conducted by the Catholic University of the North in April 2023, most people agreed with the development of the mining sector in the region (56%), while a lower share (13%) disagreed totally or partially with the activity. Disagreement against the sector has also decreased (19%) since 2021, with the undecided share increasing since then (from 15% to 30%).

However, the share of people agreeing with the mining activity in the region has decreased since 2021 (from 65% to 56%). Furthermore, when survey participants are asked to reply about how much mining contributes to the development of the region, the share of individuals considering that the sector contributes little or nothing has increased from 31% in 2021 to 46% in 2023.

When the survey asked interviewees which of the axes proposed by the regional government in the Mining Strategy they consider most important, most people ranked well-being and quality of life (36%) as the highest, followed by development in harmony with the environment.

Source: Catholic University of the North (2023[14]), *Results Report Regional Barometer Survey of Antofagasta 2023*, Institute of Public Policy, Catholic University of the North, Antofagasta.

This strategy needs to fulfil the expectations of the different parts of society to regain trust and establish a social agreement that manages to move towards a common goal. This common goal should be built on the recognition of the different priorities:

- Recognising that mining communities in Antofagasta have been left behind in some well-being dimensions and that more needs to be done to ensure local development opportunities.
- Recognising the strategic role of the mining sector in the development of Antofagasta.

Based on this recognition, the long-term vision of the strategy should be one that sets a long-term and aspirational goal for the region: a greater economic and social well-being for mining communities with an internationally competitive mining sector that protects the environment. A well-managed vision becomes a slogan that helps different actors to work in the same direction. As a marketing slogan, the vision needs to be communicated and widely shared, and could translate as follows: “A greater well-being in Antofagasta built on a competitive and environmentally responsible mining sector”.

Mining Stragegy objectives helping to address Antofagasta’s development priorities

The objectives of the Mining Strategy need to address the main regional priorities that help ensure greater quality of life with a more environmentally sustainable and competitive mining sector (Chapters 2 and 3). These main priorities were already identified in the previous chapters of this report and align with those main concerns raised across the multiple meetings and information gatherings with regional stakeholders. Table 4.5 outlines these priorities and their relationship with long-term objectives to attain the vision of the strategy.

Table 4.5. Summary of main development priorities identified for Antofagasta

Area	Priorities
Institutional dimension	Attain an efficient regulatory and institutional framework with the capacity and agility to process environmental permits, authorisation to access land for industrial purposes or monitor compliance with environmental regulations.
Economic well-being	Increase participation of local businesses in background and forward linkages of the mining value chain.
	Increase involvement of the local working force in high-value-added activities in the mining sector. This is especially relevant to adapting skills for the future demands of the industry in the face of an increasing trend of digitalisation of mining operations.
Social and community well-being	Improve access to quality education, health services or environmental amenities (green areas and parks) and drinking water.
Environmental well-being	Conduct an assessment of the mining effect on water systems and the biodiversity in the region and monitor the management of mine tailings and waste.

According to the discussions with the different regional actors throughout the engagement activities and the priorities identified, the regional government should include at least five comprehensive, challenging but trackable objectives in its 2023-2050 strategy. In this strategy, well-being is a horizontal outcome that would emerge by attaining some of the different objectives and sub-objectives. Well-being, the ultimate goal of this strategy, is a multidimensional outcome compounded by the addition of greater economic, social and environmental factors.

This structure of objectives follows the SMART (specific, measurable, action-oriented, realistic and time-bound) model to define the length and formulation of objectives. While these objectives represent a clearer and longer-term goal, framed with basic statements, they also place the region on a challenging and concrete path relative to the strategies of other mining jurisdictions (Box 4.7).

Figure 4.2. Objectives of the Mining Strategy

Source: OECD based on meetings with regional stakeholders.

Box 4.6. Governance SMART model to define general objectives in a strategy

Objectives serve as the basis for creating the policy framework and are fundamental to monitoring and evaluating performance.

The suitability of objectives should be tested against the so-called SMART model. Objectives should be:

- **Specific**: an objective must be concrete, describing the result to be achieved, and focused, contributing to the solution of the problem.
- **Measurable**: an objective should be expressed numerically and quantitatively in relation to a specific benchmark and should allow the progress of implementation to be tracked.
- **Action-oriented/attainable/achievable**: an objective should motivate action and should state what is to be improved, increased, strengthened, etc., but should also be reachable.
- **Realistic**: an objective should be realistic in terms of time and available resources.
- **Time-bound**: the realisation of the objective should be specified in terms of a time period.

The set of objectives should tell the "story" of the strategy in a logical and sequential way, so they should be logically connected. They should be connected to all of the defined and selected problems that require reform and – where multiple layers of objectives are used – should be linked to each other in order to provide a complete picture of the reforms envisaged.

Source: Vági, P. and E. Rimkute (2018[15]), "Toolkit for the preparation, implementation, monitoring, reporting and evaluation of public administration reform and sector strategies: Guidance for SIGMA partners", https://doi.org/10.1787/37e212e6-en.

Box 4.7. Different objectives of national and regional mining strategies across the OECD

Most mining strategies across OECD jurisdictions have a limited number of objectives, less than six, covering most of the challenges of mining regions and addressing transformation brought by megatrends, including climate change and digitalisation.

Table 4.6. Strategic objectives from selected regional mining strategies across the OECD

Strategy	Objectives
Canadian Critical Minerals Strategy	1. Supporting economic growth, competitiveness and job creation. 2. Promoting climate action and environmental protection. 3. Advancing reconciliation with Indigenous peoples. 4. Fostering diverse and inclusive workforces and communities. 5. Enhancing global security and partnerships with allies.
Ontario, Canada: Critical Mineral Strategy	1. Enhancing geoscience information and supporting critical minerals exploration. 2. Growing domestic processing and creating resilient local supply chains. 3. Improving Ontario's regulatory framework. 4. Investing in innovation, research and development. 5. Building economic development opportunities with Indigenous partners. 6. Growing labour supply and developing a skilled labour force.
Western Australia's Mineral and Petroleum Resources Development Strategy 2021	1. A leading global destination for exploration investment. 2. An environmentally and socially responsible industry. 3. An industry that is efficiently and effectively regulated. 4. An evolving industry. 5. An innovative industry. 6. Maximising benefits for all Western Australians.

Source: Geological Survey of Finland (2010[16]), *Finland's Mineral Strategy*, http://projects.gtk.fi/export/sites/projects/mineraalistrategia/documents/FinlandsMineralsStrategy_2.pdf.

The objectives in this strategy require specific goals to measure their success, framed as impact indicators. The specific level to be attained by these indicators in 2030 and 2050 needs to be agreed upon with the main stakeholders in the region. Agreeing on these indicators will be the process of forming regional agreements for the future development of the region. Table 4.7 depicts a suggestion of indicators in a way that is legible and easy to monitor for everyone.

Table 4.7. Impact indicators of strategic objectives

Objective	Impact indicator (examples)
Improve the well-being of local communities and Indigenous peoples	Increased life expectancy in the region
	A greater share of health centres with specialise attention
	Greater share of parks and recreation facilities
Increase the participation of regional businesses in the mining value chain	Greater share of local companies that are providers of mining operations
	Greater share of companies in the circular mining economy
Strengthen skills and the regional knowledge ecosystem	Greater share of the workforce with technical or tertiary education
	Increased investment in innovation (R&D and social) around the green transition in mining

Objective	Impact indicator (examples)
Improve governance for a more productive mining sector	Lower time to process and issue decisions of environmental permits and monitoring
	Lower time to process and issue decisions on land permits
Rehabilitate the environment	Lower GHG emissions in the region
	Reduced use of continental water for mining operations
	More specific measures to mitigate the impact of mining on the environment

This vision and these objectives can also help establish common agreements with regional stakeholders to achieve a shared development target. The government of Antofagasta has reached several common agreements with the private sector and communities to establish concrete commitments from all segments of society to fulfil the goals and vision outlined in this regional strategy. Annex 4.A outlines the commitments that different segments of society have envisaged to agree upon to support the strategy.

Materialising long-term objectives through strategic projects

Attaining the objectives requires specific actions that build trust in the strategy in the short term and ensure a long-term continuous implementation. To this end, a timeframe of strategic projects should be put in place by indicating the projects that are a priority and feasible to implement in the next few years (e.g. 2024-27) and those inscribed on a longer timeline (2030-50).

Selected projects are set to meet the most pressing priorities in the region. These projects have been identified from three types of sources: i) more than 80 meetings with regional stakeholders for the preparation of this strategy, conducted by the regional government and the OECD; ii) direct information provided to the regional government since October 2022 by key stakeholders; iii) assessment conducted by this OECD study (Chapter 2) and the regional priorities already identified by two flagship regional strategies: the regional development plan and the innovation strategy (see next section). Table 4.8 presents a suggested timeframe of strategic projects to attain the five objectives of the strategy.

Table 4.8. Timeframe of strategic project per the objective of the Mining Strategy

Timeframe/ objectives	Improve the well-being of local communities and Indigenous peoples	Increase the participation of regional businesses in the mining value chain	Strengthen skills and the regional knowledge ecosystem	Improve governance for a more productive mining sector	Rehabilitate the environment
Short term (2023-27)	Improve drinking water and sewerage systems in mining communities	Measure the participation of regional companies in the mining value chain and establish a roadmap of opportunities	Support the Lithium Institute to set a roadmap of innovative projects in lithium (e.g. water management)	Improve the capacity of environmental institutions in the region (e.g. Superintendence of the Environment)	Support civic environmental monitoring
	Facilitate the upgrade or installation of quality health centres	Expand the participation of local businesses in mining companies' programmes to upscale providers	Promote apprenticeships in mining across regional schools	Facilitate approval of industrial land (in collaboration with SEREMI of NAtional Goods)	Reduce air pollution from mining operations
	Expand the number of recreational and green infrastructure and public lighting	Promote synergies among mining companies' programmes on local procurement	Complement workforce training programmes of mining companies to make the most of the automation of	Improve collaboration between large and medium/small mining companies	Reduce mining waste generation and facilitate its valorisation

Timeframe/ objectives	Improve the well-being of local communities and Indigenous peoples	Increase the participation of regional businesses in the mining value chain	Strengthen skills and the regional knowledge ecosystem	Improve governance for a more productive mining sector	Rehabilitate the environment
			operations		
Medium-long term (2030-50)	Fund/structure to support the creation of Indigenous businesses	Support technology transfer to regional companies	Adapt basic education to prepare students for the mining automation process	Enhance the capacity of local governments to structure, submit and approve projects	Reduce to a minimum the use of inland water for mining activities
	Fund/structure to promote economic diversification (e.g. agriculture in the dessert, artisanal fishing)	Internationalise the regional mining providers	Support a network of research centres for the mining of the future	Ensure that processes for metal recovery or extraction (e.g. oxide leaching) are achieved on time and with high environmental standards	Evaluate the mechanisms to return water rights to the communities
	Improve tertiary roads and broadband infrastructure	Support local entrepreneurs/small and medium-sized enterprises (SMEs) to work circular economy activities in mining (recycling of lithium)	Support professional development	Promote greater use of renewable energies in mining operations (e.g. speeding up permits for interconnection and generation)	Produce an environmental diagnosis of the region

The short-term projects already identified for the strategy are part of the pipeline of projects to be developed in the regional plans or linked to the mining companies' CSR plans. These short-term projects can help create local alliances to work towards a unified vision and rebuild trust at the regional level by demonstrating that change.

The long-term projects are not described in detail in this document but aim to outline the main priorities identified in the region. For example, the creation of a fund to support Indigenous businesses emerged from the need of entrepreneurs and SMEs in mining communities to make business plans marketing strategies, use technological solutions and access financing. This project can get inspiration from the Canadian Council for Aboriginal Business (n.d.[17]).

Table 4.9. Short-term projects of the Mining Strategy

Objectives of the strategy	Short-term strategic project 2027	Objectives and description
Improve the well-being of local communities and Indigenous peoples	Improve drinking water and sewerage systems in mining communities	Leverage existing programmes of mining companies (e.g. AMSA or BHP) to ensure mining companies improve the network of drinking water (and add public points) and the sewerage infrastructure.
	Facilitate the upgrade or installation of quality health centres	Partner with mining companies to establish health centres, particularly outside the city of Antofagasta. Some needs include centres of preventive community care and cancer diagnostics.
		Upgrade current centres with missing specialities e.g. mammography.
	Expand the number of recreational, green and cultural infrastructure	Collaborate with mining companies to expand recreational, green and cultural in mining communities, with government support to ensure their operation in the long run.

Objectives of the strategy	Short-term strategic project 2027	Objectives and description
Increase the participation of regional businesses in the mining value chain	Measure the participation of regional companies in the mining value chain and establish a roadmap of opportunities	Clearly measure the share of companies registered in Antofagasta that are direct providers of mining companies.
		Identify future needs of mining companies to procure locally.
	Expand the participation of local businesses in mining companies' programmes to upscale providers	Improve the innovative capacity of regional companies.
	Promote synergies among mining companies' programmes on local procurement	Map and make visible ongoing programmes and their results.
		Help solve challenges to involve more local businesses.
Strengthen skills and the regional knowledge ecosystem	Promote apprenticeships in mining across regional schools	Improve the skills of basic education students to get involved in mining processes with high-added value.
	Support the Lithium Institute to set a roadmap of innovative projects in lithium (e.g. water management)	Ensuring that the decision-making board includes various stakeholders.
		Support the definition of research lines with concrete objectives (e.g. improvement of water use processes).
	Complementing workforce training programmes of mining companies to make the most of the automation of operations	Map and provide visibility to the mining companies' workforce training programmes.
		Promote involvement of universities, embedding part of the programmes in educational supply.
Improve governance for a more productive mining sector	Improve the capacity of institutions in charge of environmental monitoring and environmental permitting in the region (e.g. SEREMIs, The Superintendence of the Environment)	Establish a joint agreement with the national government to improve the staff and technical capacity of the SEREMI of the Environment.
	Improve collaboration between large and small/medium mining companies	Improve business opportunities for small/medium mining companies with the collaboration of large mining companies.
	Facilitate approval of industrial land (in collaboration with SEREMI of National Goods)	Establish an agreement of understanding with the SEREMI of National Goods to speed up priorities of land approval.
Rehabilitate the environment	Encourage civic environmental monitoring	Provide communities with equipment and capacities to carry out independent environmental monitoring (learning from experiences of Albermarle and SQM).
		Support the transfer of monitoring stations from mining companies to the Ministry of the Environment and partner with the ministry to involve citizens and create clear information.
	Reduce mining waste generation and facilitate its valorisation	Support monitoring and quantification of mining waste generation.
		Facilitate alliances with national or international companies to valorise waste mining and create new business opportunities.
	Reduce air pollution from mining operations	Incentivise and support companies' initiatives to reduce air pollution from mining operations, e.g. improving belt covering road wetting.
		Share good practices among companies.

Many of the strategic projects consist of creating better alliances with mining companies or universities to give continuity and scale to the projects already in the pipeline. An important action is related to giving visibility in a unified way to all of the projects that mining companies are carrying out. Mining companies initiate and continue workforce training, sewerage improvement or street lighting programmes. However, given their atomisation, the population is not aware of these private initiatives, their impact and their investment. The Mining Strategy website must fulfil this task of diffusion.

Links with other regional development strategies

This Mining Strategy cannot replace the regional development plan but it can contribute to attaining long-term regional development objectives and create synergies with other sectoral plans. The weight of the mining activity in Antofagasta makes it a sector with links across various areas of development and, if well-managed, a potential engine for other economic sectors in the region, such as tourism, agriculture or manufacturing. This Mining Strategy comes at the end of the first development plan (2021-24) built by a democratically elected government. Thus, it can leverage the development objectives of that plan and maintain the efforts in implementing some of the unfinished projects.

The regional government of Antofagasta has issued two other relevant strategies to guide the development of the region: the 2021-2024 Regional Development Plan and the Regional Innovation Strategy 2022-2028. The regional development plan places an important focus on increasing civil participation, improving service provision and environmental protection, as well as updating land use and territorial planning instruments. The plan also highlights the importance of innovation and diversification for the development of the region (Regional Government of Antofagasta, 2021[18]).

The Regional Innovation Strategy 2022-2028 is based on the smart specialisation strategy of the European Commission, aiming at integrating government policies to address the key priorities and mobilise the competitive advantages of the region though technological and non-technological innovation. This strategy recognised that Antofagasta is one the most innovative regions in the country, with the greater number of companies in terms of innovation rates (data for 2015-16, see Chapter 2), which is driven mainly by the mining sector, whose innovation centres mainly on business process. Yet, innovation in mining is mainly in house and with low levels of spillovers to other economic sectors. This smart specialisation approach rightly identifies a sustainable mining sector as the backbone activity to build on in order to boost the regional innovation ecosystem. Therefore, the other two regional specialisation areas identified by the strategy are: i) Nature Labs to mobilise environmental amenities (astronomy, renewable energy); and ii) niche tourism.

The Mining Strategy has synergies with different action lines of the regional development plan (Table 4.10), which requires aligning funds and efforts to accelerate the implementation of common strategies. These potentially common strategies include greater involvement of civil society in planning mining strategy governance mechanisms, improving health and education supply, supporting economic diversification and strengthening water management, reuse and recycling.

Table 4.10. Examples of synergies among the 2021-2024 Regional Development Plan and the Mining Strategy

	Main axis	Selected action lines with synergies with the Mining strategy
Strategic axis of the 2021-2024 Regional Development Plan	Civil participation (5 action lines)	• Constitution and operation of the regional Civil Society Council (COSOC) • Pilot plan of participatory budget
	Social protection (8 action lines)	• Improving health infrastructure • Offering a better housing supply and urban regeneration • Increasing coverage of education and rebuilding technical schools in some areas
	Territory and development (7 action lines)	• Building the Land Use Development Plan • Setting up a “Bio Oceanic” corridor to ease freight transport from neighbouring countries to Antofagasta’s ports
	Diversity and innovation (5 action lines)	• Mobilising and diversifying the productive matrix of the region with support to SMEs and entrepreneurship • Strengthening sectors of high potential: astronomy, agriculture in the desert or biotechnology • Developing the mining strategy

	Main axis	Selected action lines with synergies with the Mining strategy
	Harmonious environment (6 action lines)	• Setting up a regional water strategy, including new treatment plants for some communities • Setting up a regional green hydrogen strategy • Setting up a regional policy on circular economy and recycling
Regional Innovation Strategy 2022-2028	Mining committed to and from the territory	• Mining as an engine of economic development for sustainable development • Mining and digital transformation of the industry • Boosting the regional knowledge economy in the mining value chain
	Nature Labs	• Astronomy and space science • Agriculture in the desert • Biodiversity and biotechnology • Ecosystem of the coastline
	Niche Tourism	• Improving enabling conditions to strengthen tourism (e.g. broadband, information) • Tourism of experience • Antofagasta as Destination 4.0

Links with other development strategies in the region can be promoted through the following actions:

- Creating shared investment lines that target objectives of different regional strategies.
- Ensuring common goals with other development strategies, which can be translated into common outcome indicators.
- Including representatives of institutions in charge of other regional policies in the monitoring process of this strategy.

Governing, implementing and monitoring the Mining Strategy

Setting a sound governing system to oversee, monitor and adjust a long-term strategy is as important as the definition of objectives and strategic projects. A long-term strategy such as this one requires the engagement of regional stakeholders and clear long-term financial sources to ensure the efforts to attain the objectives are continuous, regardless of any political change in the regional government.

A governance mechanism to monitor progress and ensure sustainability in the long run

For the strategy to be successful and lasting, a governance mechanism capable of making the strategy last beyond political cycles must be implemented, which allows prioritising projects and deciding the best way to implement them, as well as monitoring their results until 2050. Based on international practices, this governance must be made up of various actors in the region, with a clear structure of participants and an established decision-making capacity and frequency of meetings. Other OECD regions like Brainport in the Netherlands or Morelos in Mexico have adopted multi-stakeholder governance models to oversee the design and implementation of key strategies for regional development.

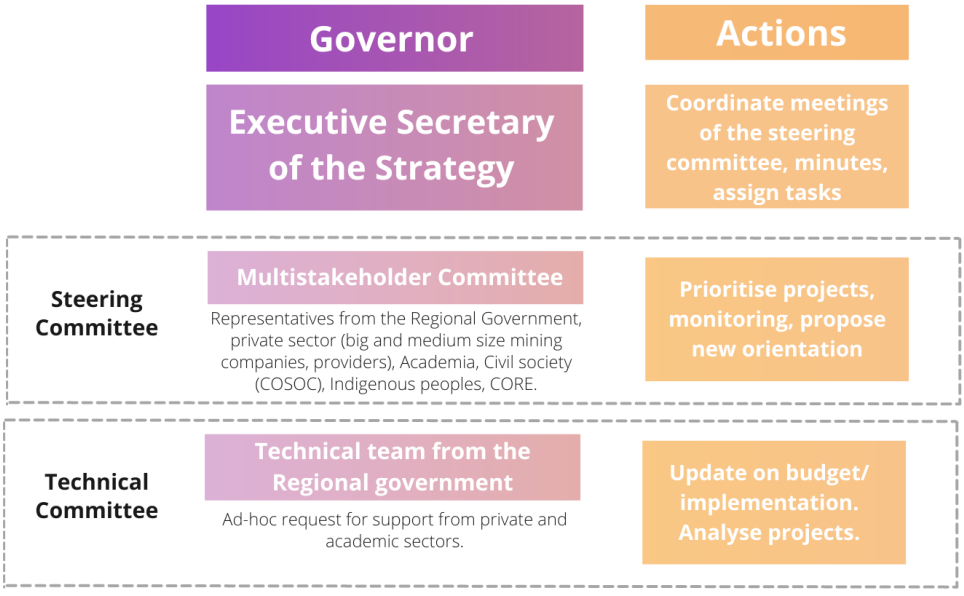
Figure 4.3 describes the suggested governance scheme for Antofagasta, which has the following characteristics:

- The executive secretary of the strategy represented by a government official with a defined budget and team for operation and co-ordination.
- The steering committee prioritises and monitors projects, and proposes new orientations to the strategy. It could be composed of different regional actors with periodic rotation (e.g. two years) whose decisions are made unanimously. The committee should consist of at least one representative from the following groups:
  - Communities: regional or municipal COSOC, among others.

- Indigenous peoples: representatives of Indigenous Development Areas and CONADI.
- Regional Council of Antofagasta (CORE)
- Large mining companies.
- Small and medium-sized mining companies.
- Academia.
- Regional government: co-ordinator of the strategy.

- The technical committee in charge of structuring and finding operators for the strategic projects, providing updates on the progress of the project and the budget, and responding to other requests from the steering committee. This committee is made up of an executive secretary with a team of professionals in collaboration with personnel from academia and private companies.

Figure 4.3. Suggested governance scheme of the Mining Strategy



Monitoring the strategy with hierarchical indicators

Antofagasta's Mining Strategy needs a monitoring framework with a clear differentiation among impact, outcome and output indicators (Schumann, 2016[19]) (Box 4.8).

- Impact indicators measure the long-term policy impact of achieving each of the strategic objectives. This impact indicators are actionable when it is horizontal to all five objectives. In this strategy, a clear impact indicator is the improvement of economic, social and environmental well-being in Antofagasta with a competitive mining sector. The government should choose a limited number of variables to measure the improvement of the multidimensional well-being and the competitiveness of the mining sector. The impact indicator is rather a referent and cannot be seen as directly reflecting the effect of implementing the strategy, as many other factors can influence the attainment of objectives in the long term.
- Outcome indicators measure the medium-term effects of implementing each strategic project in each of the objectives. In other words, outcome indicators measure the reason for implementing the strategic project in the first place.
- Output indicators measure the implementation of each strategic project and its operative tasks.

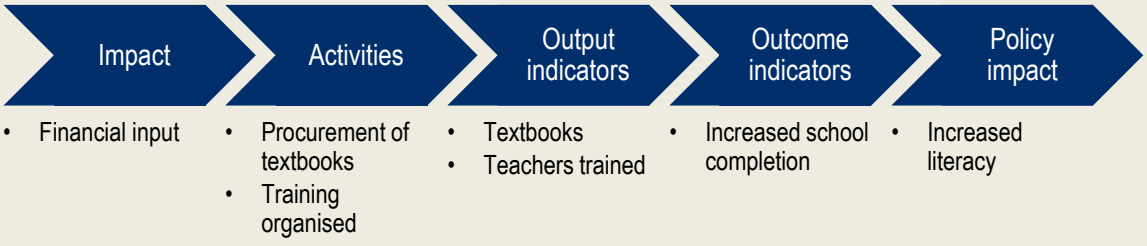
Box 4.8. Example of a result policy chain in the European Union

Monitoring the achievements of the 2014-20 European Cohesion Policy is based on specific indicators (common indicators) associated with the priority axis, category of regions (where relevant) and investment priority in each European operational programme. Each indicator has a baseline target to reach and is monitored during the entire programming period.

Figure 4.4 below shows an example of how a European Union-funded project – in the field of early childhood education – would trigger (measurable) changes at different levels, forming a "result chain". After the initial financial commitment and the activities implemented on the ground, it generates a direct output (in this example, the number of textbooks distributed to students and the teachers trained by the project), producing the project's intended outcome (increasing school completion). The outcomes of multiple projects generate the overall policy impact (e.g. increased literacy).

Indicators associated with each stage of the chain should be carefully monitored and evaluated against suitable counterfactuals (what would have happened without the project/policy?). Monitoring and evaluation should be part of gradual, transparent, evidence-based policy learning (Crescenzi, de Blasio and Giua, 2018[20]).

Figure 4.4. Example of result chain in the EU



Source (figure): Adapted from EC (n.d.[21]), *EuropeAid - DEVCO 06 - Quality and Results*, European Commission; Crescenzi, R., G. de Blasio and M. Giua (2018[20]), "Cohesion policy incentives for collaborative industrial research. Evaluation of a smart specialisation forerunner programme", https://doi.org/10.1080/00343404.2018.1502422; Crescenzi, R. (n.d.[22]), "Indicators for territorial public policy: the case of the European Union".

The strategy also needs to promote horizontal performance indicators with a sense of complementarity to avoid duplication of tasks across the parts of the government implementing the strategic projects. The success of some transversal efforts, such as infrastructure development, inclusion of small businesses or environmental protection, can benefit from transversal indicators to co-ordinate actions across different parts of the regional government. For example, strategic projects involving infrastructure development (e.g. green parks, health centres) need the participation of different divisions of regional government (e.g. Division of Infrastructure and Transport and Division of Planning and Regional Development) along with the co-ordination of different national agencies (e.g. SEREMI of National Goods, SEREMI of the Environment or SEREMI of Health).

Table 4.11 provides an example of monitoring indicators for the strategy and the short-term strategic projects.

Table 4.11. Examples of monitoring indicators for the Mining Strategy

Objective of the strategy	Strategy project	Output indicator (example)	Outcome indicator (example)	Impact indicator (example)
Improve the well-being of local communities and Indigenous peoples	Facilitate the upgrade or installation of quality health centres	Number of health centres built or upgraded	Change in waiting times to access specialists or a healthcare intervention Share of communities covered by secondary health	Increased life expectancy in the region
Increase the participation of regional businesses in the mining value chain	Expand the participation of local businesses in mining companies' programmes to upscale providers	Number of local businesses and SMEs from new towns in Antofagasta that are part of a mining company upscaling/ training programme	Change in the capacity of local businesses to provide services to mining activities	Increased participation of local businesses in the mining value chain
Strengthen skills and the regional knowledge ecosystem	Promote apprenticeships in mining across regional schools	Number of secondary students in apprenticeships in mining companies	Share of young population with training or education in mining activities	Greater share of the local workforce in high-value-added positions in mining companies
Improve governance for a more productive mining sector	Improve the capacity of environmental institutions in the region (e.g. SEREMIs, the Superintendence of the Environment)	Number of new staff in the SEREMI of the Environment and Supervisor of environment Number of processes that are done digitally	Number of permits processed per year Number of decisions appealed that are finalised	Reduce time to process and issue decisions linked to environmental permits and monitoring
Rehabilitate the environment	Support civic environmental monitoring	Number of environmental monitoring stations managed by civil organisations	Increased data on air pollution in different areas of the region	More specific measures to mitigate the impact of mining on the environment

Financing the tasks to meet the strategic objectives

The strategy needs long-term and formal financial budget lines to cover the operational tasks of the team co-ordinating the strategy and supporting the implementation of short-term and long-term projects. Some short-term strategy projects are already costed and partially funded by the mining companies or the government budget. For example, the strategic project Improve Drinking Water and Sewerage Systems in Mining Communities can leverage upcoming projects in the region, like the new wastewater treatment plant in Antofagasta to be operated by the Concessionary Company of Sanitary Services (ECONSSA Chile s.a) with an estimated value of USD 250 million.

Changes in the management of regional governments' financial sources and more flexibility and transparency are part of the discussion of decentralisation in Chile with the bill Stronger Regions, presented at the same time as the elaboration of this report. Therefore, clear autonomy and long-term financial sources for the mining strategies can be further defined in the coming months.

Regardless of the changes in the financial autonomy of the region, the regional government needs to ensure that the strategy has long-term and formal financial sources, with some strategic long-term projects attached to multi-year budgets. The government would have the capacity in the short term to use the new resources provided by lithium developments and complement them with investment funding from the National Fund for Regional Development, which finances all kinds of investment initiatives (basic studies, programmes and projects) of any public investment sector (education, culture, health, sport, etc.) that are framed within the regulations of the National Investment System (SNI).

The government should also seek a mechanism that facilitates co-funding from private companies for the implementation of specific projects. Some of the strategic projects identified for the short term are initiatives that mining companies have already put in place. Complementing this funding to expand the initiative or ensure sustainability in time is a priority for the strategy.

The role of municipal governments

As mines are geographically located, mining requires a place-based policy approach that accounts for the singularities of the hosting areas. It is instrumental in defining the possible effects of mining on local economies and ensuring local governments are aligned with the policies so as to increase social license to operate mining ventures.

Integrating municipal development plans and views in the Mining Strategy can be done through active and formal co-ordination mechanisms. While the regional government has regular interaction with local governments, this co-ordination is not formally institutionalised. Instead, it occurs through a case-by-case scenario for specific projects or to address particular issues. Aligning the Mining Strategy with the municipal development plans should be the first step to closer collaboration. The regional government should also establish a formal communication channel to ensure the continuity of co-ordination over time. This channel could be included within a formal multi-stakeholder working group on mining development that meets regularly (see next section).

The role of civil society

The concept of inclusive policy making through stakeholder engagement largely overlaps with that of open government. As a result, openness and inclusion represent two pillars to deliver better policy outcomes not only for but with citizens. Today, inclusive policy making through stakeholder engagement is set to enhance government accountability, broaden citizens' influence on decisions and build civic capacity (OECD, 2016[23]). Local communities not only have better knowledge of local conditions but also the capacity to adapt policies to the context. In addition, the participation and involvement of citizens are associated with higher levels of policy compliance and an important driver of legitimacy and trust in the government.

Antofagasta benefits from a good structure of civil society organisations. The COSOC is a citizen body that has a role in municipal governments and the regional government by being part of social co-responsibility processes between citizens and the government and monitoring public actions. This council can be instrumental in transmitting progress and changes in community priorities to the steering committee of the Mining Strategy. It should also help monitor the implementation of the projects and identify possible issues that might emerge from or within the communities.

Furthermore, communities in Antofagasta also benefit from the Neighborhood Councils (*juntas de vecinos*), territorial community organisations that represent the inhabitants of a community before the authorities and that are formally regulated by law. Their aim is to inform municipal decisions, propose projects that benefit the community or manage the solution of problems before the authorities (Biblioteca del Congreso Nacional de Chile, 2014[24]). These Neighborhood Councils can further support the role of the COSOC and be in charge of monitoring the implementation of the strategy in their communities.

Partnering with Indigenous communities

Since Chile implemented its Indigenous Law No. 19.253 in 1993 and ratified ILO Convention 169 in 2008, Indigenous communities have been negotiating with the lithium industry (Lorca et al., 2022[25]). These negotiations have included different forms of participation for Indigenous communities and indirectly helped them organise themselves to ask for greater decision power. Agreements have allowed Indigenous

communities – especially *Atacameño* communities[1] – to get involved in environmental monitoring and establish benefit sharing in the form of jobs or compensatory payments.

This strategy needs to acknowledge Indigenous land rights and involve these communities to map and help standardise the benefit-sharing agreements to be conducted with the mining companies. This implies clarifying the mechanisms and measures to share mining benefits locally. A clear framework for benefit-sharing agreements can help the region understand how private companies relate to Indigenous communities and non-Indigenous groups. This should aim to organise a more standard approach for the relationship between mining companies and the population. If well designed, these agreements are important tools to increase economic opportunities and quality of life for host communities and reduce social conflict around mining (O'Faircheallaigh, 2013[26]). There are different types of benefit-sharing agreements:

- Monetary benefits (also known as benefit funds) include payments, profit sharing, tax sharing (e.g. royalties) and investment funds.
- Non-monetary benefits comprise local hiring, skills development, education, cultural support and environmental protection and remediation. In terms of governance, agreements can be government-controlled, voluntary company-led initiatives and partnership models, among others (Söderholm and Svahn, 2014[27]).

Besides the type of agreement, the extent to which benefit-sharing agreements deliver robust results for communities comes down to how they are governed and implemented. Some agreements are privately negotiated and legally enforceable (some non-monetary benefits agreements), while others are general financial structures with revenues collected by governments (e.g. benefit funds). These agreements can be government-controlled, voluntary companies-led initiatives, partnership models or ownership and control models. While the government leads actions in the government-controlled type, it may equally play some role in voluntary, company-led and partnership models as a facilitator (Box 4.9).

Box 4.9. Lessons from benefit-sharing agreements in the context of Indigenous communities

Benefit-sharing agreements and funds are often established at the onset of resource development or the extraction process and set out a financial or working relationship that spans its lifetime. Benefits may include payments, profit sharing, local hiring, skills development, education, cultural support and environmental protection and remediation, and takes several forms and governance types.

Table 4.12. Benefit-sharing models and governance types

A. Government-controlled benefit sharing	
Resource sharing revenues/benefit funds	Sharing of industry revenues collected by governments with Indigenous peoples and/or communities. This includes but is not limited to taxes, royalties, penalties, permits and other fees.
Local content obligations	Targets for the hiring of local workers and procurement of local goods and services may be included in host government agreements with companies and, in some cases, legislated. Government-mandated local content is frequently interpreted as "national" content rather than targeting local and Indigenous communities.
Mandatory social investment	Social investment spending can be mandatory as part of a host government agreement or national legislation, whereby companies are required to invest in infrastructure programmes, such as road construction or health facilities, as a condition of their licence.
B. Voluntary company-led initiatives	
Voluntary engagement	Companies may voluntarily adopt community engagement and/or investment in addition to their mandatory obligations under the law.

Strategic social investment	Social investment spending on programmes is designed to survive beyond the life of the industrial project and/or to create value for the industrial project. These might include micro-credit programmes, local livelihood support programmes, skills training, enterprise development support or conservation programmes.
C. Partnership model	
Voluntary local content initiatives	Companies may develop partnership programmes based on voluntary targets and initiatives to train and bring in the local and Indigenous workforce to a project, with training and enterprise support linked to opportunities to secure employment or contracts, often with an element of preferential contracting. This may or may not form part of a wide benefit-sharing agreement.
Private benefit-sharing agreements	Benefit-sharing agreements are negotiated directly with communities and may include payments, profit sharing, local hiring, skills development, education, cultural support and environmental protection. These are likely to be closely related to impact assessments and may also provide the basis for a process that reflects principles aligned with the concept of free, prior and informed consent (FPIC). Benefit-sharing agreements may include benefit funds: the payment and management of royalties from development activities to affected Indigenous communities and peoples.
D. Ownership and control	
Community ownership	Community ownership of companies or equity shares in enterprises involved in extracting or processing resources or enterprises providing services to the industry. Opportunities can be enhanced through government support and preferential contracting.
Community control	In the case of Indigenous peoples, control relates to Indigenous peoples' right to determine their own development priorities and strategies and includes participation in strategic-level decision making on resource-related policies, programmes and regulations, including resource mapping, zoning and land allocation and environmental processes (such as remediation) and FPIC.

Source: Adapted from Raderschall, L., T. Krawchenko and L. Leblanc (2020[28]), "Leading practices for resource benefit sharing and development for and with Indigenous communities", https://dx.doi.org/10.1787/177906e7-en; Wilson, E. (2019[29]), "What is benefit sharing? Respecting Indigenous rights and addressing inequities in Arctic resource projects", http://dx.doi.org/10.3390/resources8020074.

The role of the private sector and academia

The private sector and academia are also fundamental in this strategy. The mining companies in the region have been one of the main promoters of diverse initiatives to improve local well-being. While often company-driven and dispersed, they have created links with local needs and helped companies establish relationships with the communities. Companies can help the implementation of the strategy mainly by committing their support and collaboration in different forms, first, sharing information with the government about projects, agreements with communities, environmental information and labour force needs. All companies in Antofagasta have a community relationship officer who should play a facilitator role in implementing this strategy.

Second, mining companies can support the implementation of some strategic projects either by sharing the capacity to structure projects or facilitating the expansion of their individual projects. Mining companies in the region tend to concentrate on the most skilful professionals and have relevant planning capacities. Finally, some resources allocated to individual ESG or CSR projects can be allocated to strategic projects in this strategy for greater impact and a more sustained outcome.

The region benefits from an important presence of private and public universities and higher education institutions. There are two public and five private universities along with at least seven educational and professional institutes. This network of institutions can be co-ordinated to improve capacities in the region, aligning the educational offer with the needs of the mining industry and diversification plans within the value chain in line with the projects identified in this Mining Strategy. Tertiary and secondary education institutions are relevant actors in the governance mechanism of the Mining Strategy They are needed to guide some strategic projects in education and innovation, as well as support the capacities of the regional government for planning and implementation when necessary.

Conclusion

The Mining Strategy can help the region of Antofagasta capitalise on the increased global demand for its minerals and make the most of the digital and green transitions with the aim of delivering greater well-being standards to its inhabitants.

This strategy needs to start by recognising the role of mining in the regional economy and the need to close the welfare gaps of the many mining communities that have been left behind.

This recognition process has been part of the strategy-building process, which has focused on thinking about what the region needs to achieve a better future for all by 2050.

This future is guided by the vision of “A greater well-being in Antofagasta built on a competitive and environmentally responsible mining sector” and materialised by the five objectives that have been co-identified with regional stakeholders. To achieve each objective, short- and long-term concrete projects have been defined, with monitoring and impact indicators.

Implementing this strategy requires a joint effort of the different regional stakeholders to participate in the governance mechanism of the strategy, monitor project implementation and adjust the path to achieving the different objectives.

Annex 4.A. Potential commitments between the regional government of Antofagasta and stakeholders to support the regional strategy.

Annex Table 4.A.1. Potential commitments between the regional government of Antofagasta and stakeholders to support the regional strategy.

Thematic of the commitments		Commitments
Environmental dimension	Transition to more sustainable mining.	With large mining companies: Move towards sustainable mining, developing the mineral and energy resources of the region and the country in a way that maximises economic and social benefits while minimising environmental impacts by 2030
	Water transition: reduction of inland water use.	-Metallic Mining: Decrease inland water use by 60% in all operations by 2030. -Non-Metallic Mining: Decrease inland water use in all operations by 40% by 2030.
	Energy transition: use of renewable energies and solar hydrogen.	-Metallic Mining: Enable 100% clean energy matrix by 2030. -Non-Metallic Mining: 100% of energy contracts coming from renewable sources by 2031.
	Reduction of greenhouse gases.	Metallic Mining: Reduce operational GHG emissions by at least 30% by 2030. Non-metallic mining: -Lithium: Carbon neutral by 2030. -Nitrate Iodine NY: 50% reduction of Scope I and II emissions by 2021.
	Reduction of air, land and water waste generation	Large mining companies: Reduction by 2030 of 50% of the industrial waste generated, by reusing, recycling or revalorising it.
	Commitment to bio-diversity and the conservation of natural capital and its restoration	Government agencies: Assess and address risks and impacts to biodiversity and ecosystem services by implementing strategy(ies) that promote conservation, restoration and/or regeneration by 2030. Aiming for 30% of land and water to be under a conservation, restoration or regeneration programme by the end of 2030.
	Transparency in environmental monitoring systems	Government agencies: Having Environmental Management Systems adjusted to global frameworks that comply with regular updating, strategic plans for dissemination and provision of public information by 2030. Aiming to transfer air quality monitoring stations to the Ministry of Environment by 2030
Social Dimension	Quality education to develop opportunities	Establish an education roundtable as an integral part of governance, in collaboration with the regional authority, to coordinate and implement quality education programmes in our region's schools by 2030.
	Contributing to the development of attractive cities	Establish a coordination table within the framework of the mining strategy to increase the attractiveness and wellbeing of the cities in our region. Its objective is to strengthen regional/local technical, financial and institutional coordination capacities to improve infrastructure in all communes of our region by 2030
	Increasing female labour participation in the mining industry	Metallic mining: 30% female staffing committed by 2025. Non-Metallic Mining: We aim to reach 30% by 2030
	Increased participation of local employment in the mining industry.	Large mining companies: Promote the hiring of local labour in all mining operations and promote the hiring of local workers in all contracting companies by 2030. In addition, seek to increase indigenous representation by 2030, based on a set of initiatives that encourage the participation of this segment in job offers.
	Contribute to the sustainable development of local communities.	Large mining companies: Operate with the highest standards of community engagement by 2030, in order to develop the mining industry in a responsible manner in the territories where operations are carried out.
	Regional commitment to competitive and innovative mining with world-class	Metallic mining: To have Cooper Mark certification and ICMM requirements by 2030, demonstrating that the extraction, processing and marketing of raw

	standards	materials are carried out under the highest global standards in terms of safety, productivity, sustainability and community engagement. Non-metallic mining: IRMA certification by 2030, demonstrating that the extraction, processing and marketing of raw materials are conducted to the highest global standards of safety, productivity, sustainability and community engagement.
Economic dimension	Strengthen the participation of local suppliers in the mining value chain.	Promote and multiply the increase in the hiring of local suppliers through programme(s) aimed at boosting regional economic development by 2030.
	Development of common logistics and infrastructure	Establish a governance coordination table to facilitate collaboration between mining companies and the public sector, with the aim of promoting the development of coordinated management of common regional logistics and infrastructure by 2030.
	Strengthening partnerships with regional universities in innovation and technology.	Recognise local universities as key partners in the development of knowledge, technologies and the training of professionals needed for the mining industry of the future. It enhances the commitment to strengthen resources and collaboration programmes with academic institutions by 2030.
Institutional Dimension	Developing a strong and coordinated regional institutional framework	To have a modern, transparent institutional framework with efficient management, ensuring the development of the industry for the benefit of the country.
	Strengthening of resources and capacities in the regional public sphere.	To have a legal framework and sufficient human resources for long-term sustainable economic growth and development.
	Capacity building for public good development	Promote the development of human resources with capacities for the design, elaboration, implementation and evaluation of public goods..
	Strengthening the institutional framework for innovation and productivity	Enhance the development of a regional system for productivity and sustainability, which integrates a framework for the economic, social and environmental sustainability of small and medium mining, taking advantage of all the regional wealth.

Source: Data provided by the Government of the region of Antofagasta on September 2023.

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Note

[1] Atacameño communities inhabit the oases, valleys and ravines of the Salar de Atacama and Loa River basins, located in the Antofagasta Region of Chile. Small populations are also found in northwestern Argentina, in the puna of Salta and Jujuy, and in the southwestern highlands of Bolivia.

OECD Rural Studies

Mining Regions and Cities in the Region of Antofagasta, Chile

TOWARDS A REGIONAL MINING STRATEGY

Antofagasta is a world leader in copper and lithium production, with strategic importance for the global energy transition and for the economic development of Chile. Located in north Chile, Antofagasta is carved by the natural contours of the Atacama Desert and home to diverse Indigenous communities. Despite the wealth brought by mining, communities in Antofagasta lag on a number of well-being dimensions. At the same time, Antofagasta's mining industry is entering a new phase of development, driven by the expected surge in global demand for its minerals and the imperative to adapt to the green and digital transitions.

Against this backdrop, a new development vision with a long-term strategy is warranted in the region to leverage mining benefits to improve well-being standards and take advantage of the opportunities brought by the digital and green transition in mining. This study presents the diagnosis, rationale and building blocks for a new mining strategy in the region of Antofagasta, Chile that prioritises well-being standards and opportunities for local communities. This medium and long-term strategy aims to create a new pact amongst different societal stakeholders to build trust and unite efforts for more inclusive and sustainable growth in the region.

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