Economic diversification strategy for Antofagasta with a focus on Mejillones

Case Study and inputs for its elaboration

September 2025

Just Energy Transition in Coal Regions

The Innovations Regions for a Just Energy Transition project is jointly funded by the German Federal Ministry for the Environment, Climate Action, Nature Conservation and Nuclear Safety (BMUKN) under the International Climate Initiative (IKI) and by the European Commission's Directorate-General for International Partnerships (DG INTPA) for the Just Energy Transition in Coal Regions Interregional Platform (JET-CR). The project is implemented by a consortium of organisations led by GIZ as Joint Project Coordinator and with the Climate Action Network (CAN), International Institute for Sustainable Development (IISD), International Labour Organisation (ILO), Wuppertal Institute für Klima, Umwelt, Energie GmbH, Solidarity Center, and APHEDA as implementing partners.

IKI JET and its JET-CR Platform aim to support and accelerate just energy transitions away from coal to renewable energies and other sustainable economic activities in Colombia, Chile, South Africa, Indonesia, Vietnam, Thailand, and Mongolia.

The **Just Energy Transition in Coal Regions (JET-CR) Knowledge Hub** is an online platform building bridges between experts, policymakers, coal industry, trade unions and civil society organizations. It's a space to bring together different perspectives, share real stories and search for effective tools and solutions.

It aims to particularly amplify the voices of workers and communities dependent on coal showing how knowledge can work in practice. It also turns practice into knowledge by bringing local experience into global conversations and advancing just energy transition expertise.

Providing regular digests of articles, research papers, news stories and events it serves as a "one-stop shop" for collecting up to date information related to just energy transitions away from coal around the world.

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Implementing partner

Executive Summary

The case study *"Economic diversification strategy for Antofagasta with a focus on Mejillones - Case Study and inputs for its elaboration"* was elaborated in the framework of the project "Just Energy Transition in Coal Regions - Interregional Platform (JET-CR Platform)" and its effort to support coal-dependent regions in the Global South to diversify their economies and move towards green and inclusive growth.

This study applies the tools of the digital handbook for the development of economic diversification strategies in coal regions, developed by the Interregional Platform, to the case of the Antofagasta region (Chile), with a special focus on the district of Mejillones. It combines analytical methodologies with the participation of local actors, generating inputs for the formulation of an economic diversification strategy.

The approach adopted allows us to assess the economic, social and environmental conditions of the region, to identify sectors and products with growth potential, and to co-create strategic objectives with relevant stakeholders.

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Abbreviations

BACI	Base pour l'Analyse du Commerce International (International Trade Database)
CCM	Consejo de Competencias Mineras (Antofagasta Council of Mining Competences)
CDEA	Centro de Desarrollo Energético Antofagasta (Antofagasta EnergyDevelopmentment Centre)
CEPII	Centre d'Études Prospectives et d'Informations Internationales (French center for research and expertise on the world economy)
CITSEJ	Comité Interministerial de Transición Socioecológica Justa (Inter-Ministerial Committee for a Just Socio-Ecological Transition)
CORFO	Corporación de Fomento de la Producción (Production Development Corporation)
CRAS	Consejo para la Recuperación Ambiental y Social (Council for Environmental and Social Recovery)
DIVE	Diversifying Industries and Value Chains for Exports
ECLAC	Economic Commission for Latin America and the Caribbean
ECLP	Estrategia Climática de Largo Plazo (Long Term Climate Strategy)
EGA	Electricity, gas, water and waste management
ENTSEJ	Estrategia nacional para una transición socioecológica justa (National Strategy for Just Socio-Ecological Transition)
EQUIP	Enhancing the Quality of Industrial Policies
ERI	Estrategia Regional de Innovación (Regional Innovation Strategy)
FAO	Food and Agriculture Organization of the United Nations
FNDR	Fondo Nacional de Desarrollo Regional (Regional Development Fund)
GDP	Gross Domestic Product
GEI	Greenhouse Gas Emissions
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
GORE	Gobierno Regional (Regional Government)

HHI	Herfindahl-Hirschman Index
IDB	Inter-American Development Bank
IDMA	Centro de Formación Técnica del Medio Ambiente (Technical Training Centre for the Environment)
ILO	International Labour Organisation
INE	Instituto Nacional de Estadísticas (National Institute of Statistics)
LCT	Low Carbon Technology
MEN	Ministerio de Energía (Ministry of Energy)
MMA	Ministerio del Medio Ambiente (Ministry of the Environment)
NCRE	Non-Conventional Renewable Energy (as per Chilean law 20.257)
NDC	Nationally Determined Contributions
OMIL	Oficina Municipal de Información laboral (Municipal Labour Information Office)
OTEC	Organismo Técnico de Capacitación (Technical Training Organisation)
OTSEJ	Oficina de Transición Socioecológica Justa (Office of Just Socio-Ecological Transition)
PDL	Política de Desarrollo Local Sostenible y Asociativa (Local Sustainable and Associative Development Policy)
PEN	Política Energética Nacional (National Energy Policy)
PLADECO	Plan de Desarrollo Comunal (District Development Plan)
PRAS	Programa de Recuperación Ambiental y Social (Programme for Environmental and Social Recovery)
SABE	Sistema de Análisis de Bolsas de Empleo (System for the Analysis of Employment Exchanges)
SEIA	Sistema de Evaluación de Impacto Ambiental (Environmental Impact Assessment System)
SENCE	Servicio Nacional de Capacitación y Empleo (National Training and Employment Service)
SERCOTEC	Servicio de Cooperación Técnica (Technical Cooperation Service)
SEREMI	Secretarías Regionales Ministeriales (Regional Ministerial Secretariats)

SERNAGIOMIN	Servicio Nacional de Geología y Minería (National Geology and Mining Service)
SII	Servicio de Impuestos Internos (Internal Revenue Service)
SME	Small and Medium Enterprise
SUBDERE	Subsecretaría de Desarrollo Regional y Administrativo (Subsecretariat of Regional and Administrative Development)
TSEJ	Transición Socioecológica Justa (Just Socio-Ecological Transition)
UCN	Universidad Católica del Norte (Catholic University of the North)
UNDP	United Nations Framework Convention on Climate Change
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
ZOIT	Zone of Tourist Interest

Acronyms

CO2	Carbon dioxide
CO2eq	Carbon dioxide equivalent
H2V	Green hydrogen
MW	Megawatt
NH3	Green Ammonia
NOx	Nitrogen oxides
PCDD/F	Polychlorinated dibenzo-p-dioxins and Polychlorinated dibenzo-p-dioxins and Polychlorinated dibenzo-furans
SOx	Sulphur oxides

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1. National and Regional Context on Just Transition and Coal phase-out

1.1. The Just Socio-Ecological Transition process in Chile

The planet is facing a triple global crisis that encompasses biodiversity loss, climate change and pollution, which are closely interrelated and mutually reinforcing phenomena (UNCC, 2022). In Chile, the climate crisis, coupled with the country's historical dependence on the intensive exploitation of natural resources and the use of fossil fuels for electricity generation, has contributed significantly to the degradation of ecosystems, intensified global warming and deepened social inequalities. This scenario highlights the need for effective action in the face of the climate emergency, whose impacts are tangibly manifested at both global and local levels.

International instruments such as the Paris Agreement (2015) and the Kunming-Montreal Global Framework (2022) set concrete targets to mitigate greenhouse gas emissions and conserve biodiversity, such as limiting global temperature rise to less than 2°C, preferably 1.5°C, compared to pre-industrial levels[1] . In response, a number of countries have made commitments tailored to their national contexts, implementing strategies that promote mitigation, adaptation and the transition to low-carbon economies. This effort has involved promoting profound transformations in production and energy matrices, especially in nations dependent on the coal sector, promoting the development of sustainable activities and cleaner energies that minimise environmental impacts and strengthen resilience in the face of climate change.

Chile has decided to face the climate crisis and move towards the coal phase-out of its energy matrix and the development of new, more sustainable productive activities through different processes, including its NDCs, the ratification of the Paris agreement, the enactment of the Framework Law on Climate Change, the **Just Socio-Ecological Transition** (TSEJ) process, among others. The latter concept of TSEJ refers to an integral transformation of social and ecological systems, understood as an interdependent whole. Justice in this process seeks to ensure that no one is left behind, avoiding the generation of new social and environmental inequities.

[1] In addition, the Kunming Montreal Global Framework, among the main targets it sets for 2030, mentions: 1) conservation of at least 30% of terrestrial, inland and coastal water and marine areas, 2) restoration of 30% of the planet's degraded ecosystems, 3) halving the introduction of invasive species, 4) ensuring that areas under production are sustainably managed, 5) identification and elimination of at least US$ 500 billion per year in harmful incentives (UNEP, 2022).

To carry this process forward, the **National Strategy for a Just Socio-Ecological Transition** (ENTSEJ) (2024[2] and 2025[3]) has been developed, which seeks to coordinate, in an intersectoral manner, various ministries to implement a set of public policy instruments that strengthen the Social Pillar of Chile's Nationally Determined Contribution (NDC) 2025-2035[4] . The ENTSEJ proposes a comprehensive change of economic and social activities that perpetuate inequalities and the environmental crisis, fostering an inclusive transition aligned with the principles of social justice, environmental resilience and strengthening of local economies. This approach prioritises productive reconversion, human capital formation and environmental remediation, promoting a sustainable and balanced development model.

The regulatory framework underpinning the ENTSEJ is composed of the **Long Term Climate Strategy** 2050[5] (ECLP) developed by the Ministry of Environment (MMA) and approved in 2021 and the **Framework Law on Climate Change**[6] enacted in 2022. The ECLP emphasises the coal phase-out of the energy matrix and placing people at the centre of the process, promoting fair social and environmental development. As goals, it considers the removal of 65% of coal-fired generation from the national grid by 2025 and establishes that 80% of electricity generation should come from renewable sources by 2030. For its part, Article 2 of the Framework Law on Climate Change establishes the State's duty to distribute environmental burdens equitably, with a gender focus and special attention to sectors and territories vulnerable to climate change, ensuring the needs of future generations.

The MMA has been structuring a new institutional framework to materialise these commitments. In 2022, the **Office for a Just Socio-Ecological Transition** (OTSEJ) was created, which works in coordination with different ministries and regional bodies in the preparation of participatory territorial diagnoses, as well as in the monitoring and evaluation of the measures defined in the transition agenda.

In the same year, the **Interministerial Committee for a Just Socio-Ecological Transition** (CITSEJ) was created to facilitate decision-making, the necessary institutional transformations

[2] For more information document available at: https://mma.gob.cl/wp-content/uploads/2025/03/Estrategia-Nacional-de-Transicion-Socioecologica-Justa.pdf

[3] For more information document available at: https://mma.gob.cl/wp-content/uploads/2025/08/10-Proyecto-definitivo-ESTRATEGIA-NACIONAL-TSEJ-2025-2035.pdf

[4] In 2022 Chile strengthens its NDC to the United Nations Framework Convention on Climate Change (UNFCCC) with a focus on methane emission reductions, just transition and climate governance at the national level through the Framework Law on Climate Change (2022). Document available at: https://mma.gob.cl/wp-content/uploads/2025/07/Actualizacion-de-la-contribucion-determinada-a-nivel-nacional-2025.pdf

[5] For more information document available at: https://cambioclimatico.mma.gob.cl/wp-content/uploads/2021/11/ECLP-LIVIANO.pdf

[6] For more information document available at: https://www.bcn.cl/leychile/navegar?idNorma=1177286

and the prioritisation of public policies, integrating various ministerial portfolios[7] in a coordinated effort. Furthermore, the ENTSEJ is based on a collaborative governance model that integrates actors from the public, private and civil society sectors, with an emphasis on local participation and territorial relevance.

The ENTSEJ is based on five key principles: Sustainable Productive Development, aimed at developing sustainable and low-emission industries; Decent Work, to promote fair and inclusive employment; Ecosystem Approach, which prioritises the restoration and protection of affected ecosystems; Gender Equality, ensuring equitable conditions and autonomy for women; and Human Rights, focused on the protection and participation of all, especially vulnerable groups, under a framework of equity and climate justice. These principles seek to guide the transition towards a sustainable and inclusive development model.

In addition, the ENTSEJ is articulated around the following four fundamental axes and specific actions to implement the transition to 2035.

- Axis 1: Opportunities for decent work
- Axis 2: Restoration and safeguarding of ecosystems
- Axis 3: Social Well-being and Gender Equality
- Axis 4: Innovation and Technology for Sustainable Productive Development

Since 2022, Chile has shown progress in some of the key axes for just transition, although the full strategy was only released in 2025. Particularly, in the decent work opportunities axis, Chile has begun to implement various actions to promote labour reconversion in transition territories, with a focus on guaranteeing green jobs and decent work. Among the advances is the creation of the Energy Agenda 2022-2026, which has prioritised the training and certification of technicians and professionals in sectors such as renewable energies, fuels and green hydrogen, with special attention to women, indigenous peoples and workers affected by the closure of coal-fired power plants. In addition, CITSEJ has led efforts for socio-environmental justice in transition zones, including the implementation of labour reinsertion plans.

However, significant challenges remain. Retraining has been more successful for direct workers, while subcontracted and indirect workers face greater difficulties due to a lack of comprehensive planning on the part of companies and the state. Furthermore, the time lag between plant closures and the generation of new investments in green sectors has hindered the effective incorporation of workers in the new green economy. Informality and labour precariousness in some cases underline the need for a robust legal framework that integrates labour, social and industrial planning to ensure an inclusive and sustainable transition.

[7] The Inter-Ministerial Committee on Just Socio-Ecological Transition is composed on a permanent basis of the Ministries of Environment, Economy, Energy, Labour, Health and Social Development. The Ministries of Interior, Mining, Women and Gender Equality, and Education will also collaborate.

Progress has also been made in the area of ecosystem restoration and protection, with pilot environmental recovery projects being developed in transition territories, although challenges persist in the implementation of a regulatory framework for the treatment of environmental liabilities.

In general, the closure of thermoelectric power plants remains a challenge in the medium term, given its technical and social complexity. The challenge is to align these actions with effective governance and comprehensive planning to ensure concrete results and tangible benefits for communities in transition.

1.2. The coal phase-out process in the framework of Just Transition. The reconversion of coal-fired power plants in Chile

Electricity generation based on coal combustion has been, from a production perspective, a key driver for the economy of Chile and the world since industrialization has started. Today, the sector only represents a small part of Chile`s economy. According to an IDB study (2019)[8] this sector represents 0.69% of national GDP and generates 4,391 direct jobs, in addition to 9,505 indirect jobs along its value chain. However, although its economic contribution is recognised, there is also consensus on its environmental impact, as thermal power plants are important emitters of both local and global pollutants, which can affect human health and ecosystems. In Chile, prior to the closure of the first coal-fired power plants in 2018, the energy sector was responsible for 77.7% of greenhouse gas emissions[9] , with coal-fired power generation being the largest contributor, accounting for approximately a quarter of these emissions[10] . By 2022, there was evidence of a decline in the contribution of the power sector being responsible for 76.4% of greenhouse gas emissions, with coal-fired power generation accounting for approximately one fifth of these emissions[11] . Faced with the need to mitigate the effects of climate change and reduce local pollution, the country has adopted measures to move towards renewable energy sources and cleaner technologies, in line with the global trend to phase out the use of coal.

[8] Inter-American Development Bank (IDB) (2019). Economic and employment impact of the retirement and/or reconversion of coal-fired units in Chile. Available at: https://energia.gob.cl/sites/default/files/Informe_Final_BID_con_resumen_ejecutivo_y_anexos.pdf

[9] National Greenhouse Gas Inventory System. Available at: https://snichile.mma.gob.cl/resultados-principales/

[10] National Greenhouse Gas Inventory Document - SERIES 1990-2022. Available at: https://snichile.mma.gob.cl/wp-content/uploads/2025/03/2024_DIN_CL.pdf

[11] National Greenhouse Gas Inventory Document - SERIES 1990-2022. Available at: https://snichile.mma.gob.cl/wp-content/uploads/2025/03/2024_DIN_CL.pdf

In this framework, Chile has established through various energy policy instruments a long-term sectoral vision that aims at the commitment to be a carbon neutral and resilient country by 2050. Specifically, the **Framework Law on Climate Change** establishes the legal mandate to be a carbon neutral country by 2050 and the **National Energy Policy**[12] considers the goal of 100% zero-emission electricity by 2050 (renewables will contribute 80% by 2030). In turn, the **Long-term Energy Planning 2023-2027**[13] defines long-term energy scenarios to show alternative development paths for the country's energy matrix. For its part, the **Initial Agenda for a Second Energy Transition**[14] , the **Just Transition Strategy for the energy sector**[15] and the **Energy Agenda 2022-2026**[16] seek to advance in the coal phase-out of the national territory to achieve a 100% clean electricity matrix by 2050 and promote the sustainable energy development of the country's municipalities, through the development of **Local Energy Strategies**, prioritising those that are in the process of closing coal-fired power plants.

Chile has completed a first stage of coal phase-out through a public-private agreement for the Retirement and Reconversion of Coal-fired Units, and its working groups, a process that was embodied in a working document[17] , which marked a milestone as the first voluntary agreement between the Government and companies for the closure or reconversion of coal-fired plants. To date, 14 of the original 28 plants have been retired, representing 1.7 GW out of a total of 5.5 GW. A further 9 units, equivalent to 2.2 GW, are projected to be available for retirement or conversion by 2026.

With the new **Coal Phase-out Plan**[18] (2025) a second stage is initiated that seeks to consolidate this process. This Plan focuses on the electric system, with the objective of ensuring an orderly and efficient retirement or reconversion of coal-fired power plants, promoting a decarbonised, safe, sustainable and resilient National Electric System. Its scope covers the energy transition

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[12] For more information document available at: https://energia.gob.cl/sites/default/files/documentos/pen_2050_-_actualizado_marzo_2022_0.pdf

[13] For more information document available at: https://energia.gob.cl/sites/default/files/documentos/informe_definitivo_pelp_2023-2027.pdf (April 2025)

[14] For more information document available at: https://energia.gob.cl/sites/default/files/documentos/agenda_inicial_para_un_segundo_tiempo_de_la_transicion_energetica.pdf

[15] For more information document available at: https://energia.gob.cl/sites/default/files/documentos/estrategia_transicion_justa_2021.pdf

[16] For more information, see document available at: https://energia.gob.cl/sites/default/files/documentos/agenda_energia_2022_-_2026.pdf

[17] Retirement and/or Conversion Plan for coal-fired units. For more information document available at: https://energia.gob.cl/sites/default/files/plan_de_retiro_y_o_reconversion_centrales_carbon.pdf

[18] Document available at: https://energia.gob.cl/sites/default/files/plan_de_descarbonizacion_vf.pdf

from an economic-productive perspective both at the national level and in the transition zones. However, this plan needs to be complemented by other public policy instruments, such as the ENTSEJ, in addition to the key role of the Environmental Assessment Service, the Superintendence of the Environment and the Environmental and Social Recovery Programmes (PRAS) (or new local governance bodies pending creation in districts where a PRAS had not been established to date) to manage closures and restore affected territories.

The plan proposes 4 central axes: (1) incentives and territorial integration for the development of energy projects, (2) strategic planning for the development of the electrical system, (3) electric transmission as an enabler for carbon neutrality, and (4) safe and flexible electrical system in a highly renewable context. This approach allows progress in a structured way towards a decarbonised electric system, aligned with national climate goals and long-term sustainability as shown in Illustration 1.

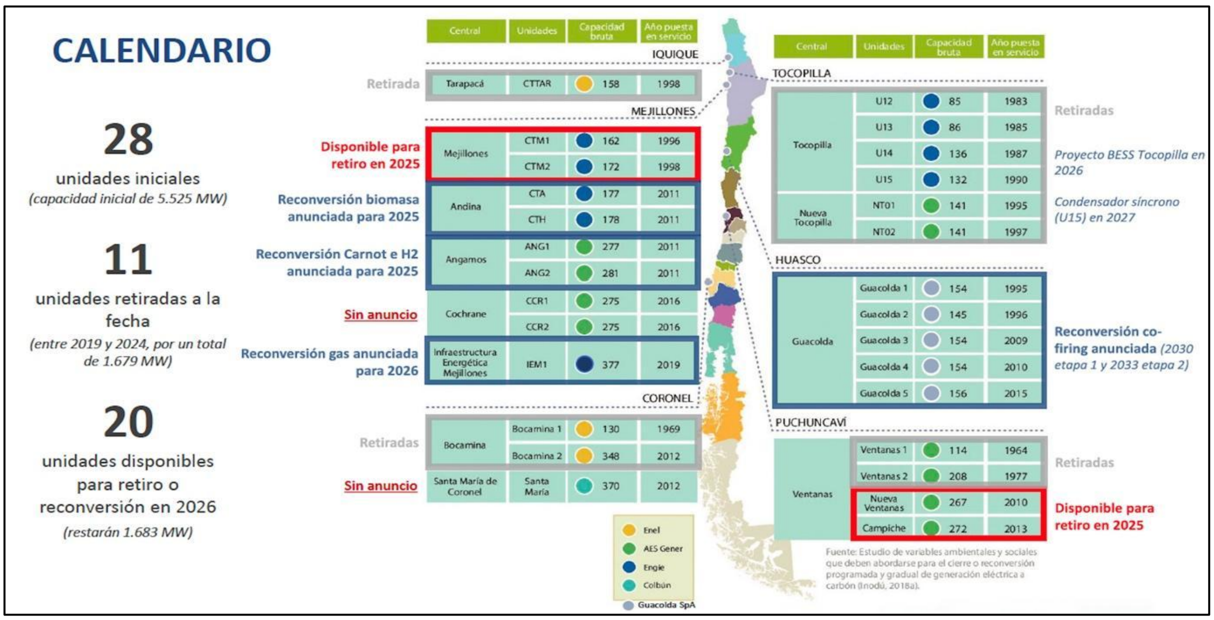

Illustration 1: Timetable for the retirement and retrofitting of coal-fired power plants.
Source: Draft Coal Phase-out Plan, 2024[19].

Subsequently, in the following years, a third phase aimed at completely eliminating coal from the electricity matrix will begin, ensuring the definitive retirement of the remaining plants and moving towards a cleaner and more sustainable energy matrix.

1.3. Just Transition and Coal phase-out for the region of Antofagasta and the district of Mejillones

[19] Document available at:
https://energia.gob.cl/sites/default/files/documentos/20241108_plan_descarbonizacion.pdf

According to the study conducted by IDB (2019), in 2019 prior to the voluntary closure of thermoelectric power plants, the coal-fired power sector generated an impact of 0.69% on the GDP of the national economy, contributing 1.01% to the GDP of the Antofagasta Region. For its part, the district of Mejillones contributed 2.64% of the GDP of the Antofagasta Region and generated 0.5% of total employment in the region. In particular, a total of 1,554 direct jobs were linked to coal power plants and their subcontractors in Mejillones, representing 3.82% of the district employment, while the indirect jobs in related sectors were estimated at 3,319. This panorama evidenced the economic relevance of the thermoelectric sector, especially considering that 15 of the 28 operational thermoelectric units in the country were concentrated in Tocopilla and Mejillones, representing 56% of the installed capacity at national level for the year 2019.

Tocopilla and Mejillones, along with the districts of Huasco, Quintero, Puchuncaví, Concón and Coronel, have been declared "Territories in Transition" due to the high concentration of productive activities dependent on fossil fuels. These districts face a double vulnerability: on the one hand, the negative impacts of pollution, derived from industrial concentration, and on the other hand, the economic consequences of the closure of thermoelectric plants. In this context, the Just Socio-Ecological Transition Committee has prioritised specific plans for these localities, highlighting the **Environmental and Social Recovery Programmes (PRAS)**, whose development and implementation are accompanied and monitored by the **Environmental and Social Recovery Councils (CRAS)**, as well as the creation of new local governance bodies in districts where a PRAS had not been established to date. These multi-sectoral governance spaces are key to guaranteeing an inclusive transition, ensuring that the measures adopted respond to local needs and promote social and environmental justice in the affected territories.

The ENTSEJ **Action Plan 2030**, on the other hand, is an instrument that collects the prioritised measures in the transition territories. Specifically, a total of 101 measures are proposed, of which 28 are national, 23 are cross-cutting measures for all the aforementioned transition territories and 50 are specific measures for each of the five transition territories. This plan focuses on repairing accumulated environmental liabilities and improving the social and economic well-being of the affected communities, with a time horizon of 2030.

As a complement, fair socio-ecological transition plans are being drawn up at the level of districts and territories in transition, as in the cases of Tocopilla and Mejillones. These plans aim to promote participatory processes that include local communities, promoting social and environmental justice. In addition, they seek to align with the guidelines established in the National Strategy for a Just Socio-Ecological Transition (ENTSEJ), ensuring coherence with national goals on sustainable development and climate resilience.

In the case of Mejillones, according to the diagnosis of the 2024 **Local Energy Strategy**, the district has a gross installed generation capacity of 3,713.3 MW, distributed in 10 generating plants. Of these, only one is Non-Conventional Renewable Energy (NCRE), three run on natural gas and six are coal-fired thermal plants in the process of conversion or closure. Of the total installed capacity, 99% corresponds to non-renewable sources (65.05% coal and 34.05% natural gas), while 0.66% comes from cogeneration and 0.24% from solar energy. By the end of 2025, one coal power plant had started its reconversion to operate with natural gas (IEM), while two other units had stopped their operations (CTM 1 and 2), leaving only the Andina, Angamos, and Cochrane power plants in operation, with the first expected to close by the end of 2026.

Mejillones is also advancing in economic diversification projects, such as the implementation of initiatives related to the hydrogen and green ammonia (H2V/NH3) industry, with a projected investment of 8,396,001 MU[20] . These actions are part of national efforts to achieve carbon neutrality by 2050, promoting sustainable, inclusive and resilient development.

The ENTSEJ action plan for Mejillones aimed at mitigating the social, economic and environmental impacts associated with specific carbon-intensive activities includes 28 measures, among which some can be identified as:

- Special access for local youth to Higher Education Institutes through agreements with regional universities, such as the Catholic University of the North, to promote employability in renewable energy and sustainable development issues.
- Environmental health training programmes for professionals and communities.
- Productive diversification through artisanal algae aquaculture, with a focus on bioremediation of the Mejillones Bay.
- Electromobility strategy for the district.
- Development of an emissions inventory that integrates public and private monitoring networks validated by the MMA.
- Elaboration of a Secondary Environmental Quality Standard for Mejillones Bay.
- Training in highly employable trades aimed at supporting the transition to a low-carbon economy, with support from the Regional Training Councils and the National Training and Employment Service.

The integration of these plans and strategies demonstrates Chile's commitment to a more sustainable, equitable and inclusive development model, positioning Mejillones and the Antofagasta region as a reference in the energy and socio-ecological transition in Latin America.

[20] Document Annex 2 Territorial Diagnosis (2024). Preliminary draft of the National Just Socio-Ecological Strategy.

1.4. Opportunities and challenges for Just Transition in the district of Mejillones

The process of just socio-ecological transition is presented as an opportunity to transform production models towards a sustainable economy, promoting economic diversification, technological innovation and strengthening local development. However, this process also faces important challenges, including the management of social and economic impacts associated with the closure of carbon-intensive industries, and the need to coordinate actions between national, regional and local levels. Achieving this balance is essential for building inclusive development that ensures both social well-being and environmental sustainability in transition territories.

In the context of the Antofagasta region, and particularly in the district of Mejillones, this process takes on special relevance. Based on interviews with key actors in the territory and an analysis of secondary information available at national[21] , regional[22] and local[23] level, various economic, social and environmental opportunities and challenges associated with the implementation of a just socio-ecological transition have been identified, which are described below:

1.4.1 Economic opportunities and challenges

Opportunities

Table 1: Economic opportunities associated with the just socio-ecological transition process.

Dimension	Detail
Productive diversification towards new activities	Mejillones has a high potential to diversify its economic matrix through the development of non-conventional renewable energies (NCRE), such as solar and wind energy, the production of green hydrogen and the manufacture of lithium batteries. These initiatives not only reduce dependence on carbon-intensive industries but also encourage the attraction of investment and technological innovation in the district.
Strategic infrastructure	Mejillones' strong port infrastructure, together with its electricity and water supply networks, positions the district as a key logistics hub for activities such as the export of green hydrogen and by-products, including green ammonia. In addition, its strategic location favours the establishment of new industries related to its energy transition.
Diversification into existing activities	Mejillones offers great opportunities for productive reconversion in its main economic activities: the electricity and gas industry, commerce and fishing.

[21] At the national level, documents referring to the draft ENTSJ (2024) and the Coal Phase-out Plan (2024) were reviewed.

[22] For the Antofagasta Region, regional policies were considered, such as the Regional Development Strategy (2009-2020), Government Plan 2021-2024, Regional Innovation Strategy 2022-2028 and the Draft Regional Action Plan on Climate Change (PARCC) of Antofagasta.

[23] To gather background information on the district of Mejillones, the ENTSJ Territorial Diagnosis (2024), the District Development Plan 2023-2033, the Local Energy Strategy of the district of Mejillones (2024) and the Report on the Systematisation of the base information for the design of a Just Energy Transition plan in the districts of Tocopilla and Mejillones of the University of Antofagasta (2023) were reviewed.

Dimension	Detail
	The electricity industry can move towards the incorporation of renewable energies, such as solar energy, promoting coal phase-out and the efficient use of local energy resources. In the commerce sector, there is significant potential to diversify products and services related to the green economy, such as the distribution of clean technologies or the promotion of sustainable practices in supply chains.
Attractive for investment	Mejillones is positioned as an attractive destination for investments in renewable energy infrastructure and energy efficiency projects. These developments complement existing industrial activities and strengthen the local economy, while promoting sustainable growth.
Fostering entrepreneurship and tourism	Promotion of activities such as sustainable tourism, which capitalises on the region's history and natural environment, and the development of projects related to the circular economy and agri-food activities through the implementation of greenhouses, which represent viable alternatives to diversify the local economy and generate new business opportunities.

Challenges

Table 2: Economic challenges associated with the just socio-ecological transition process

Dimension	Detail
Labour reconversion and productive diversification	A key challenge in Mejillones is to ensure the timely implementation of productive diversification strategies that consider both direct and indirect workers. Experience in other districts, such as Tocopilla, has highlighted the risks associated with a lack of adequate planning prior to plant closure, underlining the need to align strategies with the real demands of the labour market. For just socio-ecological transition plans to be effective, it is essential to incorporate the early identification of productive diversification opportunities, which will allow for the design of specific job training programmes adapted to emerging sectors.
Territorial planning and regulation	The update of the Mejillones Community Regulatory Plan poses a significant challenge, as many of its proposals limit new economic activities and restrict existing ones. In addition, the process of indigenous consultation, in addition to the timeframes of both this plan and the Interdistrict Coastal Border Regulatory Plan, could delay the implementation of territorial planning that promotes economic diversification in the context of an energy transition and enables sustainable productive development.
Economic dependence on carbon-intensive activities	The local economy's historical dependence on carbon-intensive activities generates resistance to change towards more innovative industrial sectors. This highlights the need to inform the public about productive diversification to ensure sustainable economic growth and mitigate the risks associated with the transition to clean energy.
Access to finance and implementation costs	High upfront costs to implement clean technologies, renovate infrastructure and finance transition programmes represent significant challenges. Small and medium-sized enterprises (SMEs) also face difficulties in meeting international standards, limiting their integration into sustainable value chains. It is crucial to establish financial incentives, business-level support programmes (such as linkages between SMEs and the large companies that drive them), among other support mechanisms to overcome these barriers.
Industry-community relations	The lack of a common project that articulates efforts between industry and citizens limits the creation of joint solutions. A better relationship between

Dimension	Detail
	these actors is fundamental to advance towards an integral and sustainable development of the region.

1.4.2 Social opportunities and challenges

Opportunities

Table 3: Social opportunities associated with the just socio-ecological transition process

Dimension	Detail
Strengthening human capital	The energy transition in Mejillones represents a key opportunity to boost the economic and social development of the region through the creation of green jobs in sectors such as sustainable aquaculture, electromobility and maintenance of renewable energy infrastructures, green hydrogen, port sector. To achieve this, educational projects and technical training programmes in strategic areas such as renewable energy and green economy are required. These initiatives not only strengthen the technical skills needed for sustainable sectors, but also promote social and labour empowerment, with a priority focus on youth and women. By improving local employability and fostering equity, these actions contribute to reducing inequalities and ensuring that the energy transition is more inclusive, just and sustainable.
Community participation and governance	Participatory instances, such as the development of Working Tables in consultation processes, strengthen social cohesion by integrating communities in planning and decision-making. This fosters inclusive governance that reinforces community well-being and co-responsibility.
Improved quality of life:	Reducing environmental impacts associated with carbon-intensive activities, along with improvements in energy infrastructure, environmental health and basic services, contribute to raising the overall well-being of local communities. In addition, these actions reduce inequalities by ensuring equitable access to essential resources.

Challenges

Table 4: Social challenges associated with the just socio-ecological transition process.

Dimension	Detail
Citizen perception	The discontent of local communities in Mejillones represents a central challenge, derived from the perception of inequality in the distribution of economic benefits and the lack of concrete results in participatory processes. The community perceives that the profits generated in the district are absorbed by Antofagasta and/or Santiago, which aggravates the malaise and reinforces the sense of abandonment. This problem does not only lie in participatory governance, but is partly explained by the continued centralization of decision-making, whereby strategic decisions and prioritisation of actions for the territories are defined at the central level, despite the fact that initiatives are designed at the local level. Furthermore, the absence of effective monitoring and evaluation mechanisms for the implementation of the demands and recommendations of participatory initiatives has eroded citizen confidence, underlining the need for a more equitable and decentralised approach to decision-making.

Dimension	Detail
Education, inclusion and empowerment	High educational demand in Mejillones, exacerbated by migration, has overburdened school capacities, limiting access to quality education. Significant gaps persist in the inclusion of women and youth in emerging labour markets, underscoring the need for inclusive strategies. It is essential to strengthen training and capacity building programmes tailored to local needs, encouraging the active participation of historically marginalised groups and promoting gender equity.
Social impacts of plant closures	The closure of thermal power plants poses significant social risks, such as the loss of direct and indirect jobs, affecting the economic stability of vulnerable communities. The absence of effective mitigation measures amplifies labour and social tensions. The energy transition should incorporate job relocation programmes, technical training and specific actions to strengthen social cohesion and mitigate negative impacts.
Social cohesion and community identity	The high labour turnover[24] in Mejillones and the lack of roots among workers negatively social cohesion and community development. It is a priority to design strategies that promote job stability, encourage the rooting of workers in the local community and guarantee their participation in the development of the territory. Likewise, ensuring equitable representation of local actors in decision-making is key to achieving an inclusive and sustainable transition.

1.4.3 Environmental opportunities and challenges

Opportunities

Table 5: Environmental opportunities associated with the just socio-ecological transition process.

Dimension	Detail
Emission reductions and environmental improvements	The energy transition in Mejillones represents an opportunity to significantly reduce greenhouse gas emissions by closing and converting coal-fired power plants, aligning with national carbon neutrality targets and improving air quality and public health at the local level.
Ecosystem restoration	The implementation of measures such as the bioremediation of Mejillones Bay and the restoration of local ecosystems to mitigate the cumulative impacts of past industrial activities is an opportunity to restore the environment and increase the region's climate resilience. These initiatives will not only strengthen biodiversity but also promote a sustainable production model.
Environmental regulation and monitoring	The development of specific regulations, such as the Secondary Environmental Quality Standard for Mejillones Bay (a draft project being prepared to protect the bay and its resources), together with the implementation of an emissions inventory, will allow for more effective environmental monitoring. These actions will lay the groundwork for preserving air and water quality in the district.
Clean technologies and energy transition	The implementation of clean technologies in energy generation will allow for a progressive decrease in the use of coal, moving towards a cleaner and more sustainable energy matrix. This approach opens up opportunities for the development of renewable energies and economic diversification in the region.

[24] According to the Chilean National Institute of Statistics, labour commutation corresponds to the movement of people from their place of residence to another area or region to carry out a work activity. This movement can occur within the same region (intra-regional commutation) or between different regions of the country (inter-regional commutation).

Challenges

Table 6: Environmental challenges associated with the just socio-ecological transition process.

Dimension	Detail
Historical environmental liabilities	The transition in Mejillones offers a key opportunity to address significant pollution accumulated over decades due to industrial activity. Issues such as contamination of soil, air and especially the Bay of Mejillones require urgent mitigation and ecosystem restoration measures. The Bay faces high levels of pollution, mainly caused by untreated sewage disposal through the submarine outfall and historical industrial activities. Because of this, additional structural solutions need to be implemented to decontaminate the area and ensure the long-term protection of marine ecosystems. Sustainable mechanisms must also be put in place to prevent the perpetuation of these impacts in future productive activities, ensuring economic development aligned with environmental sustainability.
Environmental compliance and monitoring	The transition towards sustainable productive activities requires constant monitoring and effective enforcement of environmental regulations. The implementation of real-time monitoring systems and compliance programmes are essential to avoid setbacks in ecosystem restoration and to ensure that new industries do not perpetuate environmental inequalities.
Sustainability of new industries	The installation of new industries, such as green hydrogen, should be aligned with the territorial development plans and environmental guidelines of the municipality. Ensuring that these activities are sustainable and do not perpetuate previous negative environmental impacts is fundamental to balanced growth.
Climate change impacts	Climate change intensifies environmental challenges such as water scarcity and rising temperature extremes. This requires the implementation of sustainable infrastructures that support a clean and resilient energy model, while avoiding compromising the region's natural resources.

1.5. A green economic diversification as a response to the Just Socio-Ecological Transition process

The green economy, according to the United Nations Environment Programme (UNEP), is a model that seeks to improve human well-being and social equity while reducing environmental risks. In Chile, this approach aligns with the 2050 carbon neutrality commitments and the Sustainable Development Goals, providing a comprehensive strategy that combines economic, social and environmental sustainability. This model allows diversifying the economy, reducing dependence on a few productive sectors, reducing vulnerability to external shocks, fostering innovation and generating opportunities for new industries, with the potential to achieve sustainable economic growth.

From a social perspective, green economic diversification boosts job creation in sectors such as renewable energy, the circular economy and clean technologies. It also decentralises economic development, reduces inequalities, strengthens social cohesion and improves community resilience by reducing dependence on one or a few productive sub-sectors. In the environmental sphere, it offers solutions to reverse the liabilities accumulated after decades of industrial activity, encourages sustainable productive activities that minimise negative impacts on ecosystems, promoting the efficient use of natural resources and the restoration of degraded areas. These actions not only mitigate climate change, but also ensure balanced development that respects environmental limits and protects biodiversity.

In this context, the Antofagasta region, and in particular Mejillones, faces the challenge of moving towards a sustainable, low-carbon economy. The progressive closure of thermoelectric power plants has driven the need to diversify the productive matrix, which opens up significant opportunities in the green economy. Mejillones, with its strategic industrial infrastructure and projects such as green hydrogen production and lithium battery plants, is positioned as a key centre for energy innovation. These initiatives have the potential to transform productive activities towards more sustainable models, generating also green jobs, understood as those that contribute to environmental sustainability and the promotion of decent work[25] . Green jobs in emerging sectors in the district such as aquaculture, circular economy and sustainable tourism enhance a balanced and resilient diversification, promoting sustainable income and greater social inclusion.

Additionally, in Mejillones, programmes such as the dual education models have been essential to prepare young people and women to integrate into emerging sectors such as renewable energy and environmental management. These initiatives improve employability and promote gender equality and inclusion of historically marginalised groups. Also, the district of Mejillones, considered a transition zone, is implementing bioremediation projects, wastewater treatment and clean technologies to reduce air and water pollution. In addition, initiatives such as the Secondary Environmental Quality Standard for Mejillones Bay strengthen environmental governance and establish a clear framework for monitoring progress in sustainability. These actions not only respond to community demands for greater environmental protection, but also demonstrate the region's commitment to environmental sustainability. The generation of green jobs in ecological restoration and sustainable management activities further reinforces this approach.

The generation of renewable energy and the identification of green jobs have the potential to strengthen the region's capacity to lead in sustainability. If effective skills training strategies are implemented, the transition to a green economy could be more equitable and aligned with market demands, positioning Mejillones and Antofagasta as leaders in sustainable development and energy transition.

[25] ILO (2022) How to work in the green economy? A guide for young people, jobseekers and mentors.

In conclusion, green economic diversification, both in the region and in the district, opens opportunities to build a more balanced, inclusive and sustainable development model. With a vision that integrates responsible production, innovation, green jobs and sustainability, the region can lead the way towards a just transition that benefits both the environment and local communities, ensuring a resilient future with a higher quality of life for all its inhabitants.

2. Methodology for the elaboration of the diversification strategy

2.1 The importance of an evidence-based and participatory approach to the design of economic diversification strategies

2.1.1. Evidence-based approach

The development of economic diversification strategies of coal regions for a just transition requires informed, contextualised decisions guided by a thorough knowledge of the economic, social and environmental dynamics of each territory. In this context, the **evidence-based approach** is a key tool, as it allows for a more precise identification of structural challenges and concrete opportunities to move towards more sustainable, resilient and inclusive production models.

The experience of the IKI JET project highlights this approach as a central component in the elaboration of the *Handbook on Economic Diversification for Coal Regions in Transition*, which aims to provide methodological guidance for practitioners and decision-makers to design robust, participatory strategies that are consistent with local realities. In the case of the Antofagasta region, with special emphasis on the district of Mejillones, various analytical tools were applied, including **EQUIP (Enhancing the Quality of Industrial Policies) and DIVE (Diversifying Industries and Value Chains for Exports).** These methodologies made it possible to gain evdidence and to to analyse the production and export structure, the level of employment and emissions, the degree of economic concentration and the previous diversification capacities of the territory. They also made it possible to identify opportunities for diversification by detailing strategic sectors and products with potential for growth, productive sophistication and generation of added value.

The evidence-based approach significantly strengthens the quality of the territorial diagnosis and provides more precise guidance for the formulation of a shared development vision, as well as the definition of strategic objectives and public policies consistent with the realities of the territory. By relying on concrete and verifiable information, this approach facilitates coordination between public and private actors, promotes transparency and reduces the risk of decisions being captured by particular interests. It also provides the basis for robust monitoring, evaluation and learning systems that allow strategies to be adapted, lessons learned to be incorporated and their impact to be assessed over time.

Its main benefits include more objective decision-making, the possibility of comparing contexts across regions or countries, and more effective implementation of planned actions. It also contributes to more stable and sustainable institutional conditions, especially relevant in just transition processes, where deeply rooted economic and social structures need to be transformed. Finally, this approach not only improves the technical and operational dimension of planning, but also strengthens its legitimacy by aligning strategic decisions with objective evidence. This favours ownership by local actors and creates more robust conditions for moving towards just, inclusive and sustainable development.

2.1.2 Participatory approach

Participation is a key component to ensure that transition processes towards more sustainable economies are truly inclusive, effective and legitimate. Actively involving the various actors in the territory, especially those most affected by productive changes, allows for building a shared understanding of current challenges and existing opportunities. This approach not only strengthens the capacity of territories to adapt, but also contributes to generate greater ownership of the processes by the communities.

Effective participation implies the integration of multiple voices in decision-making processes, generating open and respectful spaces for dialogue between actors from the public and private sectors, academia, civil society and local communities. Far from being a tokenistic practice, participation is a tool that enhances the design of more relevant and legitimate policies. According to the United Nations Human Development Report (2016), societies that promote the active participation of a diversity of actors achieve greater social cohesion and fairer development.

The experience of the IKI JET project highlights this approach as a central component in the *Handbook on Economic Diversification for Coal Regions in Transition*. For the elaboration of the Economic Diversification Strategy for Antofagasta with a focus on Mejillones, part of this orientation has been materialised through semi-structured interviews with key actors at national, regional (Antofagasta) and local (Mejillones) level, as well as through the implementation of participatory and informative workshops with representatives of technical areas of public, private and academic institutions. It is worth mentioning that the main objective of these instances was to socialise the quantitative methodologies used to carry out the diagnosis necessary to elaborate the strategy, to gather diverse visions on the challenges and opportunities of the transition and diversification process, as well as to facilitate the collective construction of strategic objectives from the territory based on the identified challenges. This is why the participatory process in this case was focused on a technical audience with the idea of generating a first proposal of objectives and that these can be discussed, improved and validated by the citizens in a subsequent phase.

Among the benefits that participatory processes contribute to strategic design, the following stand out: the inclusion and representation of different perspectives; the strengthening of stakeholder commitment; consensus building and conflict resolution; access to local knowledge and practical experiences; and the generation of collaborative networks that sustain strategies over time. Furthermore, these processes allow for a more dynamic monitoring and adjustment of actions, reinforcing their sustainability. In short, the participatory approach not only improves the quality of economic diversification strategies, but also guarantees their social viability, strengthening trust, co-responsibility and collective commitment in transition territories.

2.1.3 Strategy design process

The IKI JET project has established the use of evidence-based methodologies and the adoption of a participatory approach as central to its implementation, aiming to foster the co-creation of knowledge and results together with key actors involved in the processes of just socio-ecological transition and economic diversification in Chile. Within the framework of the case study in the Antofagasta region, with special emphasis on the district of Mejillones, the strategic design process considered:

1) the elaboration of a diagnosis of the state of productive and export diversification in Antofagasta, as well as relevant social and environmental aspects;

2) the identification of diversification opportunities detailing strategic sectors and products with growth potential, productive sophistication and generation of added value, among others;

3) the implementation of two cycles of informative and participatory workshops, together with semi-structured interviews with key public and private actors at national, regional and local levels.

These instances made it possible to integrate multiple perspectives, enrich the territorial analysis and collaboratively build the objectives and strategic guidelines of the process.

– Elaboration of a diagnosis on the state of productive and export diversification in Antofagasta and identification of diversification opportunities.

Two internationally recognised quantitative methodologies were used to develop the regional diagnosis and identify diversification opportunities. On the one hand, EQuIP (Illustration 2), developed by UNIDO and GIZ, supports the formulation of participatory and evidence-based policies and strategies for inclusive and sustainable industrial development . It has nine tools that include indicators to analyse the state of productive diversification, employment, gender equity, and the environmental situation of the territory. It is a flexible methodology that allows for the selection of indicators depending on the context of the country and region based on their priorities but also on the availability of information. It uses information coded according to the International Standard Industrial Classification (ISIC).

On the other hand, DIVE (Figure 2), developed by UNIDO, supports the design of diversification policies and helps to address a key question about the direction an economy should take: Is it desirable to diversify exclusively into new products that depend on existing skill sets and are linked to available resources (related products)? Or is it feasible to develop new specialisations in products that have little similarity with the country's existing production structure (unrelated products)? DIVE involves the analysis of three components, the first two support the analysis of the current state of the export structure to understand the level of concentration or diversification, and through a historical analysis it allows to understand the past ability of the territory to diversify, which allows to infer how likely it is that it can do so in the future. The third component supports the identification of productive opportunities in the short and long term based on the degree of *relatedness*[26] of potential products with products that are currently exported by the region with revealed comparative advantage[27] . The methodology uses export information coded according to the Harmonised System at 4 digits of aggregation.

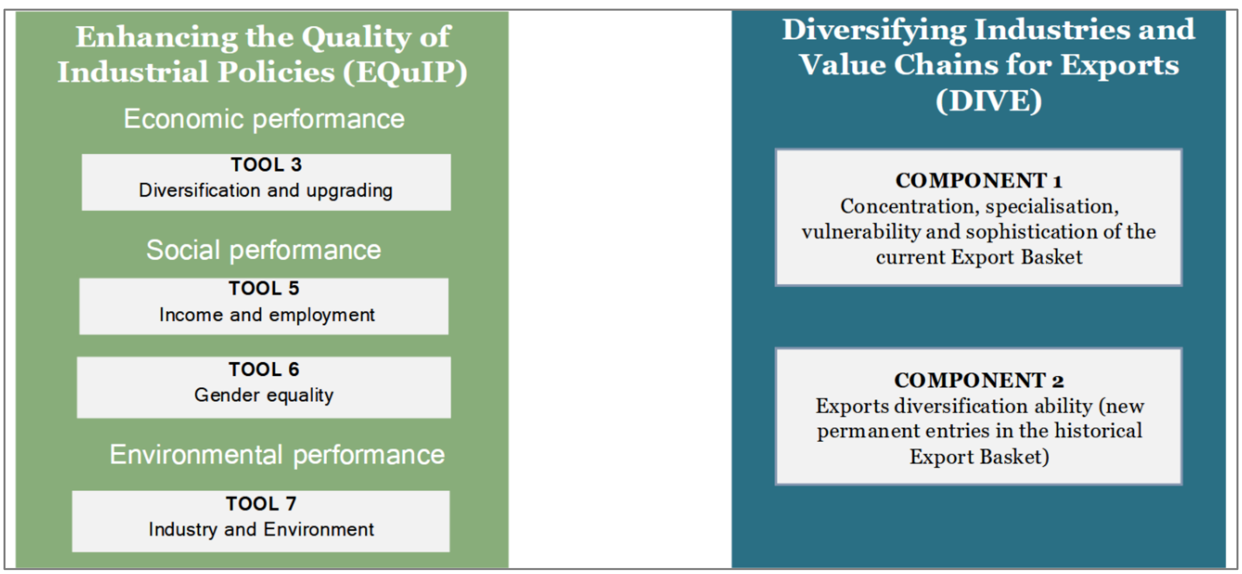

Illustration 2: Quantitative methodologies for the diagnosis and identification of diversification opportunities

Source: https://www.equip-project.org/the-equip-toolkit-2024/
https://www.unido.org/sites/default/files/files/2023-06/DIVE_Tool_Manual.pdf

[26] The degree of relatedness measures the proximity between a product outside the current export basket and products that are already exported with a level of specialisation above the world average.

[27] The level of revealed comparative advantage measures the degree of specialisation of a country or region in a given product compared to the degree of specialisation of the world.

The two methodologies were combined for the development of the diagnosis of the current state and the identification of future opportunities according to the phases and steps detailed in Illustration 3. Annex 1 details the methodology and calculation of EQuIP and DIVE indicators used in chapter 3 and chapter 5 together with their interpretation logic.

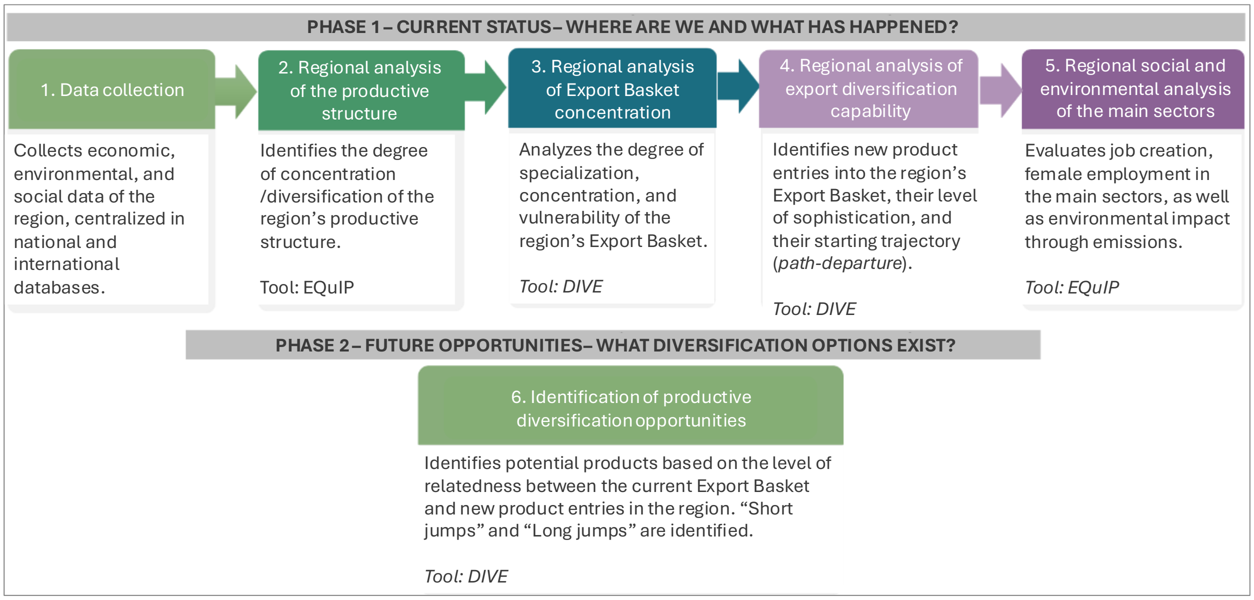

Illustration 3: Phases and steps for the development of the diagnosis and identification of diversification opportunities

In addition, for the identification of diversification opportunities, the opinion of relevant actors at national, regional and local level was considered through semi-structured interviews carried out in December 2024, which allowed to survey their perception and knowledge about the productive potential of Antofagasta and particularly Mejillones (Table 8).

– First cycle of workshops

The first cycle of workshops, entitled **"Development of economic diversification strategies for coal regions",** included two information sessions aimed at technical staff from various public institutions involved in the processes of just transition and economic diversification in the country, such as Regional Ministerial Secretariats (SEREMI), Regional Governments (GORE) and Municipalities, as well as technical advisors linked to these areas.

The objective of the workshops was to present methodologies and practical tools to develop more robust diagnoses on the degree of economic diversification or concentration, as a basis for moving towards a just and sustainable energy transition. Preliminary results were also shared on the current state of economic diversification in Chile and in the Antofagasta region, using quantitative methodologies applied for analysis and evaluation.

The workshops were held in the cities of Santiago (9 December 2024) and Antofagasta (11 December 2024), which included an agenda (see Annex 2 and Annex 3, respectively) that incorporated a series of presentations and discussion spaces aimed at strengthening capacities around green economic diversification in coal regions. The day began with an introduction to the National Strategy for a Just Socio-Ecological Transition and the Coal Phase-out Plan, followed by the presentation of the project and the digital guide to develop diversification strategies. Subsequently, the conceptual and methodological frameworks were addressed, highlighting the importance of the evidence-based and participatory approach. Finally, initial results of the diagnosis of economic diversification in Chile and the Antofagasta region were presented, ending with a discussion on opportunities and challenges to advance a just transition.

In total, 21 professionals participated in the workshops of the first cycle: 14 participants in Santiago and 7 in Antofagasta. The participants represented key institutions linked to the processes of just socio-ecological transition and economic diversification, including the Ministry of Energy, the Ministry of Environment, the Ministry of Social Development and Family, the National Training and Employment Service (SENCE) and the United Nations Development Programme (UNDP), as well as the Municipality of Tocopilla. Table 7 details the number of participants per workshop and the institutions present in each one.

Table 7: Stakeholders who participated in the first cycle of workshops

First cycle of workshops	Number of participants	Institutions present
Santiago, 9 December 2024	14	Deutsche Gesellschaft fur Internationale Zusammenarbeit (GIZ Chile) Global Policy Incubator (GPI) RST Andes, Ministry of Energy Ministry of Environment Ministry of Social Development and Family UNDP Chile SENCE
Antofagasta, 11 December 2024	7	GIZ Chile GPI RST Andes Ministry of Environment UNDP Municipality of Tocopilla

– Interviews

Semi-structured interviews with key actors in the process were conducted in December 2024. The purpose of these interviews was to identify the main challenges and opportunities (economic, social and environmental) associated with the processes of just transition and green economic diversification in the region. It also sought to gather information on the concrete actions that the different institutions have implemented or plan to implement to address these challenges and take advantage of the opportunities identified. Finally, information was gathered on the productive potential of Antofagasta and Mejillones, and the perception of the interviewees regarding the functioning of the multilevel governance process (national, regional and local) and its capacity to enable a just transition and effective economic diversification in the territory of Antofagasta and Mejillones was explored.

The semi-structured interviews conducted in the framework of the IKI JET project involved key actors at national, regional and local levels, as shown in Table 8. At the national level, representatives of the Ministry of Energy and the Ministry of Labour and Social Welfare were interviewed. At the regional level (Antofagasta), institutions such as the SEREMI of the Ministries of Environment, Economy and Energy, the GORE of Antofagasta GORE, the Corporación de Fomento Productivo (CORFO), SENCE and the Universidad Católica del Norte participated. At the local level (Mejillones), representatives of the Municipality, the Mejillones Industry Association and ENGIE were included.

Table 8: Stakeholders interviewed

Level	Stakeholders interviewed
National	Ministry of Energy Ministry of Labour and Social Security
Regional (Antofagasta)	SEREMI Ministry of the Environment SEREMI Ministry of Economy, Development and Tourism SEREMI Ministry of Energy Catholic University of the North / Regional Observatory of Human Development SENCE GORE of Antofagasta CORFO ENGIE Company
Local (Mejillones)	Municipality of Mejillones Association of Industries of Mejillones

– Second cycle of workshops

The second cycle of workshops, entitled **"Economic diversification strategies: Applying the IKI JET guide to the case of Antofagasta with a focus on Mejillones"**, included two complementary sessions: one participatory and the other informative. Both workshops were aimed at technical staff and decision-makers from various institutions linked to economic diversification processes in coal regions, including ministries, technical advisors, private sector representatives and civil society organisations.

The objective of the meetings was to present the preliminary results derived from the application of the quantitative and qualitative tools contained in the guide and to offer concrete inputs that would allow participants to strengthen their capacities to develop diagnoses on the level of diversification or economic concentration of the territory, and thus advance in a just transition towards a green economy.

The workshops were held in Mejillones (1 April 2025) and Santiago (3 April 2025). In both spaces, the IKI JET project, the methodological guide for the design of economic diversification strategies and the preliminary diagnosis of the region of Antofagasta and the district of Mejillones were presented. Particularly in the Mejillones workshop, a participatory exercise was carried out to collectively build the strategic objectives for the region (see the agenda in Annex 4). The results of this participatory work were presented at the Santiago seminar, highlighting the proposal of objectives for the regional strategy, as well as a preliminary list of opportunities for economic diversification as input for the process of Just Socio-Ecological Transition in the region (see the agenda in Annex 5).

A total of 48 people participated in the meetings: 22 in the Mejillones meeting and 26 in the Santiago meeting, as shown in Table 9. The activities were attended by a wide institutional representation, including national, regional and local bodies, as well as representatives of international cooperation, the private sector and consultancy firms. Among the institutions present were sectoral ministries (Energy, Environment, Economy, Mining, Labour, among others), embassies (Germany, Italy, Greece), multilateral organisations such as UNDP and Food and Agriculture Organization (FAO), industrial and green hydrogen associations, as well as regional public services such as the National Geology and Mining Service (SERNAGIOMIN), CORFO, SENCE and the Undersecretariat of Regional and Administrative Development (SUBDERE).

Table 9: Stakeholders who participated in the second cycle of workshops

Second cycle of workshops	Number of participants	Institutions present
Mejillones, 1 April 2025	22	GIZ Chile GPI RST Andes SEREMI Energy SEREMI Science SEREMI Public Works SEREMI Sports Antofagasta SUBDERE CORFO Ministry of National Assets Sernageomin SENCE Antofagasta Industrialists H2 Antofagasta Association Consultancies and Business Services (COMOV)
Santiago, 3 April 2025	26	GIZ Chile GPI RST Andes German Embassy European Union Delegation Embassy of Italy Embassy of Greece Ministry of Energy Ministry of Economy Ministry of Environment Ministry of Mining Ministry of Labour and Social Welfare UNDP Food and Agriculture Organization (FAO Chile) H2 Chile COMOV

3 Diagnosis of the Antofagasta region

3.1 Context of Antofagasta

The Antofagasta region, located in the Norte Grande of Chile, is the second largest in the country, with an area of 126,049 km² and an estimated population of 714,142 people (3.6% of the national total)[28] , 94% of whom reside in urban areas . [29]

Historically, the Antofagasta region has been closely linked to large-scale mining, which has been the driving force behind its economic development. It is the main producer of copper and lithium in the country, concentrating a large part of the national extractive activity.

In the last decade Antofagasta has also emerged as Chile's energy capital. Between 2018 and 2024, the region increased its installed electricity generation capacity by 80%, reaching 10,036 MW, which represents 27% of the national capacity[30] . In particular, it has gained prominence as a strategic territory for the development of Non-Conventional Renewable Energies (NCRE), especially photovoltaic solar energy, thanks to the fact that it has the best irradiation rates on the planet and has large tracts of land. Currently, Antofagasta has more than 3,900 MW of installed solar PV capacity .[31]

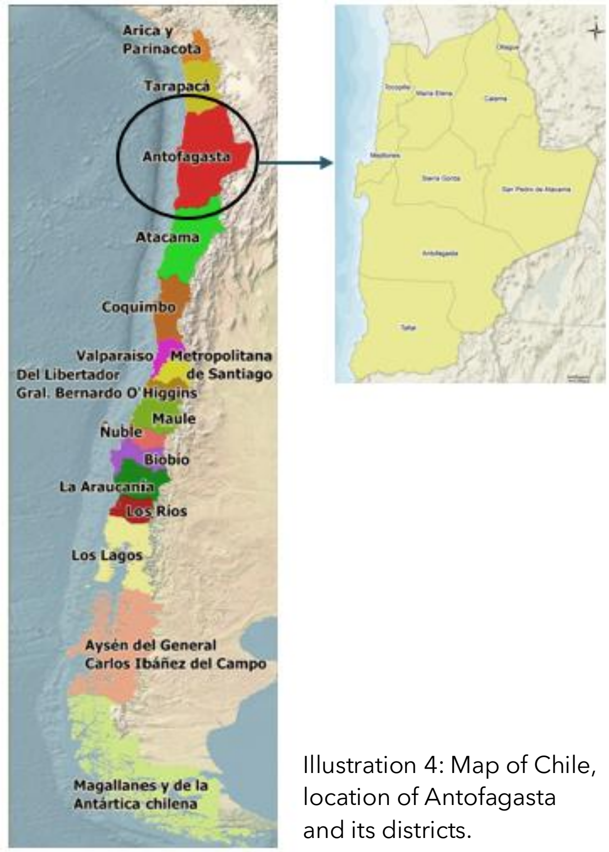

Illustration 4: Map of Chile, location of Antofagasta and its districts.

This transformation process has energised the regional economy, promoting employment generation, productive diversification and new opportunities for small and medium-sized enterprises and local suppliers.

The region also plays a strategic role in meeting Chile's climate commitments, framed in national policies such as the draft Coal phase-out Plan (2024), the National Green Hydrogen Strategy

[28] SIIT Territorial Statistics, Library of the National Congress of Chile. https://www.bcn.cl/siit/estadisticasterritoriales//resultados-consulta?id=235297
[29] Projection by the National Statistics Institute (INE) for 2022 based on the 2017 CENSUS.
[30] National Energy Commission (CNE), Chilean Association of Renewable Energy and Storage (ACERA).
[31] National Electricity Coordinator (CEN)

(2020), the Just Socio-Ecological Transition Strategy (2024) and the National Energy Policy (2022). These policies establish objectives such as eliminating coal-fired thermoelectric generation by 2040, achieving a 100% renewable electricity matrix by 2050 and positioning the country as a leading exporter of green hydrogen and its derivatives.

In this context, the district of Mejillones is positioned as a strategic enclave within the Antofagasta region for the development of renewable energy projects, especially solar, and green hydrogen production. Its proximity to the main mining centres, together with a wide availability of industrial land and port connectivity, reinforce its potential as a logistics and energy platform to advance national coal phase-out objectives. Thus, Antofagasta, and in particular Mejillones, are consolidated as key territories in the country's energy transition, articulating coal phase-out with an agenda of productive diversification and territorial justice.

3.2 Production structure

The national productive structure, observed through the development of the Gross Domestic Product (GDP) between 2013 and 2023, shows a general growth trend, with the exception of 2020, when the country experienced a sharp economic contraction due to the COVID-19 pandemic. This downturn was followed by a marked recovery in subsequent years (Figure 1).

In a counter-cyclical manner, regional GDP has been on an upward trajectory in line with the national trend. However, it showed a sharp rise during the period of the COVID-19 pandemic for a number of cyclical reasons, mainly the considerable increase in international prices and the rise of the US dollar (USD) which benefited mining exports. Given the importance of the mining industry at the national level, this strong rise allowed the general trend of national economic growth to continue during the COVID-19 pandemic. The decline in 2023 was due to the national and global economic downturn (Figure 2).

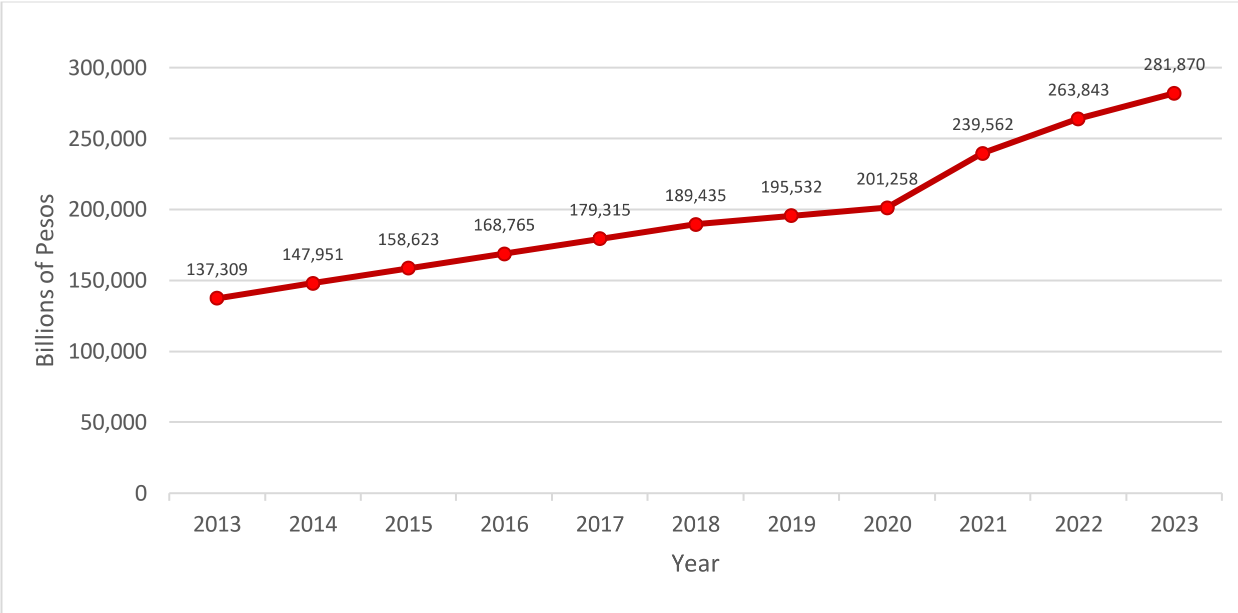

Figure 1: Chile's GDP at current prices

Source: Central Bank of Chile

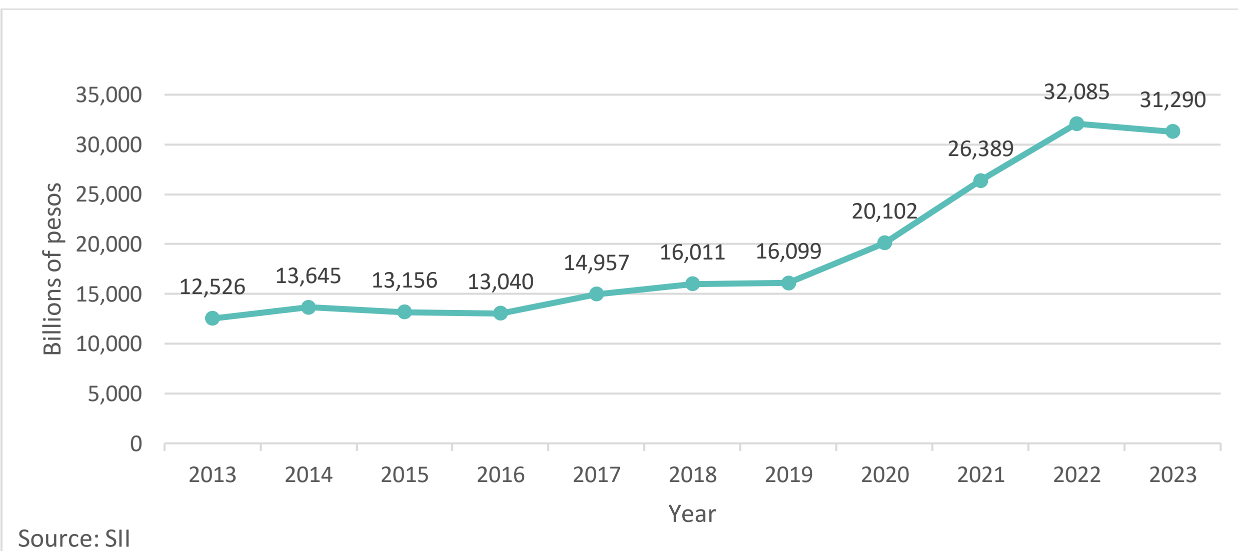

Figure 2: GDP Antofagasta Region at current prices

Source: Central Bank of Chile: Central Bank of Chile

Although Chile has a total of 16 regions, 5 of them contribute to almost 75% of the national GDP. The Antofagasta region is, after Santiago de Chile (43.4% of national GDP in 2023), the region that contributes the most to GDP, with a share of over 11% (Graph 3).

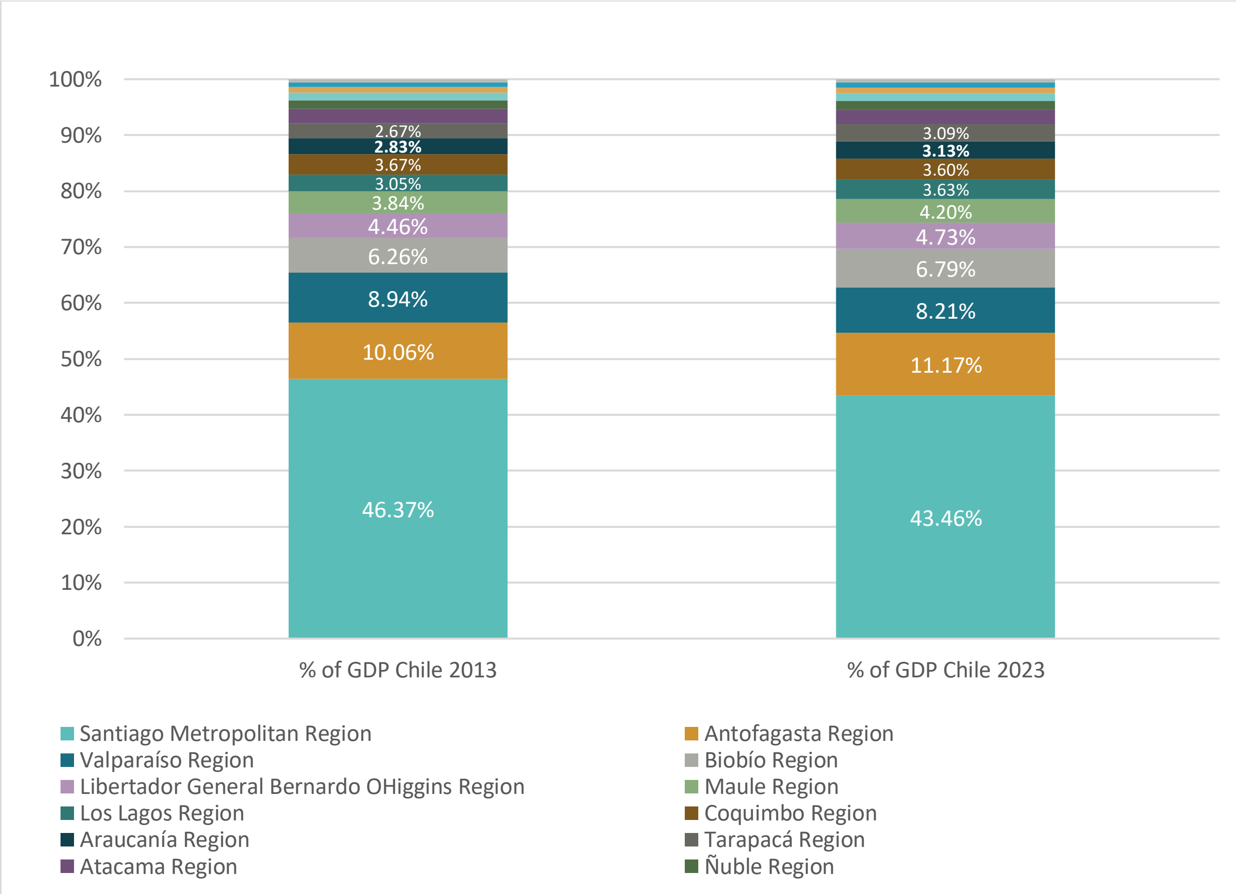

Figure 3: Regional share in Chile's GDP

Source: Central Bank of Chile

Chile's GDP is composed of a relatively balanced structure, in which nine economic sectors contribute similarly to national productive activity, with shares ranging from 9% to 13% each (Graph 4). Together, these sectors accounted for 95% of GDP in 2013 and 93% in 2023, reflecting a broad and sustained distribution across the country's main productive areas. In contrast, the economy of the Antofagasta region shows a strong concentration in the mining industry, which accounts for 52% of regional GDP in 2023 despite the sector's declining share compared to 2013. It is followed by the construction (11%) and electricity, gas, water and waste management (7%) sectors, both closely linked to mining activity (Graph 5).

These figures show the high dependence of the Antofagasta region on the mining sector, configuring an economic structure marked by a quasi-monoexport character based on the extraction of non-renewable natural resources, mainly minerals. This specialisation has had a significant impact on the national budget and development. However, also shows a progressive growth of other complementary economic activities, which point towards efforts to diversify the regional productive matrix.

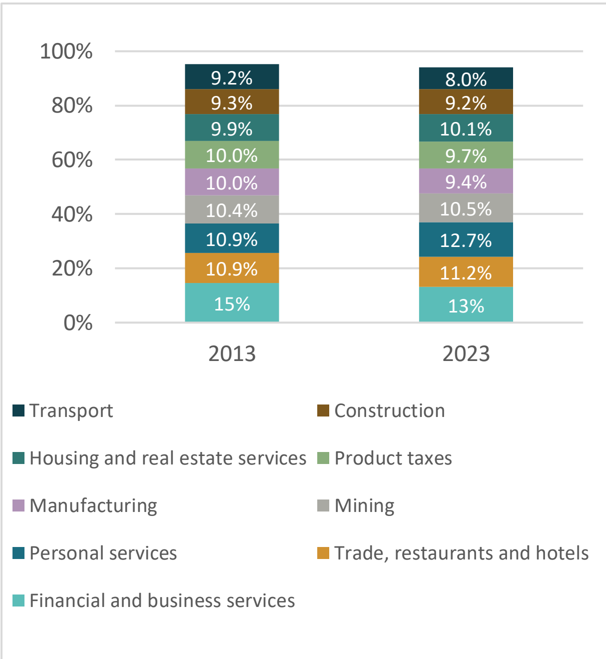

Figure 5: Percentage relevance of economic sectors in Chile's GDP

Source: Central Bank of Chile

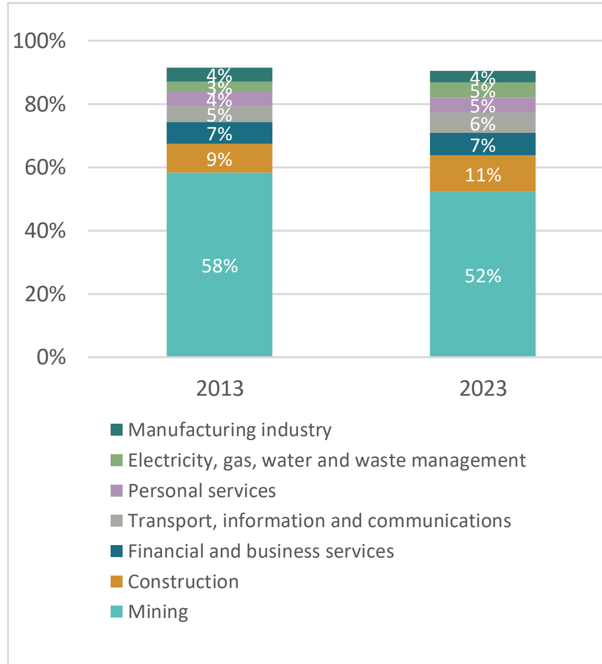

Figure 4: Percentage Relevance of Economic Sectors in the GDP of the Antofagasta Region

Source: Central Bank of Chile

According to the Central Bank, the Antofagasta region's GDP, especially the energy sector, has experienced significant growth in recent years, driven mainly by mining, electricity generation (including renewable energies such as solar) and construction. In 2023, the regional GDP for electricity, gas, water and waste management (EGA) was COP 824 billion, increasing its absolute value by 93% compared to 2013 (when GDP for the sector reached COP 426.4 billion). However, its contribution to regional GDP has remained relatively stable, increasing by 2% compared to 2013 (with a share of 3% in 2013 and 5% in 2023).

Complementarily, the report of the University of Antofagasta (2023) the production of Mejillones reached 376 million dollars, highlighting construction, electricity, gas and water supply, and metal manufacturing industries as the main items. In terms of sub-headings, construction (34.4%), the generation, collection and distribution of electricity (21.1%) and the manufacture of basic chemicals (10.5%) stand out as key drivers of the local economy. These figures reinforce the strategic character of the district in sectors linked to the energy transition, while highlighting the potential for expansion into other productive activities and associated services.

3.3 Structure of the export basket

The export basket of Antofagasta, according to the definition used by the DIVE tool, is composed only of products that the region exports with a revealed comparative advantage in relation to the world, i.e. it exports in a specialised manner.

Taking this into consideration, the structure of Antofagasta's export basket analysed for the period 2019-2021 is highly concentrated in a few products according to the Herfindahl-Hirschman Index (HHI). The level of concentration is even higher than in Chile at the national level, in high-income countries and in relation to the world average (Table 10). However, the degree of vulnerability of the Antofagasta basket, while considerable, was lower than that of Chile and the world average. This can be explained by three factors considered by the vulnerability index: 1) the set of local capacities available in Antofagasta to produce the goods in the basket are less easy to acquire in other regions of the country and in the world in general, 2) the existing capacities in Antofagasta are not as present in other regions of Chile and other countries worldwide, and 3) the barriers to entry for the products exported by Antofagasta are not as low and therefore the level of competition in the medium and long term is not significantly high.

From a historical perspective, the evolution of the level of concentration of Antofagasta's export basket shows a decreasing trend in the period 2002-2020. However, the degree of vulnerability has remained practically unchanged. These two aspects are part of the major economic challenges facing the region, which are structural (Figure 6).

Table 10: Degree of concentration and vulnerability of Antofagasta's export basket and comparators

	Export basket vulnerability index (2019-2021)	**Export basket concentration index in specialised products (HHI) (2019-2021)**
Antofagasta	0.677	0.358
Chile	0.695	0.149
High income countries	0.661	0.127
World average	0.685	0.177

Source: Chilean Customs and BACI/CEPII.

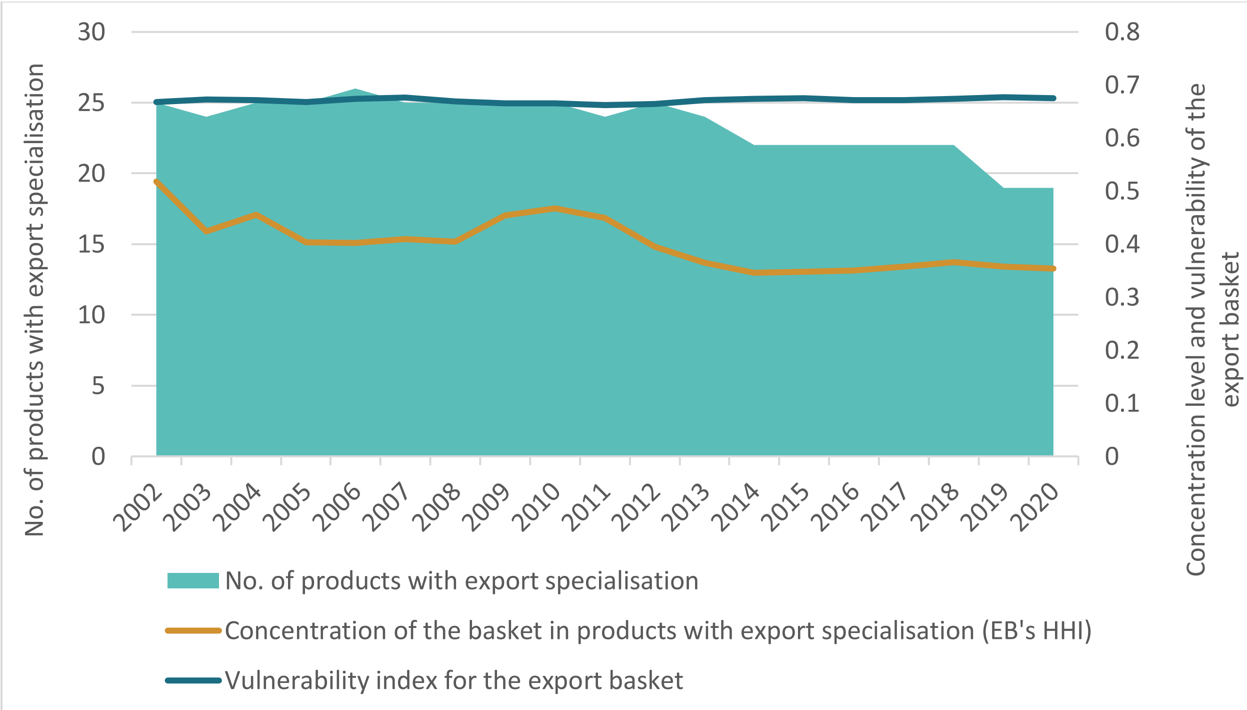

Figure 6: Evolution of the level of concentration and vulnerability of the Antofagasta export basket

Source: Chilean Customs and BACI/CEPII

An analysis of the composition of Antofagasta's export basket in 2023 shows that it depends on few products, as the three most important ones together accounted for 80.7% of total exports. Specifically, copper sector products such as ore and refined copper represent the bulk of the region's exports, which is evidence of the high degree of exposure to both supply and demand shocks. In addition, chemical sector products such as carbonates, iodine, nitrates and fertilisers are also important products for the region and exported with a revealed comparative advantage.

These types of products are known to be energy-intensive, which is why the region could benefit from transforming the coal-based energy matrix towards the use of renewable energies, on the one hand, and diversifying the productive matrix towards less energy-intensive goods, on the other.

Table 11: Structure of Antofagasta's export basket.

Code (SA1992)	Product description	Sector	Exports in 2023 (US$ million)	Share in total exports 2023	Cumulative share
7403	Refined copper and copper alloys	Metals	13,370.00	33.67%	33.67%
2603	Copper Ore	Ore	12,620.00	31.77%	65.44%

Code (SA1992)	Product description	Sector	Exports in 2023 (US$ million)	Share in total exports 2023	Cumulative share
2836	Carbonates (lithium)	Chemical	6,063.00	15.27%	80.71%
2613	Molybdenum ore	Ore	1,733.00	4.36%	85.07%
7402	Unrefined copper	Metals	1,585.00	3.99%	89.06%
2801	Iodine	Chemical	1,017.00	2.56%	91.62%
2825	Basic metal oxides, ne	Metals	1,010.00	2.54%	94.16%
2834	Nitrites, nitrates	Chemical	285.00	0.72%	94.88%
3105	Mixed Fertilisers	Chemical	198.40	0.50%	95.38%
3102	Nitrogen fertiliser	Chemical	181.40	0.46%	95.84%

Source: Chilean Customs

Another important element to analyse is the level of sophistication of Antofagasta's export basket, considering that worldwide evidence shows that the more sophisticated the productive and export structure of countries, the higher and faster long-term growth they experience (Atlas of Complexity)[32] . This is related to the degree of technology, innovation and specialised capacity that these types of goods require. In this sense, the degree of sophistication of the region's export basket shows a higher level (US$ 12,434.5) compared to Chile's basket (US$ 10,890.8) but well below that of high-income countries (US$ 20,605.4) and the world average (US$ 14,825.0).

Figure 7 shows the level of sophistication of products in Antofagasta's export basket with the highest share and their average annual growth rate (2013-2023), as well as the value of exports 2023. It is evident that the growth pattern of the region's export basket depends on products with low and moderate levels of sophistication such as copper products, other minerals such as molybdenum and some chemicals such as carbonates. This is another important element to consider when establishing what type of products the region could benefit from focusing its diversification strategy on.

[32] https://atlas.hks.harvard.edu/countries/276/export-complexity

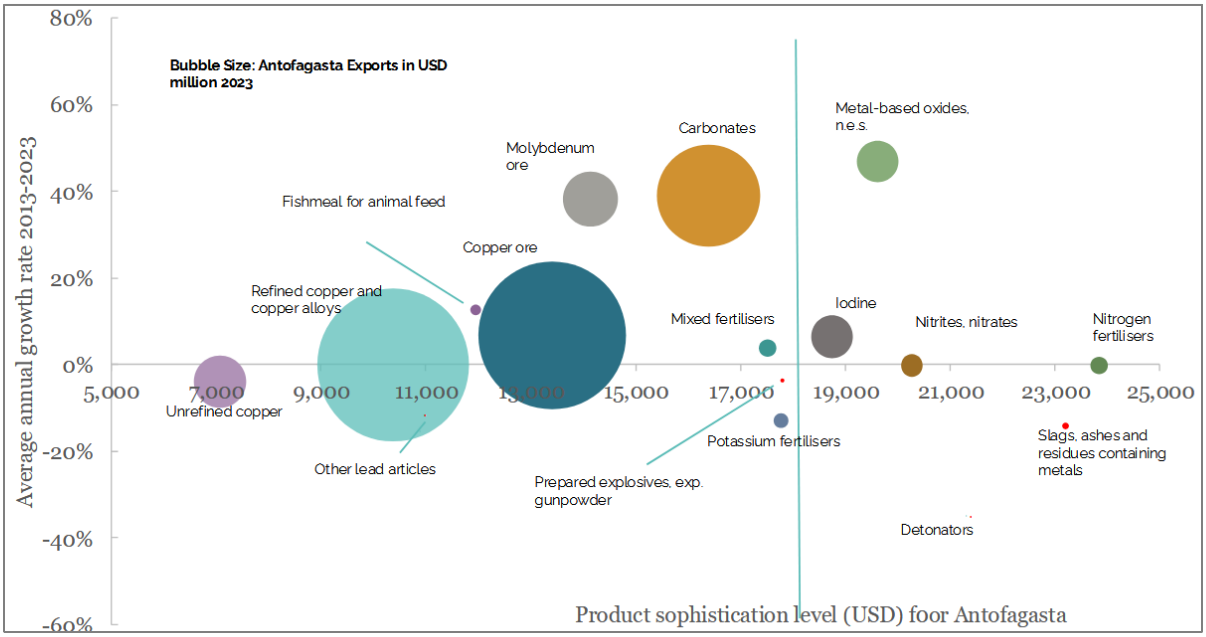

Figure 7: Growth and level of sophistication of the main products in Antofagasta's export basket.

Source: Chilean Customs

Finally, through a historical analysis of Antofagasta's export basket to identify the region's ability to diversify, Table 12 shows that between the period 2002-2022 only three products were identified as new entries with permanent specialisation. This means that they are products that the region started exporting with a revealed comparative advantage and on a constant basis.

Two of these products are from the chemical sector and one from the mineral sector (basic metal oxides, sulphonitric acids and bituminous mixtures) and although their number is limited, they have at least contributed to increase the degree of sophistication of Antofagasta's basket. As Table 12 shows, the level of product sophistication in 2022 increased compared to the value recorded in the year of entry.

Table 12: New entries of products with permanent specialisation in the Antofagasta export basket

Year of entry	Code (HS 1992)	Product description	Sector	Latest product sophistication		Product sophistication in the year of entry
2005	2825	Basic metal oxides	Chemicals	$ 14,345.26	>	$ 9,422.55
2017	**2808**	**Sulphonitric acids**	**Chemicals**	**$ 30,909.86**	**>**	**$ 11,724.89**
2017	2715	Bituminous mixtures	Minerals	$ 22,495.37	>	$ 11,724.89

Source: Chilean Customs and BACI/CEPII

3.4 Employment situation in Antofagasta

In 2023, the Antofagasta region reaffirmed its position as one of the most active in the country in terms of employment, with a labour force of 367,110 people and an employment rate[33] of 59.2% and a labour participation rate[34] that reached 64.5%. These figures reflect an improvement in the integration of the population into the labour market compared to 2013, when employment was 56.9% and labour participation 60.2%, which shows a progressive strengthening of employment in the region over the last decade (INE, 2016 and 2024).

However, gender gaps persist: men continue to represent 63% of the employed population, compared to 37% of women[35] , which is evidence of a structural inequality that has persisted over the last decade (Figure 8). In addition, the labour market shows a strong masculinisation in sectors such as mining, construction and heavy industry, where female participation is very low, for example, in civil engineering works, 90% of jobs correspond to men, contrasting with the high participation of women in health, education and social services sectors (SII, 2023).

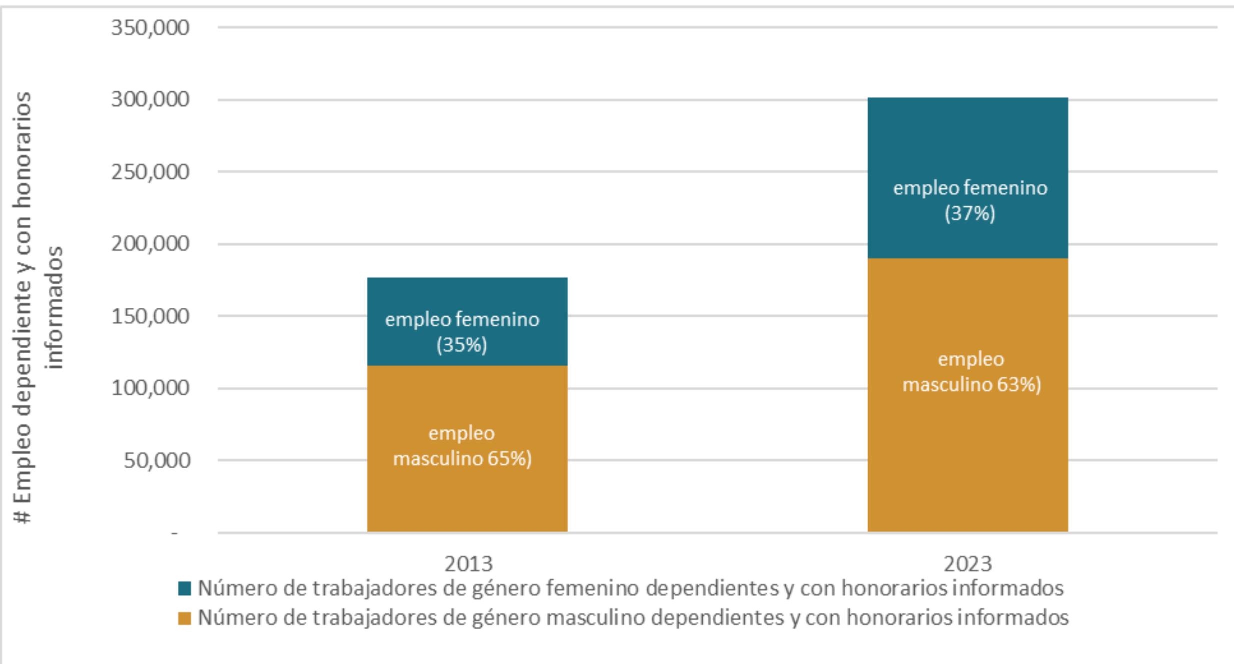

Figure 8: Workers by gender - Antofagasta region 2023

Source: SII

[33] According to the Chilean National Statistics Institute (INE), the employment rate corresponds to the percentage of employed people in relation to the total working age population. This indicator measures the degree of labour integration of the population able to participate in the labour market.
[34] The labour participation rate, according to INE, is an indicator that expresses the percentage of people who are part of the labour force - that is, who are employed or seeking employment - in relation to the total working-age population.
[35] Chilean Internal Revenue Service (SII) Database. 2023.

In terms of labour segmentation by gender and age, the 30-44 and 45-59 age groups have the highest employment rates, exceeding 70%. In contrast, the young population between 15 and 29 years of age shows a significantly lower rate, reaching only 40.5%, which shows a lower labour market insertion in this age group (Labour Observatory, 2024) .[36]

On the other hand, the unemployment rate in the Antofagasta region reached 20.2% in 2023. This figure contrasts sharply with that recorded in 2013, when the unemployment rate in the region was only 5.5%, evidencing a considerable deterioration in access to employment over the last decade (INE, 2016 and 2024). However, according to the Antofagasta Labour Observatory (2024), the region is currently positioned as an important employment hub at the national level, not only because of its capacity to absorb local labour, but also because it attracts workers from other regions of the country. This dynamic of inter-regional commutation[37] is evidence of the economic weight of the territory, particularly in sectors such as mining and construction, which account for around 80% of the so-called commuting workers. Currently, it is estimated that 21% of the total number of people employed in the region do not live there, which reaffirms its strategic role in the generation of employment in Chile.

In terms of sectoral behaviour, over the last ten years, the structure of employment in the Antofagasta region has undergone some relevant transformations according to information provided by INE (2016 and 2024). Between 2013 and 2023, the structure of employment by branch of economic activity shows a slight trend towards diversification, although mining remains the sector with the highest proportion of employed direct workers. In 2013, this sector accounted for 20.94% of regional employment, while in 2023 it decreased to 18.4%, showing a slight relative reduction, although in absolute terms the number of employed increased. Trade also reduced its share, from 18.23% in 2013 to 15.26% in 2023. Sectors such as transport and communications (from 9.13% to 8.41%), manufacturing (from 9.52% to 6.63%) and education (from 8.59% to 8.25%) also slightly decreased their relative shares. Construction maintained a relatively stable share (6.87% in 2013 and 6.79% in 2023). These data reflect a slight decline in the concentration of employment in traditional sectors and could be interpreted as signs of a slow but progressive diversification of the regional productive base. In the following graph it is possible to visualise the contribution of the main sectors and the transformations indicated above (Graph 9).

[36] It is important to clarify that this rate of 40.5% (which may be low) is partly explained by the fact that it includes young people between 15 and 18 years of age who should not be working and young people between 18 and 22 years of age who could be completing their university studies.

[37] According to the National Institute of Statistics of Chile, labour commutation corresponds to the movement of people from their place of residence to another area or region to carry out a work activity. This movement can occur within the same region (intra-regional commutation) or between different regions of the country (inter-regional commutation).

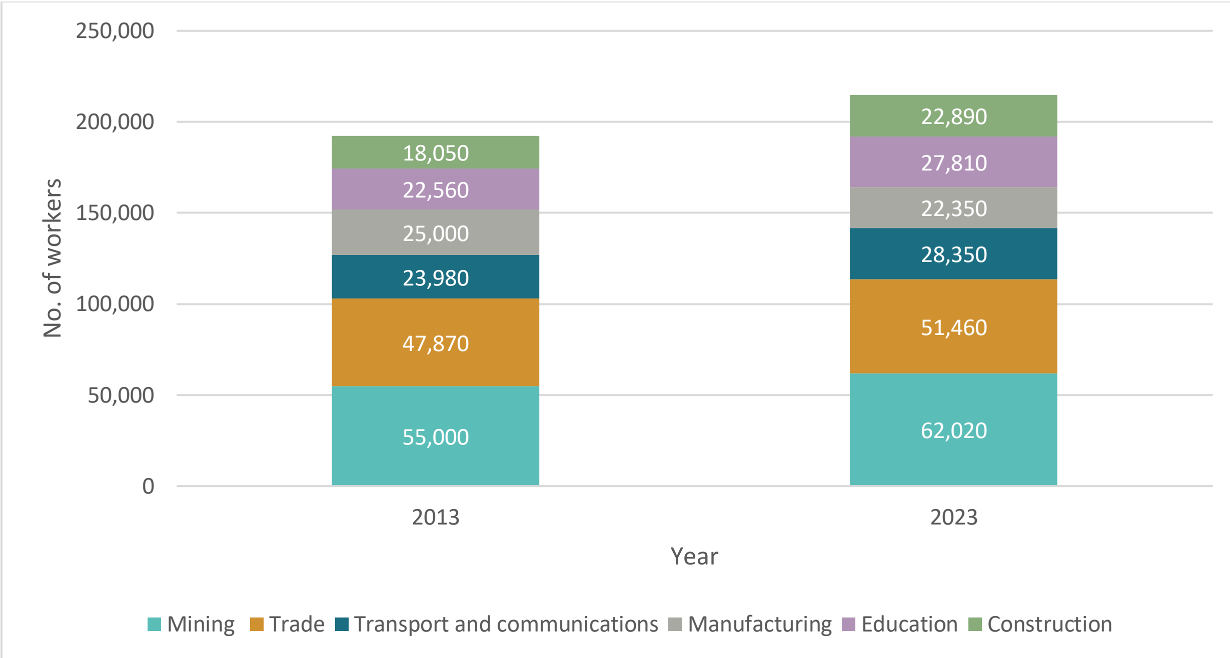

Figure 9: Workers by economic sector - Antofagasta region 2013 - 2023

Source: SII

However, according to the study developed by Viteri (2019) for the Ministry of Energy, the energy generation and distribution sector is an important generator not only of direct employment but also of indirect employment. This is why the closure of coal-fired power plants in the Antofagasta region, particularly in the districts of Mejillones and Tocopilla, will have significant impacts on both types of employment. According to the study, the plants located in these districts together generate an impact of 3.65% of regional GDP, and their operation represents 3.8% and 4.4% of district employment in Mejillones and Tocopilla, respectively. In Mejillones, although only 18.5% of the workers reside in the district, its role as an energy and logistics hub amplifies the effects on neighbouring districts such as Antofagasta, which accounts for 25% of direct employment in the sector. In addition, a large part of employment is subcontracted (63%), 91% of which is male and highly qualified, with income levels above the national average.

In addition to the direct impact, the closure of power plants has a significant effect on indirect employment, through the production chains that these facilities generate. For each direct job in coal-fired generation, 2.16 indirect jobs are estimated in sectors such as commerce, transport, professional services, industry and support activities. This dimension is key in the context of a Just Transition, as official data often only capture direct employment, underestimating the true impact of plant closures in terms of employment.

In summary, the Antofagasta region exhibits a dynamic labour market, with high levels of labour participation, but faces persistent challenges in terms of sectoral diversification, overcoming gender and age gaps, and consolidating sustainable jobs in the context of an ongoing energy and productive transition.

3.5 Antofagasta's environmental status

Regarding the environmental situation in the Antofagasta region, this section includes a brief analysis on air emissions from point sources[38] , water emissions and hazardous waste, considering that these are factors that are highly linked to the mining and energy industries of high productive relevance at regional level.

3.5.1 Air emissions from point sources

Air emissions and exposure to them are associated with numerous negative effects. That is why air pollution is one of the environmental problems that requires most attention when analysing the situation of the country and the region, as well as identifying the economic activities that generate the greatest amount of pollution. For the year 2022, according to the Consolidated Report of the Pollutant Release and Transfer Register (PRTR), air emissions from point sources of the main pollutant gas was 65,751,138.30 tonnes of carbon dioxide. From a territorial perspective, the Antofagasta region contributed 21.72% of the national total of carbon dioxide point source air emissions, making it the region with the highest level of carbon dioxide emissions from this type of source, followed by the Biobío region (21.29%).

During 2023, according to the PRTR databases of air pollutants from point sources[39] , 55% of the total corresponded to emissions of carbon dioxide and monoxide as well as nitrogen oxides (Graph 10) . [40]

[38] Point source emissions refer to direct emissions to air from industrial establishments and specific sources (Consolidated Report 2022 - PRTR).
[39] The databases used in this section come from the PRTR and were downloaded in February 2025.
[40] In this section 3.5.1, the absolute values of emissions for the year 2023 are not detailed due to an inconsistency in the unit of measurement reported in the PRTR databases and the consolidated PRTR reports. However, it is assumed that this does not affect the relative weight or contribution of each type of pollutant within the total.

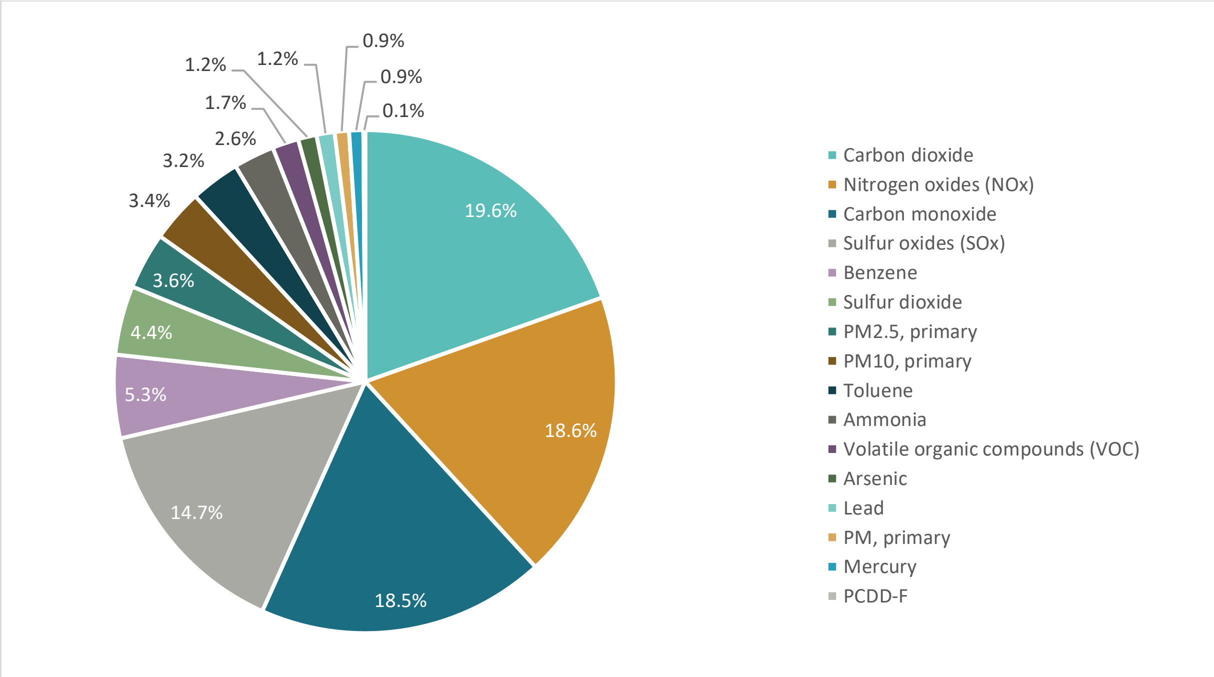

Figure 10: Share by type of pollutants in total air emissions from point sources 2023

Source: Ministry of Environment - Pollutant Release and Transfer Register - PRTR

The concentration of the production structure of the Antofagasta region on very few hihgy polluting sectors is directly reflected in the composition of its air emissions. Carbon dioxide accounted for more than 19% of local emissions, followed by nitrogen oxides (18.6%), carbon monoxide (18.5%) and sulphur oxides (14.6%). Benzene and sulphur dioxide also stood out, adding close to an additional 10 per cent between them.

Antofagasta also led national emissions of arsenic, mercury and PCDD-F, with a share of around 23% for each of these compounds at the national level (Table 13). However, these are pollutants with a low incidence in the national total, representing together only 0.9% of the country's emissions.

Table 13: Contribution of the Antofagasta region to total air pollutant emissions in Chile (tons/year) 2023

Pollutant	% Antofagasta out of national total
Carbon monoxide	7,58%
Carbon dioxide	8,18%
Nitrogen oxides (NOx)	8,98%
Sulphur oxides (SOx)	10,60%
PM2.5, primary	4,61%
PM10, primary	4,34%
Sulphur dioxide	8,21%
Volatile Organic Compounds	3,78%
Ammonia	6,07%

Pollutant	% Antofagasta out of national total
Benzene	12,75%
PM, primary	2,80%
Toluene	10,88%
Lead	19,73%
Arsenic	23,57%
Mercury	23,32%
PCDD-F	23,76%
Total	**8,01%**

Source: Ministry of the Environment - Pollutant Release and Transfer Register -RETC

In terms of the sectoral origin of emissions in the region, mining - particularly copper extraction and processing, as well as the supply of electricity, gas, steam and air conditioning - were responsible for 41.68% of the total (Table 14). This was followed by other mining and quarrying with 13.46%, and the manufacture of base metals with 7.68%.

It is important to mention that in order to determine which are the most polluting economic activities, it is necessary to analyse the intensity of emissions generation per unit of value added or production at the sectoral level. However, at the moment this information is not available at the required level of disaggregation. It would be appropriate to complement this type of analysis in the future.

Table 14: Economic sectors with the highest emissions of air pollutants in the Antofagasta region 2023.

ISIC	Detail Activity	% of regional total
04	Extraction and processing of copper	28,22%
35	Electricity, gas, steam and air-conditioning supply	17,77%
08	Other mining and quarrying	13,46%
24	Manufacture of base metals	7,68%
20	Manufacture of chemical substances and products	5,15%
47	Retail trade, except motor vehicles and motorbikes	3,57%
23	Manufacture of other non-metallic mineral products	2,55%
	Other	21,61%
	TOTAL	**100,00%**

Source: Ministry of the Environment - Pollutant Emissions and Transfers Register -RETC

At the district level, the case of Mejillones stands out, which accounts for 16.05% of regional emissions. This district shows high levels of nitrogen oxides (19% of the regional total of this pollutant), due to its energy matrix based on electricity generation by means of oil/diesel, coal and natural or liquefied gas. Coal-fired power generation, in particular, accounted for 34% of the district's nitrogen oxide emissions (Figure 11).

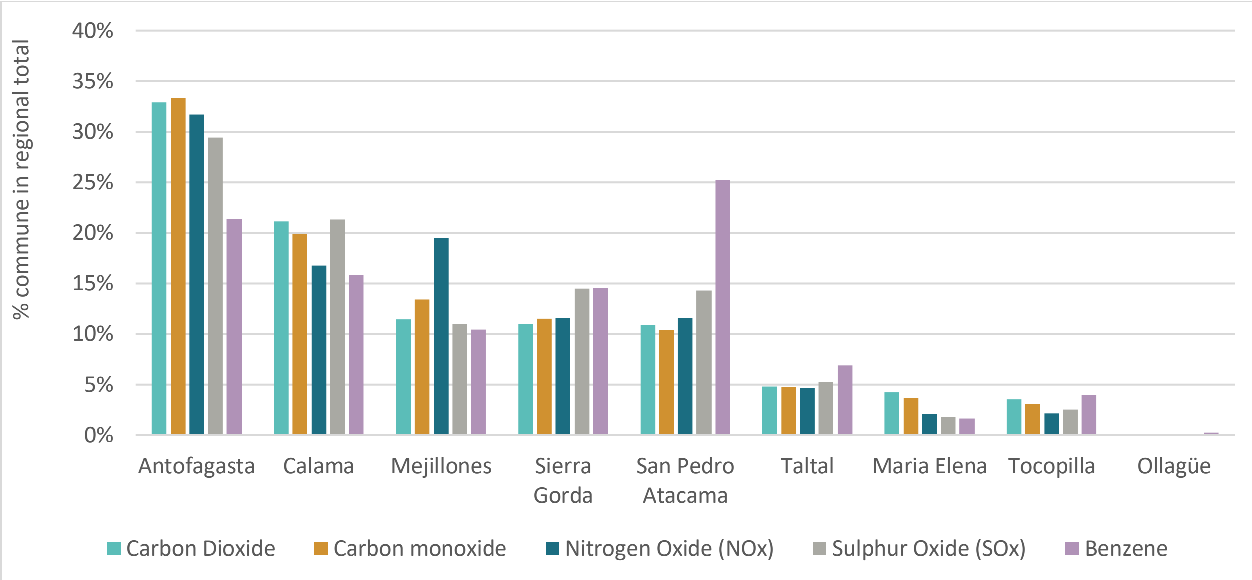

Figure 11: Emissions of the 6 main air pollutants by district in the Antofagasta region 2023

Source: Ministry of Environment - Registro de Emisiones y Transferencias de Contaminantes -RETC (Pollutant Release and Transfer Register).

When analysing CO2eq intensity, which measures CO2eq emissions per unit of GDP, it is observed that in the Antofagasta region it is lower than the national average, which suggests a commitment of the industries established in the territory to sustainable and responsible production over time (Table 15).

Table 15: COeq intensity for Chile and the Antofagasta region 2023.

	GDP at current prices in millions of Chilean pesos (CLP)	GHG in kton/year	Intensity ktonCO2eq/million CLP
Antofagasta	31.290.300	24.242.162	0,775
Chile	281.870.000	270.128.562	0,958

Source: Ministry of Environment - Registro de Emisiones y Transferencias de Contaminantes -RETC and Central Bank.

3.5.2 Emissions to water

During 2023, Chile will emit a total of almost 162 million kilo tonnes of pollutants to water[41] , with the Valparaíso region accounting for 38.1%, followed by the Antofagasta region with almost 21% of the national total (Graph 12).

[41] Details of the pollutants considered can be found in Annex 6.7.

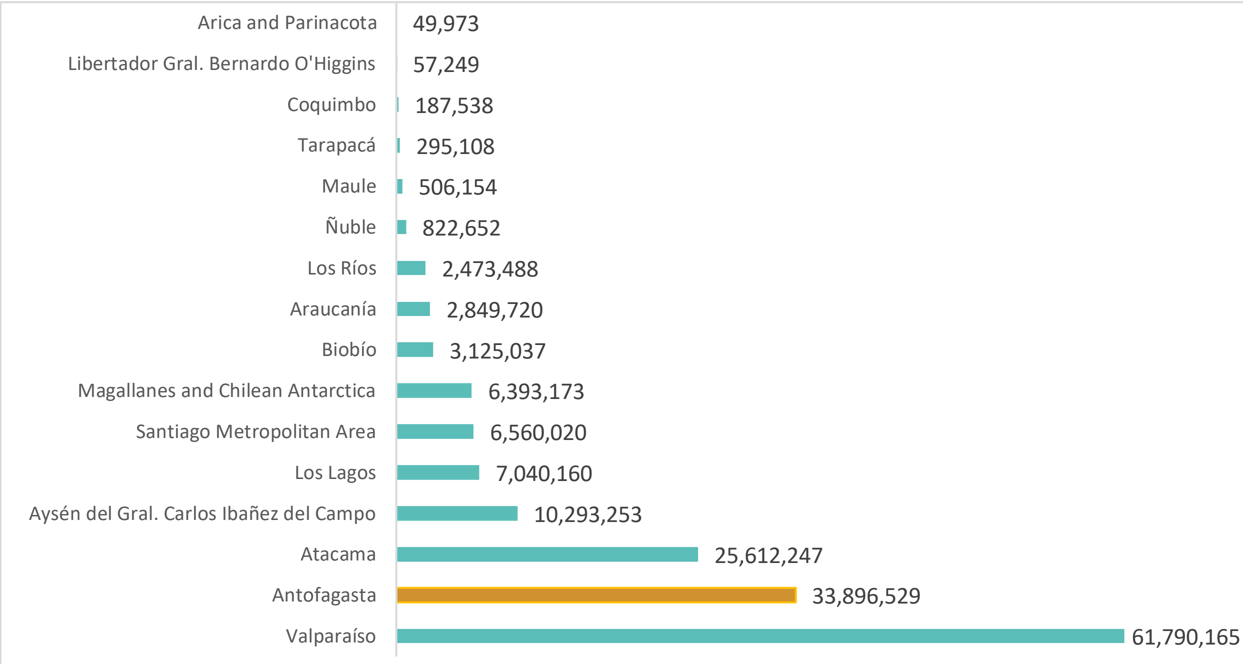

Figure 12: Emissions to water by region kton/year 2023

Source: Ministry of the Environment - Pollutant Release and Transfer Register (PRTR)

Of the more than 33 million kilo tonnes of water pollutants emitted by the Antofagasta region, more than 90% corresponded to just two compounds: chlorides and sulphates. Chlorides accounted for 75% of total regional emissions, while sulphates accounted for 17%, which shows a clear dominance of these two pollutants in the total load discharged into the water resource (Graph 13).

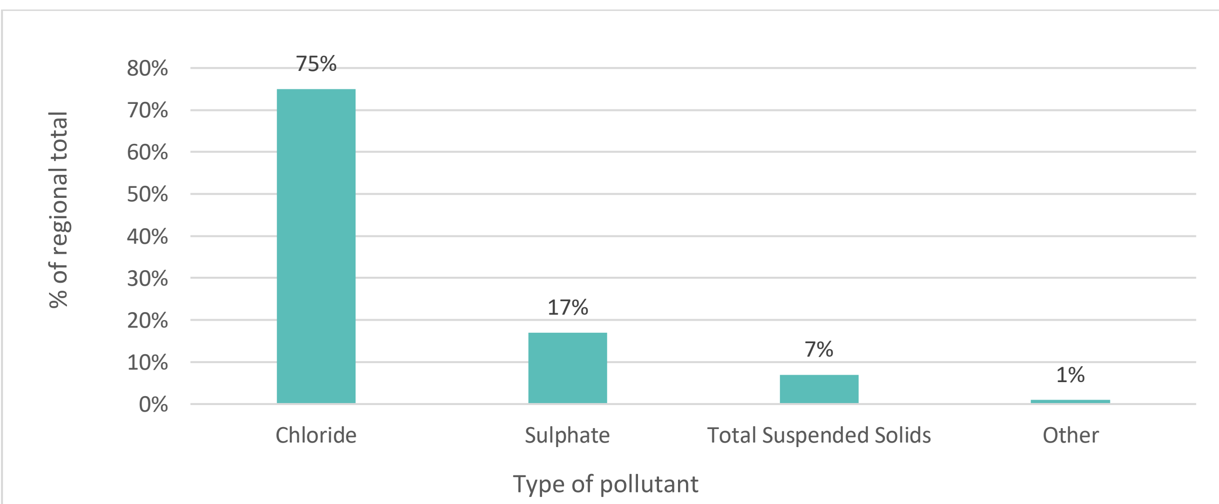

Figure 13: Share of pollutants discharged to water. Antofagasta Region 2023

Source: Ministry of the Environment - Pollutant Release and Transfer Register -RETC

When analysing the economic sectors responsible for emissions to water in the Antofagasta Region, a strong concentration around resource-intensive activities can be observed. The energy sector - particularly the supply of electricity, gas, steam and air conditioning - contributed 81.2% of the regional total, mainly associated with thermoelectric generation. It is followed by mining, specifically copper extraction and production, with 17.2% (Table 16). These data again reflect how regional economic concentration translates into significant and cross-cutting environmental impacts.

Table 16: Main economic sectors emitting pollutants to water-region of Antofagasta 2023.

ISIC	Detail Activity	million ton/year	% of regional total
35	Electricity, gas, steam and air conditioning supply	27.547	81,27%
04	Copper mining and processing	5.834	17,21%
	Other	515	1,52%
	TOTAL	33.896	100,00%

Source: Ministry of Environment - Registro de Emisiones y Transferencias de Contaminantes -RETC (Pollutant Release and Transfer Register).

3.5.3 Hazardous Waste

Chile will generate more than 218 million kilo tonnes of hazardous waste in 2023. Of this total, 67% is attributed to the Antofagasta region (34%), followed by the Metropolitan region (33.6%). In third place comes the Valparaíso region with 8.17%, after which the overall contributions drop drastically (Figure 14).

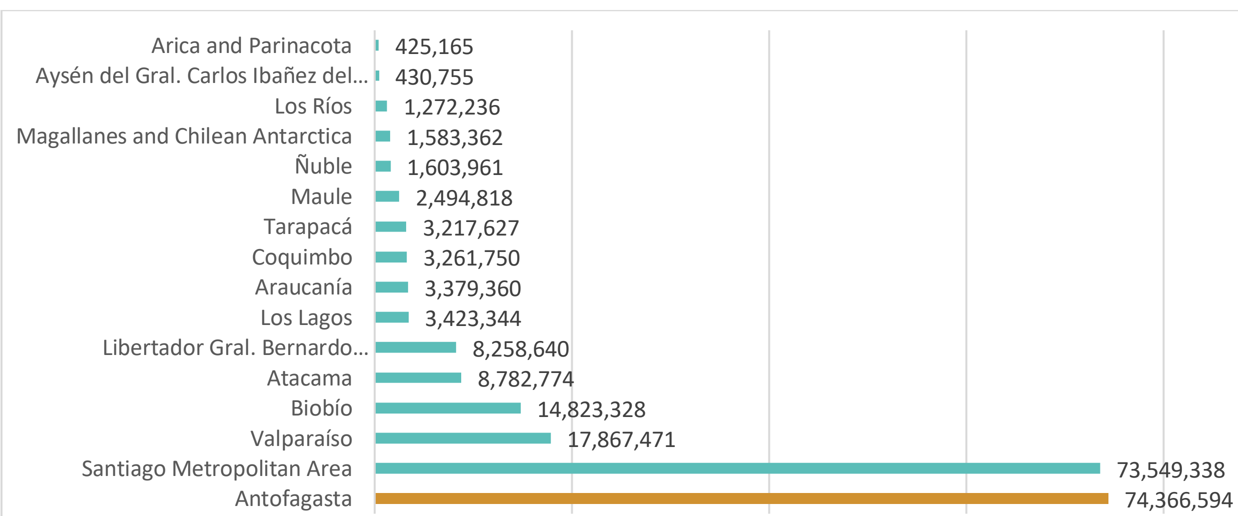

Figure 14: Hazardous waste generation by region in kton/year 2023

Source: Ministry of Environment - Pollutant Release and Transfer Register (PRTR).

When analysing the economic sectors with the highest generation of hazardous waste, the mining industry is again among the most relevant at regional level (Antofagasta). Copper extraction and production activity is responsible for 37.4% of the regional total, followed by the storage and transport support activities sector with a share of 9.3% (Table 17).

ISIC	Detail Activity	kton/year	% of regional total
4	Copper extraction and production	81.977.256	37,48%
52	Warehousing and support activities for transport	20.494.964	9,37%
38	Collection, treatment and disposal of waste; materials recovery	17.725.381	8,10%
86	Human health care activities	13.508.822	6,18%
46	Wholesale and retail trade and repair of motor vehicles and motorbikes	12.612.384	5,77%
20	Manufacture of chemicals and chemical products	10.887.920	4,98%
	Other	61.533.796	28,13%
	TOTAL	218.740.523	100,00%

Table 17: Main economic activities that generate hazardous waste in the region of Antofagasta 2023.

Source: Ministry of Environment - Registro de Emisiones y Transferencias de Contaminantes -RETC (Pollutant Release and Transfer Register).

4 Strategic objectives for the economic diversification of the Antofagasta region with a focus on the district of Mejillones

The definition of strategic objectives for economic diversification in the region of Antofagasta, and in particular in the district of Mejillones, is part of the process of just transition that Chile has begun to implement. This process aims to move towards the coal phase-out of the national energy matrix by replacing the use of coal with renewable sources and promoting the development of new productive activities that are sustainable, inclusive and resilient.

In the framework of the workshop **"Economic diversification strategies: Applying the IKI JET guide to the case of Antofagasta with a focus on Mejillones",** held in the city of Mejillones, the strategic objectives that the region seeks to achieve in terms of economic diversification were defined in a participatory manner. This definition was based on the analysis of economic, social and environmental challenges (shown in Chapter 2) through quantitative and qualitative tools contemplated by the IKI JET project.

The workshop was attended by technical staff and decision-makers from various institutions responsible for promoting economic diversification, including ministries, technical advisors and private sector representatives. During the workshop, different alternatives of key economic, environmental and social elements were presented, considering both the regional context of Antofagasta and the district of Mejillones. These elements were prioritised by the participants and based on the selection made, the following objectives were established.

4.1 Economic objectives

Table 18: Economic objectives

1	Promote **the maximisation of local benefits** through the productive diversification of the region, guaranteeing the use and development of human capital and local infrastructure.
Maximising local benefits refers to ensuring that the benefits generated by economic development, especially in the context of new sectors such as renewable energies, **remain and are redistributed within the territory**, in this case, within the **region and district** where they are generated. This implies that: • The income, jobs and technical capacities derived from new investments or economic activities directly favour local communities. • The regional productive fabric is strengthened, prioritising the use of local infrastructure, regional suppliers and local labour.	

	• Invest in regional human capital, through technical and professional training that allows the local population to actively participate in the new economy. • A more equitable redistribution of economic benefits is promoted, reducing existing territorial gaps.
2	Increase **value added and productive sophistication** through the development of value chains with low environmental impact.
	Value added refers to the increase in the value of a good or service as a result of a process of transformation, improvement or incorporation of technology, knowledge or complementary services. **Productive sophistication** refers to the degree of complexity, innovation and knowledge incorporated into the goods and services produced by an economy or region. The greater the sophistication, the higher the level of technology, specialisation and innovation capacity involved. In this context, increasing value added and productive sophistication through the development of value chains with low environmental impact makes it possible to focus on the links and products in the chain that are most beneficial in terms of the level of income they generate and the degree of innovation, technology and specialised labour involved. This approach contributes not only to building a more diversified and resilient economy, but also to strengthening regional competitiveness, and generating greater opportunities for sustainable economic growth and quality jobs.

4.2 Environmental objectives

Table 19 : Environmental objectives

3	**Reduce greenhouse gas emissions (coal phase-out)** generated by the region's economic activities, through energy efficiency actions, closure of coal-fired power plants and reduction of waste and other sources of pollution.
	Reducing greenhouse gas (GHG) emissions in a context of coal phase-out implies progressively reducing the release of gases such as carbon dioxide and methane, which are responsible for global warming and climate change. In Chile, this goal is a central part of the coal phase-out plan, which includes the gradual closure of coal-fired thermal power plants, the promotion of renewable energies and the transformation of the energy matrix towards a cleaner, more efficient and sustainable one. Along with this, the **reduction of waste and other sources of pollution,** such as industrial emissions and solid waste, is essential to reduce pressure on ecosystems and improve environmental quality. These actions are key to meeting the country's international climate commitments, moving towards carbon neutrality and protecting the health of communities most exposed to environmental degradation.
4	Support **territorial environmental protection** by considering optimal extraction rates and efficient use of resources.
	Territorial environmental protection refers to the sustainable management of the natural environment within a specific territory, ensuring the conservation of its ecosystems, its biodiversity and the benefits they bring to people. In this context, it involves limiting **the rates of extraction of**

natural resources (such as water, minerals, animals, among others) so that they do not exceed their capacity for regeneration or renewal, i.e. maintaining optimal rates of extraction. In addition, it seeks to promote the **efficient use of resources**, reducing the environmental impact of productive activities and prioritising circular practices that extend the life cycle of materials. This approach seeks to ensure that the economic development of the territory is compatible with the long-term preservation of its ecological conditions, ensuring well-being for present and future generations.

4.3 Social objectives

Table 20: Social objectives

5	**Increase formal and quality employment in the region**, promoting the generation of inclusive job opportunities, especially for young people and women.
This implies expanding **opportunities for access to the labour market**, especially for those groups that face greater difficulties in finding employment, such as young people and women. This requires fostering the creation of **formal and quality jobs** in sectors with development potential, promoting technical and vocational training programmes, and promoting public policies that reduce gender and generational gaps in the labour market. Strengthening formal and quality employment not only improves social protection and working conditions, but also contributes to the well-being of the population and to the economic development of the region in a more equitable and inclusive manner.	

4.4 Alignment of prioritised objectives with policy objectives at national, regional and local levels

In response to the global climate crisis and in compliance with international commitments that establish concrete targets for the reduction of greenhouse gas emissions and the conservation of biodiversity, Chile, as mentioned in Chapter 1, has developed a robust policy framework that includes instruments such as the Coal phase-out Plan and the National Strategy for a Just Socio-Ecological Transition, among others. In addition, productive innovation and competitiveness plans have been promoted that seek to diversify the economic matrix, promoting knowledge-intensive, sustainable sectors that generate quality employment. These efforts are key to strengthening local capacities, promoting productive linkages and moving towards a more resilient and environmentally responsible development model.

In this context, it is essential that the objectives of the green economic diversification strategy are aligned with existing regulatory frameworks at national, regional and local levels, and that this allows coordinating efforts, optimising resources and ensuring that different policies and strategies associated with just transition contribute to the same vision of the country but taking into account the specific realities and needs of each territory. The convergence between these levels of planning and action allows economic diversification processes to generate effective impacts, promoting employment, reducing inequalities and advancing towards sustainable development with territorial relevance.

Table 21 presents a scheme that allows verifying the alignment of the strategic objectives proposed in a participatory manner during the workshop held in Mejillones (see section 3.1) and the objectives of the main legal and regulatory instruments in force at national, regional and local levels. This linkage makes it possible to visualise how the guidelines proposed by the territory are articulated with the country's institutional framework, contributing in a coherent and coordinated manner to the advancement of a just socio-ecological transition.

Specifically, the **economic objectives (**Table 18**)**, such as maximising local benefits, increasing added value and sophistication, are aligned with national instruments that promote low-carbon economies (such as the National Strategy for Just Socio-Ecological Transition and the Energy Sector Mitigation Plan). At regional and district level, these objectives coincide with the promotion of innovation, productive specialisation and the strengthening of strategic sectors, mainly oriented towards areas such as sustainable mining, renewable energies, logistics and industrial services, and other activities with high potential for sustainable development and productive linkages, as proposed by the Regional Innovation Strategy and the District Development Plan (PLADECO) of Mejillones.

For their part, the **environmental objectives (**Table 19**)**, aimed at reducing emissions, waste and other sources of pollution, and protecting natural resources, are directly related to the coal phase-out, energy transition and sustainability policies promoted by the Ministry of Energy and the Ministry of the Environment. These goals are also reflected in regional strategies and district planning, which prioritise local environmental management and efficient use of resources.

Finally, the **social objective (**Table 20**)** of fostering formal and quality employment with an inclusive approach is fully in line with the National Strategy for a Just Socio-Ecological Transition, which promotes labour reconversion and the generation of decent employment. This approach is also present in regional and district instruments that promote social cohesion, equity and the strengthening of human capital as pillars of territorial development.

Table 21: Aligning economic diversification objectives with the national, regional and local policy framework

Level	Regulations	Objectives of the instruments	Alignment with the objectives proposed in the workshop
National	**Coal Phase-out Plan (2025),** **Ministry of Energy** Plan that outlines a roadmap for the coal phase-out of the national electric system to move towards a low-carbon electric system.	1. Incentives and territorial integration for the development of energy projects,	1, 3, 5
		2. Strategic planning for the development of the electrical system,	-
		3. Electric transmission as an enabler for carbon neutrality,	3

Level	Regulations	Objectives of the instruments	Alignment with the objectives proposed in the workshop
		4. Safe and flexible electrical system in a highly renewable context	3
	Energy Climate Change Mitigation and Adaptation Plan (2024), Ministry of Energy Sectoral plan that contemplates a short-term time horizon to achieve the intermediate goals on the way to the 2050 commitments, aligned with the Paris Agreement.	1. Achieve a low-carbon energy matrix by 2050.	3
		2. Position energy efficiency as a basis for development and coal phase-out.	3, 4
		3. Increasing the use of clean technologies such as green hydrogen in all sectors.	2
		4. Ensure equitable and quality access to energy services.	1
		5. Decentralise and diversify the matrix for greater resilience and lower emissions.	3
		6. Reduce climate vulnerability in the development of the energy sector.	3, 4
		7. Promote economic instruments that accelerate the energy transition.	1
	National Strategy for a Just Socio-Ecological Transition (ENTSEJ) (2024), Ministry of the Environment. Main instrument that coordinates actions for coal phase-out, productive reconversion and socio-environmental reparation, with a focus on social justice and participation.	Opportunities for decent work.	5
		2. Restoration and safeguarding of ecosystems.	4
		3. Social Welfare and Gender Equality.	3
		4. Innovation and technology for sustainable productive development.	1, 2
Regional (Antofagasta)	**Regional Innovation Strategy (ERI) (2022-2028) Regional Government** Instrument aimed at consolidating the Region as a competitive and innovative territory, promoting its productive transformation at by focusing resources and public/private investments in areas of specialisation where there are differential characteristics and attributes with high potential.	1. Strengthen the innovation ecosystem and public-private partnerships in the region.	1
		2. Improve the transfer of knowledge and attract talent and infrastructure for R&D.	2
		3. Promote social innovation to improve the quality of life.	-
		4. Diversify the productive matrix and increase high value-added businesses.	1, 2
		5. Valuing natural resources and positioning the region as a leader in climate action.	2, 3
	Regional Development Strategy (2009-2020) (to be updated) Regional Government Long-term instrument that defines how the region's development will be achieved	1. Improve education with equity to develop innovative human capital.	5
		2. Strengthen the mining-industrial sector and diversify the regional economy.	1
		3. Promote environmental and territorial sustainability with efficient planning.	3, 4
		4. Position the region as a platform for integration and commercial exchange.	-

Level	Regulations	Objectives of the instruments	Alignment with the objectives proposed in the workshop
	and where the emphasis will be placed.	5. Increasing the quality of life with inclusive development and social cohesion.	5
		6. Valuing regional identity and heritage with a view to the future.	-
		7.To promote participatory and decentralised governance for regional development.	-
Local (Mejillones)	**District Development Plan (PLADECO) (2023-2033)** Key planning and management instrument of the municipality for land use planning and the planning of new economic activities in harmony with the environment.	1. Strengthen local environmental management through education, control and promotion of recycling.	3, 4
		2. Diversify the economy by promoting tourism, the green economy and linkages with the industrial sector.	1, 2
		3. Protect and enhance local heritage with community participation and public-private partnerships.	-
		4. Promote social inclusion and the participation of migrant organisations and communities.	5
		5. Promote access to culture and reinforce local identity and multiculturalism.	-
		6. Reducing insecurity through prevention and strengthening community networks.	-
		7. Expand health coverage and quality by promoting healthy lifestyles.	-
		8. Improve the coverage, quality and infrastructure of education with a focus on innovation.	5
		9. Order urban development, reduce the housing deficit and optimise the use of the coastline.	4
		10. Modernise municipal management with a citizen focus and the use of technology.	-

5. Economic diversification opportunities

5.1 Diversification opportunities identified through the DIVE tool

For the identification of diversification opportunities at the regional level, the DIVE tool developed by UNIDO was used, which provides a methodology to guide the strategic design of productive and export diversification policies. Its methodological approach is based on an in-depth analysis of a country's current productive and export panorama (at the 4-digit level of the Harmonised System), considering both existing capacities and the potential for developing new specialisations in existing and/or completely new sectors.

Based on the analysis of the structure of the region's export basket (as specified in Chapter 2), the degree of closeness within the "*option set*" between products outside the export basket and those that the region exports with a revealed comparative advantage is analysed[42] . This makes it possible to identify two potential diversification paths and answer the question of what options exist.

These potential diversification paths can be summarised as follows:

– **Short jumps**: Diversification towards related products that could take advantage of the capacities and resources already available in the region, i.e. products with a high degree of relatedness to the products in the current export basket. These in turn can be classified into short jumps:

  ✓ With many global competitors

  ✓ With few global competitors

  Illustration 5 shows examples of what short jumps mean within the set of options. For example, if Antofagasta currently exports copper ore in a specialised way, then it could in the short term export refined copper if the required capacities exist in the region.

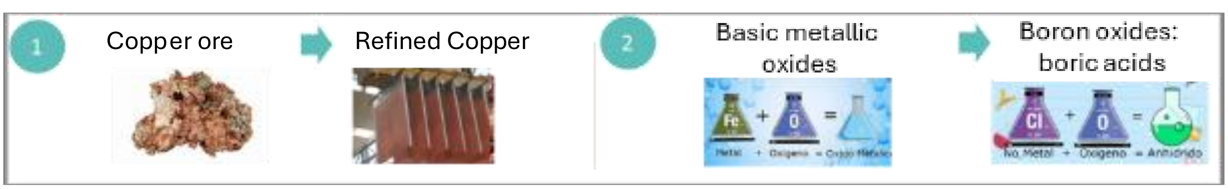

Illustration 5: Examples of short jumps

[42] To access all the methodological aspects of the tool, consult the manual: https://www.unido.org/sites/default/files/files/2023-06/DIVE_Tool_Manual.pdf

These diversification options are alternatives that can be pursued in the short term considering that the required capacities are likely to exist in the region. They are usually products that can generate good results quickly.

- **Long jumps**: Development of new specialisations in products that are not very closely related (but which meet a minimum of relatedness), which require the construction of new capacities and resources. However, based on experiences in other countries, they can be classified into products with high or low path-dependence. The degree of path-dependence is a proxy for understanding the relative importance of other countries having had a degree of relatedness in order to specialise in these new products. In this sense, they can be classified as long leapfrogging:

  ✓ With low degree of path dependence. The degree of linkages for other countries has not been a major barrier and therefore they are more likely to specialise.

  ✓ With a high degree of path dependence. The degree of linkages to other countries has been a major barrier and therefore they are more ambitious diversification opportunities.

Illustration 6 shows examples of what long leaps within the set of options mean. For example, if Antofagasta currently exports fertilisers in a specialised way, then it could in the long term export electrical appliances (understanding that the level of linkage meets a minimum) but considering that it would need to develop the capabilities required to do so. At the same time, based on the experiences of other countries, there are long leaps that constitute a major challenge.

Illustration 6: Examples of long jumps

These diversification options are alternatives that can be promoted in the long term, considering that the required capacities in the region need to be developed. Although these products represent a greater challenge for the region, they allow for more significant transformations of the production matrix.

In this sense, the region's economic diversification strategy does not necessarily have to focus on short or long jumps; it can and should contemplate both trajectories. In this way, specialising in short jumps in the short term can allow it to acquire the necessary resources to boost the capabilities required to aspire to long jumps in the medium and long term.

It is important to mention that these diversification opportunities take into consideration the feasibility of a region diversifying into certain types of products, but do not take into account whether this is desirable for the region in terms of its strategic criteria, which may include other economic, social and environmental elements.

This is why the DIVE tool suggests a battery of **economic criteria** that can be useful for decision-makers when prioritising products. These criteria are:

Supply factors:

- Sophistication gained: level of sophistication of the product compared to Antofagasta's current export basket.
- Degree of competition: number of countries that have the product in their export basket, which implies that they have a specialisation in that product.
- Vulnerability of the product: vulnerability index that considers different dimensions related to the degree of competition that the product would be exposed to.

Demand factors:

- Increase in global demand: growth in world trade of the product in the last decade (2013-2023).
- Demand potential for Chilean exports: import penetration index for Chilean products. This is calculated considering both countries worldwide and those that have a trade agreement with Chile.

Undoubtedly, these factors must be complemented with other strategic criteria for Antofagasta related to social and environmental aspects. The usefulness of this methodology is to reduce as much as possible the opportunities for diversification from a set of options of approximately 1200 products to a list of 70-80 products that can be analysed more exhaustively with other additional criteria.

The results of the diversification opportunities identified after applying the DIVE methodology are presented below. In addition, Table 22, Table 23, Table 24, and Table 25 show suggested economic criteria that may be useful for decision-makers in prioritising these opportunities.

5.1.1 Short jumps with many global competitors

The methodology identified 14 diversification opportunities that are short jumps but where competition is significant at the global level. The products belong to sectors such as agribusiness, chemical, mineral and metal manufacturing.

Table 22 details the products identified, which show that they are close or related to the products in Antofagasta's current export basket and for which the region is likely to have the required capacities for their production. In the case of agro-industrial products belonging to the fishing activity, the alternative would be to promote it on an artisanal scale, but through the incorporation of added value, it would constitute a beneficial productive bet for the region, in addition to the potential it has in terms of employment generation.

In addition, Table 22 shows various economic criteria that can be taken into account to prioritise products within this list, in order to subsequently assess their contribution in social and environmental terms (e.g. employment generation, gender equity, low carbon footprint) according to the objectives defined in Chapter 3. The products are ordered according to the degree of relatedness with the current export basket.

Table 22: Diversification opportunities: Short jumps with many competitors

HS Code 4-dig	HS description	Sector to which the product belongs	Sophistication gained ($)	Average annual growth in world trade (2013-2023)	# countries with the product in the export basket (2019-2021)	Degree of relatedness of the product	Import potential for Chilean exports (world)	Import potential for Chilean exports (importers with trade agreement)
1604	Prepared or canned fish	Agroindustry	-2,260.34	0.94%	42	0.542	0.998	0.969
7408	Copper wire	Metal fabrication	5,895.52	1.78%	25	0.474	0.948	0.816
2905	Acrylic alcohols	Chemical	7,343.27	-2.50%	31	0.474	0.974	1.009
3814	Organic compound solvents and thinners	Chemical	8,156.03	-0.06%	37	0.473	0.712	0.559
0304	Fresh, chilled or frozen fish fillets	Agro-industry	10,146.05	3.15%	49	0.466	1.125	1.230
0307	Molluscs	Agro-industry	-3,486.63	0.79%	44	0.461	0.707	0.746
2608	Zinc ore	Minerals	-5,959.60	2.75%	34	0.450	0.910	0.983

HS Code 4-dig	HS description	Sector to which the product belongs	Sophistication gained ($)	Average annual growth in world trade (2013-2023)	# countries with the product in the export basket (2019-2021)	Degree of relatedness of the product	Import potential for Chilean exports (world)	Import potential for Chilean exports (importers with trade agreement)
0811	Frozen fruit	Agro-industry	1,059.00	5.25%	37	0.445	1.005	1.092
0305	Dried, salted, smoked fish	Agro-industry	13,392.83	1.48%	43	0.442	0.883	0.843
3307	Toiletries	Chemical	10,978.07	2.13%	33	0.436	0.895	0.836
6807	Asphalt	Construction	10,189.42	-0.38%	30	0.433	0.979	0.930
0302	Fish, fresh or chilled, excluding fillets	Agro-industry	4,119.78	4.04%	47	0.432	0.912	0.971
7601	Unwrought aluminium	Metal fabrication	14,773.03	3.64%	38	0.416	0.880	0.955
0712	Vegetables, dried	Agro-industry	-3,037.95	1.44%	26	0.347	0.770	0.767

Higher value in the   Lower indicator value

Source: Chilean Customs and BACI/CEPII

Note: Table sorted according to the degree of linkages (column 7)

The products that stand out in terms of their high degree of relatedness with Antofagasta's current export basket and for which there is a high import potential are those shown in Graph 15: 1604 (Prepared or canned fish), 7408 (Copper wire), 2905 (Acrylic alcohols), 0304 (Fresh, chilled or frozen fish fillets), 2608 (Zinc ore). It is worth mentioning that of these products, copper wire is a product that could be interesting to manufacture domestically considering that it is an input used in the manufacture of electrolysers used in the green hydrogen sector, which, as will be seen later in Box 2, has interesting prospects in the region. It is important to mention that although the region tried to bet on copper rod production some years ago without much success, now could be the right time to try again, knowing that through CORFO support has been awarded for the production of electrolysers in other regions of the country . [43]

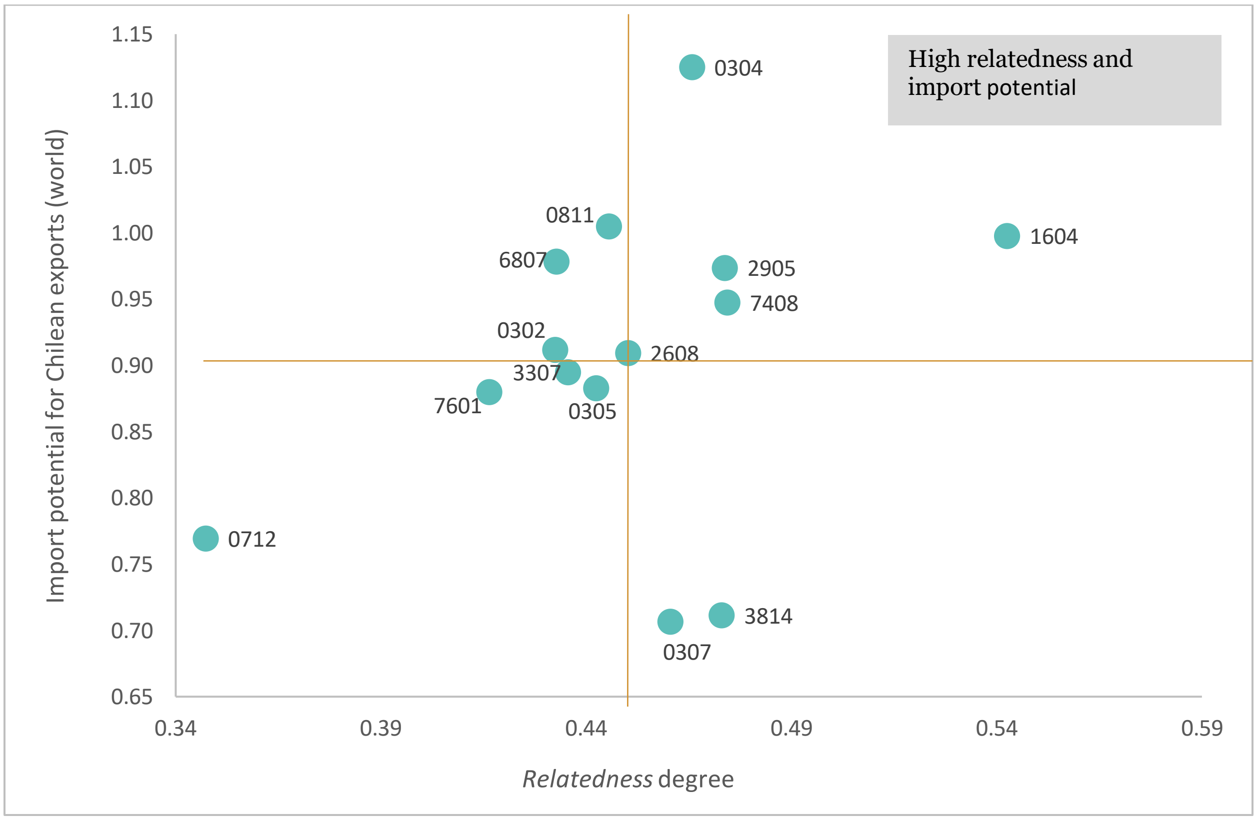

Figure 15: Diversification opportunities (short jumps with many competitors) ranked according to degree of relatedness and import potential

Source: Chilean Customs and BACI/CEPII

[43] https://corfo.cl/sites/cpp/sala_de_prensa/nacional/18_03_2025_electrolizadores

5.1.2 Short jumps with few global competitors

In the case of diversification opportunities that constitute short jumps and with which Antofagasta would face less competition at the global level, 16 potential bets were identified. It may be attractive to have less global competition, but it may also be related to the fact that these are products that have a higher number of barriers to entry. Similarly, these are products for which it is highly likely that the region has the necessary capabilities.

Table 23 details the products identified, which belong to some of the sectors mentioned in the previous group such as chemicals, metal manufactures and agro-industry, but also to other sectors such as machinery, construction, and electronics. The products are ordered according to the degree to which they are related to the current export basket.

Table 23: Diversification opportunities: Short jumps with few competitors

HS Code 4-dig	HS description	Sector to which the product belongs	Sophistication gained ($)	Average annual growth in world trade (2013-2023)	# countries with the product in the export basket (2019-2021)	Degree of relatedness of the product	Import potential for Chilean exports (world)	Import potential for Chilean exports (importers with trade agreement)
2810	Boron oxides; Boric acids	Chemical	15,885.19	0.90%	9	0.630	1.097	1.179
2925	Carboxymide function compounds	Chemical	18,304.35	5.12%	13	0.476	1.354	1.381
7611	Aluminium containers, >300 litres	Metal fabrication	11,665.42	0.31%	18	0.463	0.821	0.773
8427	Forklift trucks	Machinery	18,045.18	8.51%	14	0.456	1.041	1.061
4705	Semi-chemical wood pulp	Agribusiness	23,987.96	0.28%	11	0.455	0.785	0.719
3909	Amino resins	Chemical	16,340.23	2.62%	16	0.431	0.867	0.838
8462	Metal forming and forging machine tools	Machinery	16,200.64	-0.71%	13	0.430	1.055	1.031
6902	Bricks, bricks, tiles and similar refractory ceramic products	Construction	7,094.67	1.34%	15	0.422	0.920	0.759
8547	Insulating accessories for electrical machines	Electronics	7,060.68	3.14%	19	0.404	0.773	0.728

HS Code 4-dig	HS description	Sector to which the product belongs	Sophistication gained ($)	Average annual growth in world trade (2013-2023)	# countries with the product in the export basket (2019-2021)	Degree of relatedness of the product	Import potential for Chilean exports (world)	Import potential for Chilean exports (importers with trade agreement)
3801	Artificial graphite	Chemical	11,098.33	7.41%	13	0.401	1.085	1.164
1522	Degras and wax residues	Agro-industry	3,298.23	16.33%	17	0.385	0.597	0.620
2806	Hydrochloric acid	Chemical	10,215.09	6.13%	19	0.366	0.823	0.765
2850	Hydrides, nitrides, azides, silicides and borides	Chemicals	20,817.90	2.28%	8	0.346	0.783	0.762
6901	Bricks, blocks and other ceramic products	Construction	-3,618.22	0.88%	16	0.333	0.804	0.614
1603	Fish extracts and juices	Agro-industry	20,828.82	-0.64%	12	0.333	0.832	0.927
3803	Pine oil	Chemical	27,947.50	7.75%	10	0.325	0.792	0.827

Higher value in the   Lower indicator value

Source: Chilean Customs and BACI/CEPII

Note: Table ordered according to the degree of linkages (column 7).

Within this group, five products stand out for their high degree of relatedness and import potential (Graph 16) such as: 2810 (Boron oxides; boric acids), 2925 (Carboxymide function compounds), 8427 (Forklift trucks), 8462 (Machine tools for metal forming and forging), 6902 (Bricks, tiles and similar refractory ceramic products). Interestingly, product 2810 (Boron oxides; boric acids) is used as a key input in ceramics, glass, steel production and as a flame retardant (some of these inputs for the manufacture of green hydrogen).

Also 7611 (Aluminium containers) stands out in the overall list as a Low Carbon Technology (LCT) product according to the IMF classification.

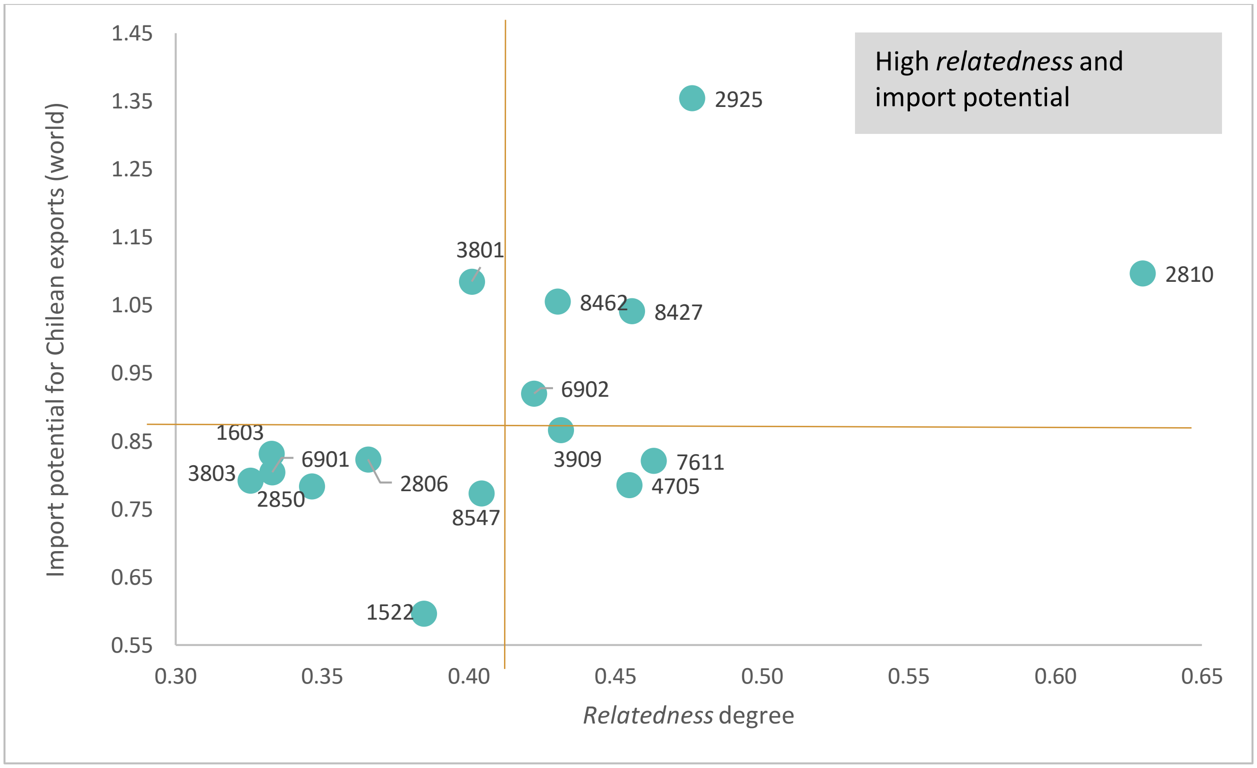

Figure 16: Diversification opportunities (short jumps with few competitors) ranked according to the degree of relatedness and import potential.

Source: Chilean Customs and BACI/CEPII.

5.1.3 Long jumps with low degree of path-dependence

The methodology also allows for the identification of diversification opportunities that are considered long jumps because their degree of linkage with the current export basket of Antofagasta is limited; however, the experiences of other countries show that the degree of linkage is not a major barrier for other countries to specialise.

Table 24 shows 17 productive bets belonging to the chemical sector, metal manufactures, toys, electronics, construction, instruments & appliances, and vehicles that are interesting considering the level of sophistication that would allow the region to gain if it specialises in these products. This is why in this case the products are ordered based on the level of sophistication gained.

Table 24: Diversification opportunities: Long jumps with a low degree of path dependence

HS Code 4-dig	Description HS	Sector to which the product belongs	Sophistication Earned ($)	Average annual growth of world trade (2013-2023)	# countries with the product in the export basket (2019-2021)	Degree of product relatedness	Product vulnerability index	Import potential for Chilean exports (world)	Import potential for Chilean exports (importers with trade agreement)
2933	Heterocyclic compounds with nitrogen atoms only (world)	Chemical	39,563.48	7.27%	11	0.220	0.444	1.144	1.242
7904	Zinc bars, rods and wire	Metal fabrication	32,480.39	0.93%	12	0.232	0.617	0.754	0.703
9504	Games	Toy shop	25,280.73	6.53%	12	0.235	0.577	1.182	1.302
7107	Silver-coated metals	Metal fabrication	20,690.00	-1.14%	6	0.173	0.386	0.625	0.687
7004	Extruded and blown glass	Construction	19,539.19	-8.34%	6	0.211	0.554	0.600	0.601
8508	Hoovers	Electronics	17,232.56	3.84%	14	0.279	0.458	1.190	1.256
7613	Aluminium containers for compressed or liquefied gas	Metal fabrication	16,263.21	5.03%	12	0.285	0.493	0.949	0.978
2930	Organosulphur compounds	Chemical	15,731.68	0.33%	14	0.273	0.524	1.653	1.711
8523	Sound storage media	Electronic	15,721.36	3.85%	10	0.258	0.516	1.011	1.085
2909	Ethers	Chemical	15,233.44	-1.93%	16	0.249	0.468	0.816	0.846

HS Code 4-dig	Description HS	Sector to which the product belongs	Sophistication Earned ($)	Average annual growth of world trade (2013-2023)	# countries with the product in the export basket (2019-2021)	Degree of product relatedness	Product vulnerability index	Import potential for Chilean exports (world)	Import potential for Chilean exports (importers with trade agreement)
9001	Optical fibres	Instruments and apparatus	14,561.45	0.66%	16	0.260	0.497	0.868	0.933
7218	Stainless steel ingots	Metal fabrication	13,474.80	10.98%	7	0.177	0.489	0.825	0.904
3817	Mixed alkylbenzenes	Chemical	11,699.66	-1.90%	13	0.277	0.454	1.042	0.795
8605	Passenger railway or tramway coaches, not self-propelled	Vehicles	9,932.35	-0.47%	14	0.263	0.605	1.180	0.734
2906	Cyclic alcohols	Chemical	9,497.25	0.66%	14	0.232	0.444	1.067	1.070
8509	Electromechanical household appliances	Electronics	7,966.95	4.04%	14	0.249	0.450	1.016	1.062
7406	Copper powders and flakes	Metal fabrication	2,531.54	7.86%	12	0.240	0.460	0.864	0.940

Higher value in the

Lower indicator value

Source: Chilean Customs and BACI/CEPII

Note: Table ordered according to the level of sophistication gained (column 4).

In this list of opportunities, three main products stand out for their high level of earned sophistication and import potential: 2933 (Heterocyclic compounds with nitrogen atoms only), 9504 (Games), and 8508 hoovers (Graph 17).

Other products in this list that are interesting for diversification are 7904 (Zinc rods and wires strategic for the development and expansion of renewable energy infrastructure) and 7613 (Aluminium containers for compressed or liquefied gas used for the storage and transport of green hydrogen or other renewable energy infrastructure) (Graph 17).

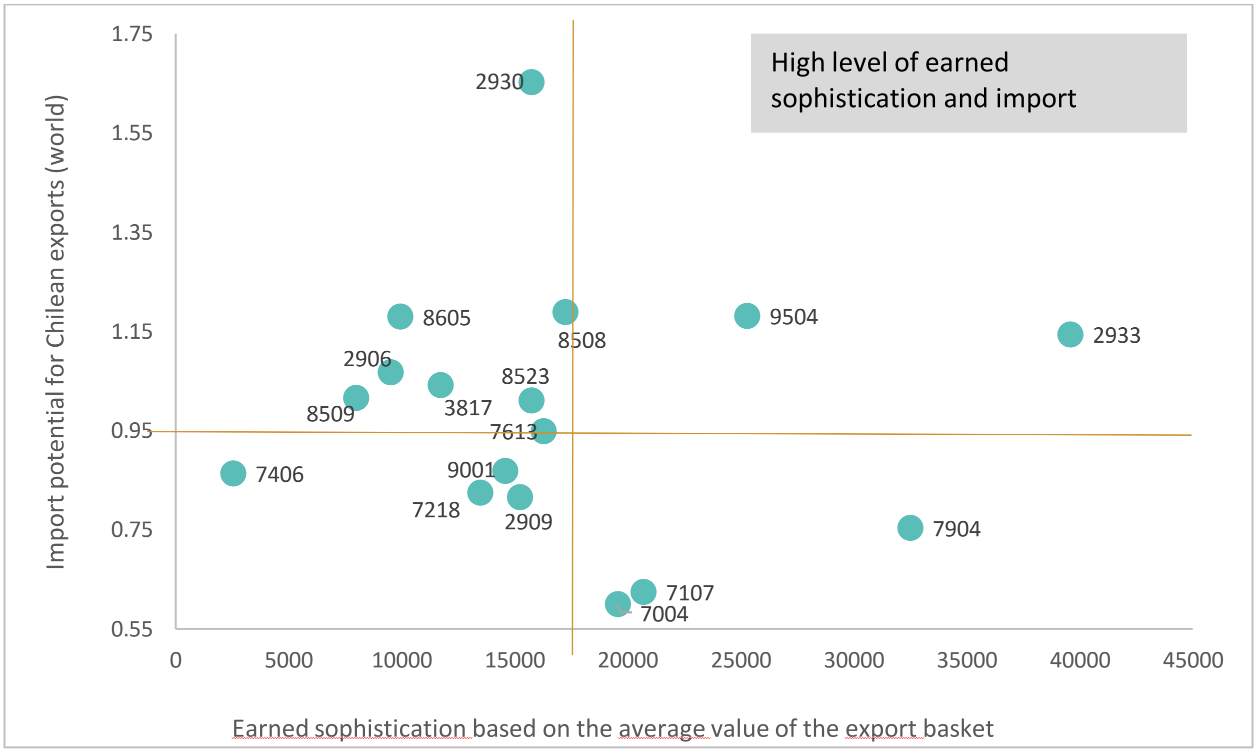

Figure 17: Diversification opportunities (long jumps with low degree of path dependence) classified according to the degree of linkages and import potential

Source: Chilean Customs and BACI/CEPII

5.1.4 Long jumps with a high degree of path-dependence

Finally, this group of products are considered more ambitious diversification opportunities to be developed in the long term, because their degree of linkage with the current export basket is limited, but also because the experience of other countries shows that the lack of linkages is a major barrier for a country or region to specialise.

Table 25 details 27 diversification opportunities considered long jumps with a high degree of path dependence that pertain to textiles, chemicals, instruments and appliances, metal fabrications, electronics, vehicles, construction and agribusiness. Although these are more distant diversification opportunities, it is important for the region to analyse whether some of these are worth prioritising because of their contribution to the level of sophistication of the current export basket.

Table 25: Diversification opportunities: Long jumps with a high degree of path dependence

HS Code 4-dig	HS description	Sector to which the product belongs	Sophistication gained ($)	Average annual growth of world trade (2013-2023)	# countries with the product in the export basket (2019-2021)	Degree of relatedness of the product	Product vulnerability index	Import potential for Chilean exports (world)	Import potential for Chilean exports (importers with trade agreement)
5902	Tyre cord fabric	Textile	42957.01	-0.56%	13	0.261	0.357	1.039	0.986
3918	Plastic floor coatings	Chemical	39814.17	6.68%	8	0.189	0.214	1.354	1.441
2937	Hormones	Chemical	38280.91	8.61%	13	0.193	0.354	1.098	1.210
3002	Serums and vaccines	Chemical	33394.42	12.32%	18	0.284	0.411	1.147	1.228
3914	Polymer-based ion exchangers	Chemical	24146.02	6.02%	13	0.269	0.337	1.042	1.084
9021	Orthopaedic appliances	Instruments and appliances	22560.38	4.76%	22	0.258	0.480	1.064	1.145
3822	Diagnostic or laboratory reagents	Chemical	21183.97	-8.28%	20	0.253	0.407	1.023	1.035
7222	Other stainless steel bars and rods	Metal fabrication	20516.00	2.80%	15	0.286	0.347	0.884	0.919
9022	X-ray machines	Instruments and apparatus	19100.27	2.29%	12	0.266	0.243	1.149	1.153
2911	Acetals and hemiacetals	Chemical	18042.75	-0.81%	7	0.261	0.262	1.168	1.200
8518	Microphones	Electronic	14899.49	4.64%	14	0.193	0.304	1.022	1.060
9032	Automatic regulating instruments	Instruments and apparatus	13029.07	0.21%	20	0.255	0.441	1.162	1.225

HS Code 4-dig	HS description	Sector to which the product belongs	Sophistication gained ($)	Average annual growth of world trade (2013-2023)	# countries with the product in the export basket (2019-2021)	Degree of relatedness of the product	Product vulnerability index	Import potential for Chilean exports (world)	Import potential for Chilean exports (importers with trade agreement)
3812	Stabilisers for rubber or plastic	Chemical	12998.77	1.01%	15	0.271	0.327	0.929	0.862
7607	Aluminium foil < 0.2 mm	Metal fabrication	12695.36	2.48%	21	0.222	0.491	0.932	0.889
5903	Textile fabrics impregnated with plastics	Textile	11753.18	1.03%	12	0.215	0.358	0.840	0.738
3006	Pharmaceuticals	Chemical	11082.31	2.86%	25	0.279	0.565	1.195	1.237
8714	Motorbike or wheelchair parts	Vehicles	9686.78	4.00%	13	0.228	0.266	0.944	0.923
8415	Air conditioning	Instruments and apparatus	7106.02	4.56%	17	0.216	0.374	1.155	1.142
7604	Aluminium bars and rods	Metal fabrication	6708.64	3.03%	39	0.282	0.716	0.794	0.752
7204	Scrap and ferrous scrap	Metal	6438.80	0.19%	79	0.284	0.822	0.578	0.507
7609	Aluminium tube or pipe fittings	Metal fabr.	5930.25	4.09%	17	0.262	0.432	1.134	1.205
3405	Polishes and creams	Chemical	5786.09	0.84%	23	0.274	0.463	0.738	0.702
9009	Electrostatic photocopiers	Instruments and apparatus	5311.20	15.56%	15	0.276	0.323	1.197	1.136
7013	Glassware for interior decorative use	Construction	3348.51	0.59%	21	0.275	0.444	1.040	0.982
4421	Other wooden articles*	Agro-industry	1143.58	1.90%	23	0.248	0.574	1.086	1.173
4414	Wooden frames**	Agribusiness	989.94	-0.90%	13	0.259	0.308	1.291	1.425
6910	Washbasins, washbasins and similar ceramic sanitary fixtures and fittings	Construction	86.60	3.37%	17	0.261	0.459	0.974	0.830

Higher value in the   Lower indicator value

Source: Chile Customs and BACI/CEPII

Note: * and ** are products that could be related to potential industrial wood recycling initiatives in Mejillones.

Table sorted according to the level of sophistication gained (column 4)

Within this group of 27 products, Figure 18 highlights 12 products by the high level of sophistication gained and the potential for import by other countries worldwide. These products are 5902 (Tyre cord fabric), 3918 (Plastic floor covering), 2937 (Hormones), 3002 (Sera and vaccines), 3914 (Polymer-based ion exchangers), 9021 (Orthopaedic appliances), 3822 (Diagnostic or laboratory reagents), 9022 (X-ray machines), 2911 (Acetals and hemiacetals), 8518 (Microphones), 9032 (Automatic regulating instruments), and 3006 (Pharmaceuticals). 3914 (Polymer-based ion exchangers) is also interesting because it is categorised as a low-carbon environmental good according to the IMF classification and is used for the manufacture of electrolysers.

In the case of 7222 (Other stainless steel bars and rods) it is also interesting because it can be used for renewable energy infrastructures.

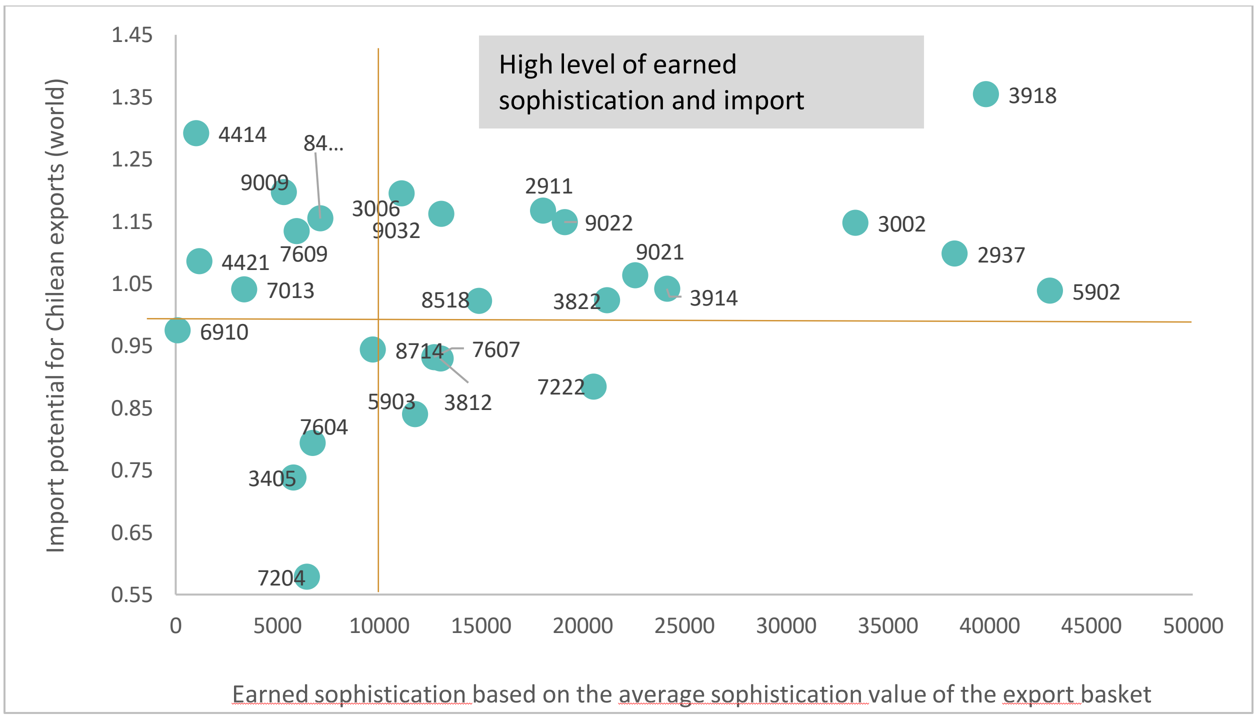

Figure 18: Diversification opportunities (long jumps with a high degree of path dependence) classified according to the degree of linkages and import potential

Source: Chilean Customs and BACI/CEPII

5.2 Diversification opportunities identified through stakeholder surveys

The diversification opportunities specified in the previous section use as a basis for analysis information on export products from both Antofagasta-Chile and countries worldwide. In this context, it is important to take into account opportunities and potentialities that the region may have, but which are not represented by a tariff code in the Harmonised System and therefore are not reflected in the results.

Consequently, through the interviews carried out in December 2024 with key actors at national, regional and local level (Table 8), a list of sectors was identified that are considered feasible and desirable productive bets for the territory, considering that there are initiatives under development, potential investments, and local interest because they are considered strategic. In the future, within these sectors, an analysis could also be carried out to identify potential products in greater detail. Figure 19 summarises the findings.

Renewable Energy	• Especially solar and wind (Box 1)
Green Hydrogen	• Includes green hydrogen and derivatives such as ammonia (Box 2)
Metallic Minerals	• Includes the copper and processed metals chain and the lithium and battery chain. Within the framework of the National Lithium Strategy, CORFO is promoting initiatives for the industrialization of lithium at the local level, encouraging the creation of production and value-added plants (batteries and cathodes)
Mining Services	• Related to the copper chain
Aquaculture	• From an artisanal perspective, but including value-added and/or differentiation in the fish chain
Agriculture	• In specific areas through the use of smart greenhouses. The Municipality of Mejillones has a pilot project in the design phase for vegetable production
Industrial Waste	• From the valorization of waste from industries located on the Mejillones coast (e.g., wood, paper, plastic, others). As a pilot program, the Mayor's Office has implemented a project for the reuse of wooden pallets, giving the community of Mejillones access to materials for the manufacture and sale of various
Water	• With a focus on efficient use in key industries, as well as reuse between industries, especially between mining and desalination plants.

Figure 19: Sectors with potential for economic diversification in Antofagasta with a focus on Mejillones according to key actors.

Source: Interviews and workshops with local stakeholders December 2024 and April 2025

Box 1: Engie Energía Chile. Leadership in energy transition and boosting productive diversification in the north of the country

ENGIE is a global leader in low-carbon energy solutions and services, with a presence in more than 70 countries. In Chile, its subsidiary ENGIE Energía Chile has operations in generation, transmission, energy transport and port infrastructure. In line with global and national sustainability challenges, the company has made a commitment to coal phase-out, planning to completely eliminate the use of coal by 2025 and achieve an installed capacity of 2,000 MW in renewable energies. With this, it is consolidating its position as a strategic player in the country's energy transition process.

ENGIE has had a consolidated presence in the Antofagasta Region for more than twenty years. It has played a key role in coal-fired power generation, particularly in the districts of Tocopilla and Mejillones, where it has operated an important part of the energy matrix in the north of the country (Inodú, 2022). As part of its alignment with the National Coal phase-out Strategy, in 2019 ENGIE announced the early closure of six coal-fired units in both districts, a process that was completed in mid-2022. In addition, the company has planned to convert three units in Mejillones before 2025, one of them to biomass and two to natural gas, reaffirming its commitment to a cleaner and more sustainable energy matrix.

Aware of the social and territorial impact of this process, ENGIE designed and implemented a **Just Transition Plan**, aimed at mitigating the negative effects of plant closures and promoting sustainable opportunities in the territories. The plan is structured around three strategic pillars:

Employment and Skills

The company seeks to generate green jobs, retrain workers, and strengthen job skills. Since 2019, it has implemented planned workforce reductions, offering technical and professional training in areas with regional and internal potential. A total of 267 employees have benefited from retraining and entrepreneurship training programs focused on territorial development.

Territorial Development

The company promotes productive diversification, strengthens local economies, and fosters production chains. Working groups have been established with local stakeholders, entrepreneurship support funds have been created, and partnerships have been forged with organizations such as the fishermen and workers of Tocopilla Bay. As part of its diversification strategy, ENGIE is promoting the development of a green hydrogen plant powered by photovoltaic solar energy, co-financed by CORFO, with the goal of moving towards a large-scale project by 2030.

Environmental Management and Decommissioning

- Aims to ensure that decarbonization does not generate negative environmental impacts through a technically and environmentally rigorous process of dismantling thermal units, circular economy practices for waste management, and the development of clean energy

In its transformation process, ENGIE has invested in renewable infrastructure in the region, highlighting the Lomas de Taltal Wind Farm (342 MW) and the BESS Tamaya and BESS Capricornio storage systems. It currently has 2.6 GW of installed capacity in Chile, of which 900 MW are renewable, and plans to reach 2 GW in clean energy by 2028 with an estimated investment of USD 1.8 billion.

Through this strategy, ENGIE has not only mitigated the impacts of the closure of its coal-fired units, but has also promoted territorial development, green jobs and a more resilient and sustainable economy. Its commitment to the conversion of infrastructure into renewable energy hubs reinforces its leadership in the energy transition in northern Chile, positioning itself as a benchmark in the coal phase-out and energy transformation of the country.

Source: ENGIE interview

Box 2: Productive diversification and development of green hydrogen in northern Chile

The Antofagasta region is projected as one of the strategic territories for the development of green hydrogen (H2V) in Chile, due to its unique combination of comparative advantages: high solar generation potential, consolidated energy infrastructure and strong public-private articulation. In line with the National Green Hydrogen Strategy (2020), which seeks to position Chile as one of the top three global exporters by 2040, the region can stand out for its capacity to produce H2V at low cost and on a large scale, with the ability to both supply the domestic market and export clean energy globally.

According to data from the Ministry of Energy, by 2023 there are 34 green hydrogen projects in the pre-feasibility stage, 76% of which are concentrated in the Antofagasta Region. Within this scenario, Mejillones has established itself as the main pole of interest for the development of these initiatives, due to its logistical and energy advantages, such as the availability of port infrastructure, transmission networks, electrical substations and proximity to key industrial sectors. However, the district faces important challenges in terms of land-use planning, especially in terms of updating its regulatory plan. In this context, coordination between public, private and social actors is essential to build an industrial development model that is sustainable, inclusive and generates shared value for the local community.

The consolidation of this industry not only represents a way to advance in the fulfilment of the country's climate commitments, such as achieving carbon neutrality by 2050, but also a strategic opportunity to diversify the regional productive matrix, historically concentrated in the mining sector. The development of H2V would expand the economic fabric of Antofagasta, generate quality employment, promote technological innovation and strengthen local production chains. In this regard, the National Energy Policy (2022 update) and the Green Hydrogen Action Plan 2023-2030 recognise the need to integrate this industry as an axis of sustainable productive reconversion, directing investments and capacities towards sectors with low environmental impact and high added value.

At the institutional level, key mechanisms have been implemented, such as the Regional Green Hydrogen Commission and the H2 Antofagasta Association, which have promoted a territorial roadmap, identifying more than 20 initiatives under development that could reach more than 16 GW of electrolysis capacity by 2030. Of note are the HyEx (ENGIE) and AMER (Air Liquide) projects, both financed by Corfo, which are aimed at the industrial production of H2V and its derivatives for both local and export purposes. Likewise, the Antofagasta Green Hydrogen Hub, supported by the Regional Corfo Committee, reinforces the competitiveness of the local energy ecosystem by promoting applied research, innovation and training of specialised human capital.

In this way, the development of green hydrogen in the Antofagasta region, and particularly in Mejillones, constitutes a key lever to achieve a just energy transition, while at the same time boosting productive diversification in a territory that has optimal conditions to lead this transformation. Its consolidation could mark a structural change in the regional development model, integrating environmental sustainability, social equity and economic dynamism under the same strategy for the future.

Source: Interview CORFO, Ministry of Energy

5.3 Suggested next steps for prioritisation of potential products

Based on the results obtained in section 5.1, the following suggested steps for the prioritisation of products (and therefore the sectors to which they belong) are detailed below. It is important that the team in charge of this analysis has a technical and political profile to ensure a balanced decision making.

- Selection of economic, social and environmental criteria to be used for prioritisation. Within the economic criteria, some of those suggested in Tables 22, 23, 24 and 25 can be used. In the social area, criteria for total employment generation, female employment and youth employment can be included. From the environmental aspect, CO_2 emissions criteria can be considered, and for the products that apply, current resource extraction rates (to analyse whether they are at the optimum or already exceeded). These suggested criteria are aligned to the objectives defined in chapter 4. For those criteria where quantitative data is not available, expert opinion can be used.
- Using these economic, social and environmental criteria, a weighting is then established according to their importance for the country or region. In practice, however, many choose to give equal weight to all three areas as priorities.
- From this, the criteria and their indicators are standardised (there are some that need to be inverted, as in the case of CO_2 emissions, since it is desirable to prioritise products with a low carbon footprint). After this, a combined index is calculated to rank the products and select the 20 or 25 products with the highest index, i.e. performance based on the criteria.
- Based on this shorter list, it is necessary to discuss with companies the potential capacity to engage in the manufacture of these products, the type of labour and technologies required. This process is usually carried out in workshops and focus groups with related companies.

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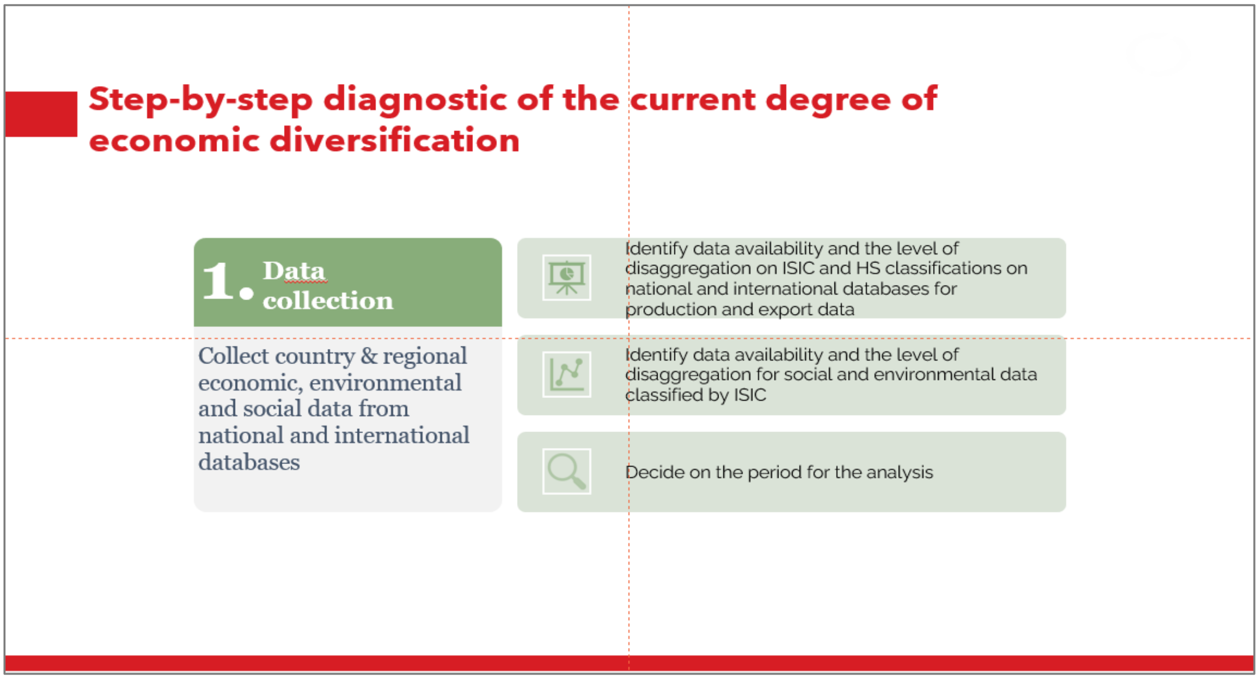
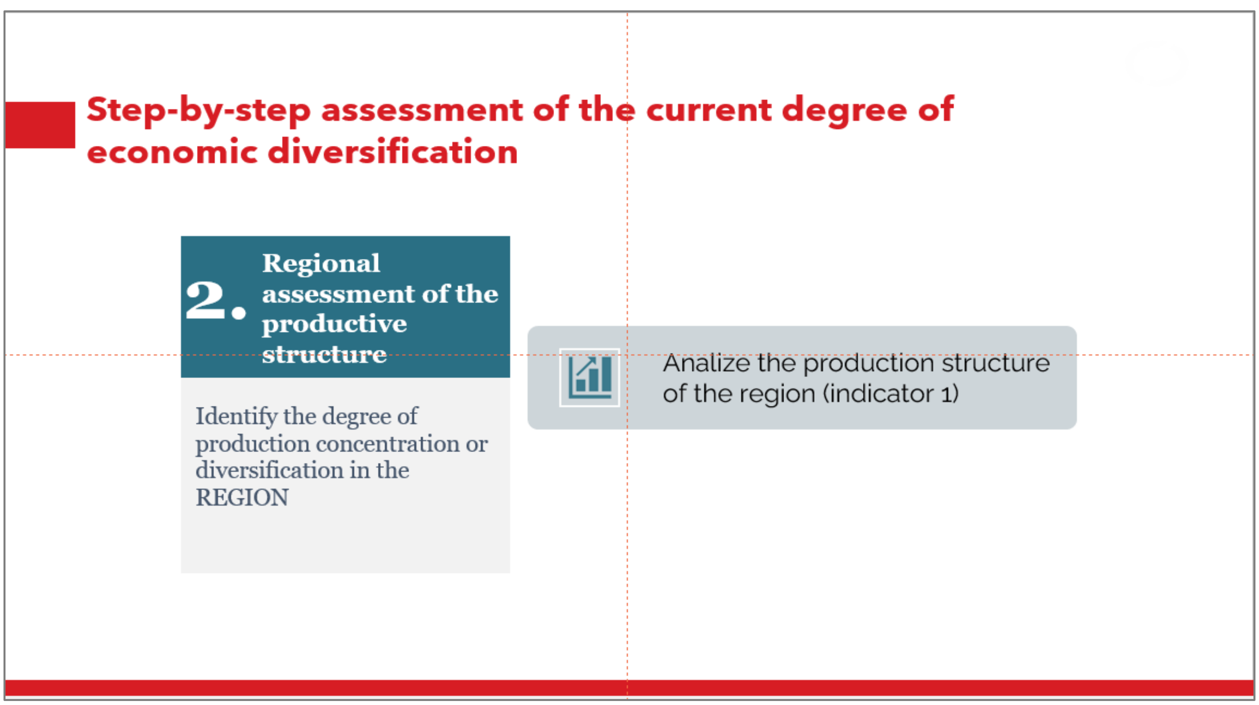
7. Annexes

Annex 1. Methodology and EQuIP and DIVE indicators used for the analysis of Antofagasta's current economic diversification and identification of diversification opportunities.





Indicator (1): Share of the 3 or 5 main sub-sectors in total GDP

- Calculation: Sum of value added of the 5 main sub-sectors divided by total GDP.
- Source: National or Regional Accounts of the country by ISIC / Central Bank
- Tool: Enhanced the Quality of Industrial Policies (EQuIP) – Tool 3

Indicator logic and interpretation:

- This indicator provides information on the **importance of sub-sectors in the economy and the level of concentration** in a few key sub-sectors.
- **Dependence on a limited number of sub-sectors makes the overall economy vulnerable** to any shocks in those industries. Shocks such as changes in demand patterns, technological advances or policy changes could have significant effects on total output and economic stability.
- The **higher the participation, the higher the level of importance and concentration of** the economy.

Step-by-step assessment of the current degree of economic diversification

3. Regional assessment of the current specialization of the export basket

Analyze the degree of concentration and vulnerability of the export basket in the REGION

- Determine the Revealed Comparative Advantage (specialization) of each product exported by the region (indicator 5)
- Identify the Export Basket of the region with specialized products (use the specified criteria in slide 33)
- Identify the level of concentration of the Export Basket of the region (indicator 6a or 6b)
- Define the level of vulnerability of the Export Basket of the region (Indicator 7a and 7b)

Indicator (5): Revealed Comparative Advantage (RCA)

- Calculation: The Balassa Revealed Comparative Advantage Index is used to quantify the degree of specialisation of a region in each export product i, in each year t, compared to the structure of the world.

$$RCA_{ikt} = \frac{x_{ikt} / \sum_i x_{ikt}}{\sum_k x_{ikt} / \sum_i \sum_k x_{ikt}}$$

where x_{ikt} is the export value of product i in the region k at time t. The $\sum_k x_{ikt}$ is the export value of product i in the world at time t

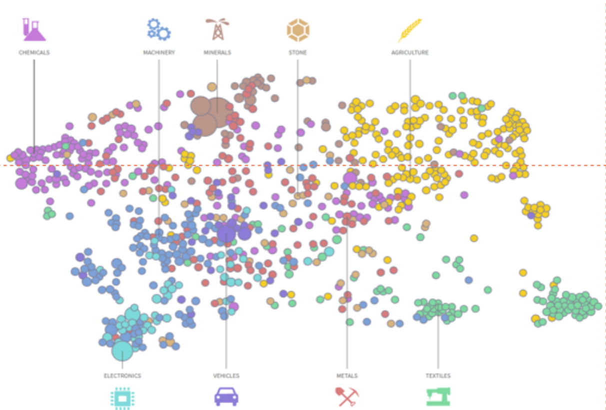
- Source: Custom Office in a country and BACI/CEPII -HS at 4-digit
- Tool: Diversifying Industries and Value Chains for Exports (DIVE-Component 1)

Indicator logic and interpretation:

- The RCA index compares the export structure of a region (numerator) with the export structure of the world (denominator) for a specific product. If the RCA > 1 for a region in product i means that is specialized in that product.
- It is generally beneficial for a region to have a greater number of products with revealed comparative advantage. A wider range of products can indicate a diversified economy, making it less vulnerable to external shocks and fluctuations in demand for specific goods.
- Additionally, this diversification can lead to more stable economic growth, job creation, and enhanced resilience in the face of market changes.

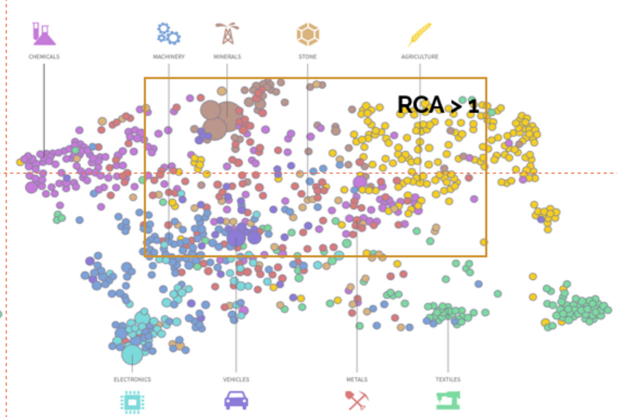
Identifying the Export Basket with specialized products

Regional Total Exports



All products that the region exports in a specialized or non-specialized manner

Regional Export Basket with specialized products



Criteria: A product is included in a region's Export Basket only if the RCA >1 for at least two years in the interval (t, t+2). This means that the **Export Basket** only considers products in which the **region shows relative specialization** with respect to a *benchmark* (usually the world economy).

Indicator (6a): Share of exports of top 3 or 5 products in the Export Basket

- Calculation: Sum of the value of exports of the 3 or 5 products divided by exports of specialized products included in the Export Basket.
- Source: Custom Office in a country and BACI/CEPII -HS at 4-digit
- Tool: Diversifying Industries and Value Chains for Exports (DIVE-Component 1)

Indicator logic and interpretation:

- Measures **the degree of concentration of a region's Export Basket with specialized products.** High export dependence on a few products creates risks for the economy to crises and shocks.
- The **higher the export share, the higher the level of importance;** but also the **higher level of** export **concentration.**

Indicator (6b):Hirschman-Herfindahl Index (HHI) for the Export Basket with specialized products

- Calculation: Sum of the squared shares of products in total exports as follow:

$$HHI_{kt} = \sum_{i} expshare_{ikt}^{2}$$

where i refers to products, k to countries and t to time. It is a measure bounded between 0 and 1 where 1 represents the presence of a unique product in the exports.

- Source: Custom Office in a country and BACI/CEPII - HS at 4-digit
- Tool: Diversifying Industries and Value Chains for Exports (DIVE-Component 1)

Indicator logic and interpretation:

- The **HHI** index **of the export basket seeks to analyse the level of concentration in products with a high degree of specialisation, understanding that the country has developed capacities and depending on whether these capacities are easy or difficult for other countries/regions to acquire, it can generate greater or lesser vulnerability for the country or region.**
- **High levels of Export Basket concentration pose risks** to a country's economy by making it **vulnerable to fluctuations in global demand, price volatility or shocks** in specific industries.
- An **HHI** index **of the export basket close to 1 implies higher concentration**

Indicator (7a and 7b): Product and Region Vulnerability Indexes

- Calculation: the vulnerability index of product is equal to the square root of the sum of the squares of the three components divided by the square root of 3 (the denominator serves to obtain an index that lies in the interval [0,1]). Assuming that the frequency index, the path-departure index and the ubiquity index are three dimensions represented as a 3x1 vector, the numerator corresponds to their norm. A vulnerable product is one with 1) a high level of path-departure (suggesting that the set of local capabilities available in the region are not difficult to acquire), 2) high ubiquity (as capabilities are present in several countries, so international competition is high) and, 3) high frequency of entry (low-entry barriers and high level of competition in the medium to long term). The three dimensions are merged into a single index calculated with values ranging from 0 to 1.

$$IPV_i = \sqrt{{freq_i}^2 + {pathdepa_i}^2 + {ubiq_i}^2} \Big/ \sqrt{3}$$

where IPVi is the vulnerability index of product i, $freq_i$ is the frequency index of product i, $pathdepa_i$ is the path-departure of product i, and $ubiq_i$ is the ubiquity index of product i

Turning to the regional dimension, is posible to calculate the structural vulnerability index of the Export Basket for the region as a whole as the weighted average of the product vulnerability indices, where the weights are given by the export shares of product i from region k.

$$ISV_k = \sum_i sh_{ik} IPV_i$$

where ISVk is the vulnerability index of region k, $sh_{ik}$is the structural vulnerability index of the Export Basket of region k

Indicator (7a and 7b): Product and Region Vulnerability Indexes

- Source: Custom Office in a country and BACI/CEPII – HS at 4-digit
- Tool: Diversifying Industries and Value Chains for Exports (DIVE-Component 1)

Indicator logic and interpretation:

- The **region vulnerability index (ISVk)** seeks to understand **how vulnerable is the type of export specialisation that the region has**. The index assesses **how responsive a region's export basket can be based on its specialisation.** The higher the level of specialisation in products that have low entry barriers, the higher the degree of vulnerability of the export basket to international competition.
- This is relevant because it can **help guide policy decisions and justify the need to introduce diversification measures.**

Step-by-step assessment of the current degree of economic diversification

4. Regional assessment of the ability to diversify exports

Identifies REGIONS´s new entries and their sophistication level and path-departure. This allows to understand REGION's historical ability to diversify exports

- Determine the degree of sophistication of the Export Basket at a product and regional level (indicator 8a and 8b)
- Identify new export specialization – permanent entries (use the specified criteria slide 45)
- Calculate the product index of path-departure for new export specialization – permanent entries (indicator 9)
- Analize the past ability of the region to diversify exports using the new permanent entries and complementing with the level of sophistication and index of path-departure (slide 47)

Indicator (8a): Sophistication of the Export Basket (at product level)

- Calculation: The product sophistication level (PRODY) is computed as the weighted average of the per capita GDP of countries exporting each product in a specialized manner worldwide.

$$PRODY_{it} = \sum_k \frac{x_{ikt}/X_{kt}}{\sum_k x_{ikt}/X_{kt}} Y_{kt}$$

where Ykt is the GDP per capita of country/region k at time t, Xikt represents the exports of product i by country/region k at time t, while Xkt represents the total exports of country /region k at time t.

- Source: Custom Office in a country and BACI/CEPII – HS at 4-digit
- Tool: Diversifying Industries and Value Chains for Exports (DIVE - Component 2)

Indicator logic and interpretation:

- The indicator seeks to **analyse the level of sophistication or complexity of products in the Export Basket**, with the understanding that countries or **regions that export more complex products than expected for their income level grow faster.**
- **Economic growth** can then be achieved through a **process of diversification to produce more complex goods.**
- A **higher value** on the indicator means that the **level of complexity or sophistication of the product is higher.**

Indicator (8b): Sophistication of the Export Basket (at regional level)

- Calculation: The level of sophistication of a country/region (EXPY) is calculated by the weighted average of the product sophistication level (PRODY) of goods in the export basket. It is a proxy indicator of the level of productivity associated with exports. It is calculated using country/region level data.

$$EXPY_{kt} = \sum_i \frac{x_{ikt}}{X_{kt}} PRODY_{it}$$

where Xikt represents the exports of product i by country/region k at time t and Xkt the total exports of country/region k at time t. It is thus a weighted average – with weights given by the export shares – of the PRODY.

- Source: Custom Office in a country and BACI/CEPII – HS at 4-digit
- Tool: Diversifying Industries and Value Chains for Exports (DIVE-Component 2)

Indicator logic and interpretation:

- The indicator seeks to **analyse the level of sophistication of the Export Basket of the region in an aggregated measure** in order to compare it with other countries and regions. It has the same logic as PRODY.
- A **higher value** on the indicator means that the **level of complexity or sophistication of the country/region is higher.**

To understand the past ability to diversify exports the first step is identifying new export specialization products (permanent entries)

New export specialization (entries) of an economy (a region or a country) represents the set of products in which the economy has recently developed a comparative advantage in a stable and economically significant way (export values larger than 1 million US$). The criteria detailed below allow us to consider new products that are not just occasional or temporary or of very modest economic value.

A product is a new export specialization at time *t* if:

i) it is exported with RCA higher than unity at time t;

ii) it has been exported with RCA lower than 0.5 for at least two of the previous 5 years;

iii) it has never been exporter with RCA higher than unity in the previous 5 years;

iv) alternatively

a) it has been exported with RCA higher than unity for at least 2 years in the following 5 years and it has been exported with RCA lower than 0.5 for no more than once in the following 5 years;

b) it has been exported with RCA higher than unity for the following 3 years;

i) the average export values in the following 5 years is higher than the average export values in the previous 5 years;

ii) the export value at time t is higher than 1 million US dollars.

Step-by-step assessment of social and environmental aspects as part of the economic diversification diagnostic

5. Regional assessment of social and environmental aspects

Analyze employment generation and female participation of the main economic activities in the REGION, as well as emissions generation

- Identify employment generation by key economic subsectors of the region (indicator 10)
- Identify female participation in key economic subsectors of the region (indicator 11)
- Identify emissions generation of key economic subsectors in the region (indicator 12)

Indicator (10): Share of economic sub-sectors in total employment

- Calculation: Employment of each subsector divided by total employment in the region.
- Source: National Employment Survey by ISIC / National Statistics Office
- Tool: Enhanced the Quality of Industrial Policies (EQuIP) – Tool 5

Indicator logic and interpretation:

– This indicator allows to identify how much employment is generated by key subsectors of the economy (considereing value-added), therefore analyze potential social implications of the transition process and design strategies to plan the reallocation of employees affected (e.g. rekilling and uskilling measures).

Indicator (11): Share of female employment in key economic sub-sectors

- Calculation: Female employment of each subsector divided by total employment in the subsector
- Source: National Employment Survey by ISIC / National Statistics Office
- Tool: Enhanced the Quality of Industrial Policies (EQuIP) – Tool 6

Indicator logic and interpretation:

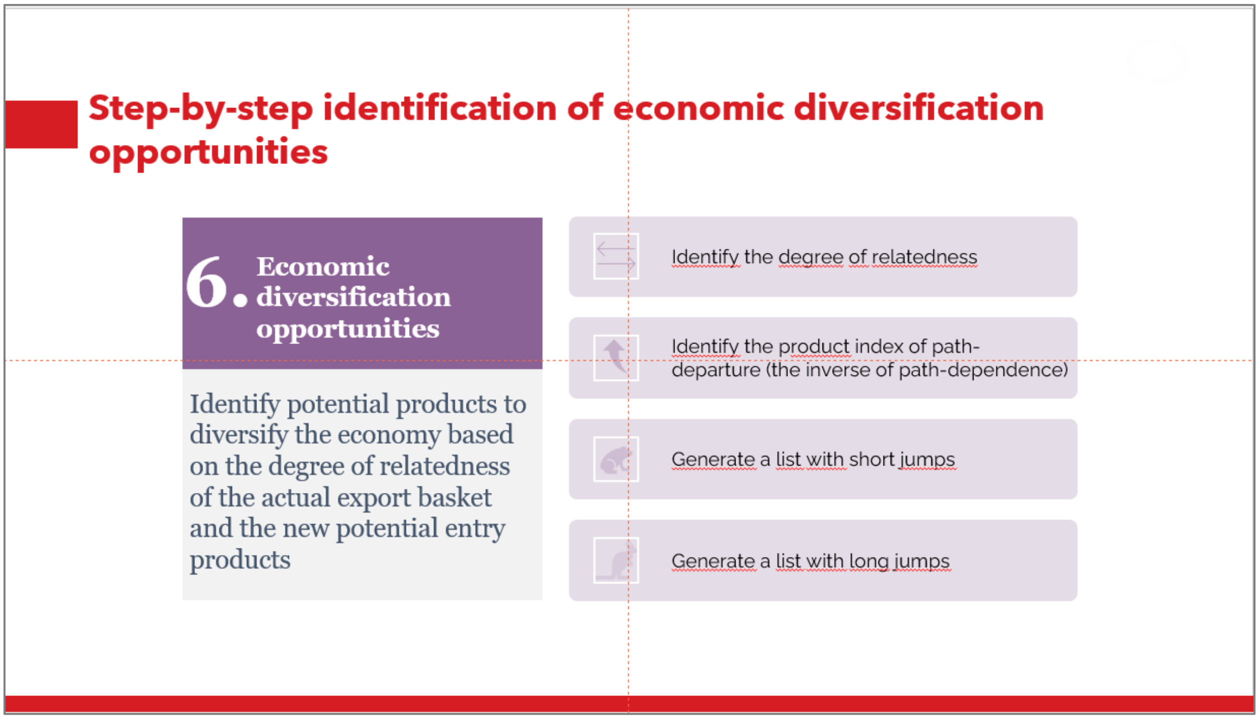
- This indicator allows to identify female participation in key subsectors of the economy (considereing value-added), therefore is a measure to understand gender equity in the region,
- At the same time allows enables to understand the potential social implications of the transition process for this group of the population and design strategies to plan their reallocation in other industries (e.g. rekilling and uskilling measures).

Indicator (12): Share of economic sub-sectors in total emissions

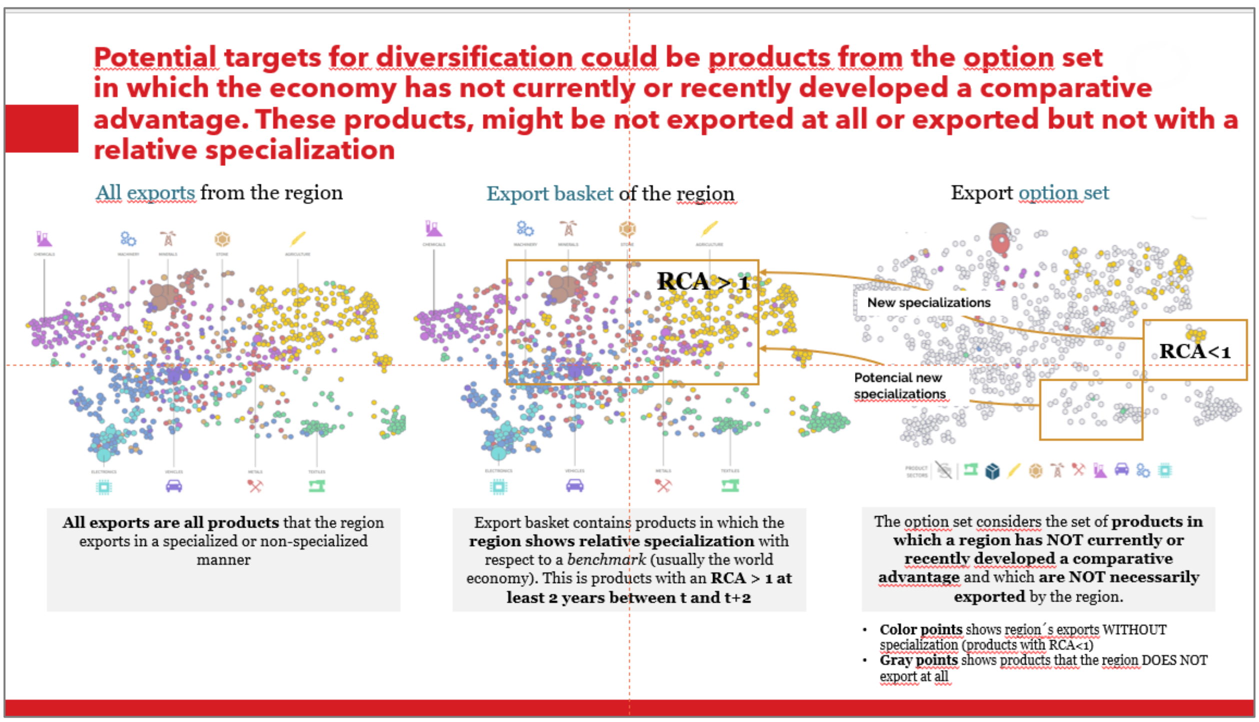
- Calculation: Emissions (or CO2 emissions) of each subsector divided by total emissions (or CO2 emissions) in the region.
- Source: National Environmental Survey by ISIC / National Statistics Office
- Tool: Enhanced the Quality of Industrial Policies (EQuIP) – Tool 7

Indicator logic and interpretation:

- This indicator measures the environmental impact (in terms of emissions) of key economic subsectors in the region allowing to understand the potential benefits of moving away from polluting activities.



Step-by-step identification of economic diversification opportunities
6. Economic diversification opportunities
Identify potential products to diversify the economy based on the degree of relatedness of the actual export basket and the new potential entry products
Identify the degree of relatedness
Identify the product index of path-departure (the inverse of path-dependence)
Generate a list with short jumps
Generate a list with long jumps



Potential targets for diversification could be products from the option set in which the economy has not currently or recently developed a comparative advantage. These products, might be not exported at all or exported but not with a relative specialization
All exports from the region
Export basket of the region
Export option set
RCA > 1
New specializations
RCA<1
Potencial new specializations
All exports are all products that the region exports in a specialized or non-specialized manner
Export basket contains products in which the region shows relative specialization with respect to a benchmark (usually the world economy). This is products with an RCA > 1 at least 2 years between t and t+2
The option set considers the set of products in which a region has NOT currently or recently developed a comparative advantage and which are NOT necessarily exported by the region.
Color points shows region´s exports WITHOUT specialization (products with RCA<1)
Gray points shows products that the region DOES NOT export at all

Key indicator 1 : Degree of "relatedness"

Indicator logic and interpretation:

- **"Relatedness" between products in the export basket or with products that enter the export basket (new specializations) or might enter (potential new specializations) is a useful device for understanding to which degree any two products share some common productive capabilities.** For instance, 7403 Refined copper & copper alloys and 2603 Copper ore – are clearly related in the sense that their specializations are driven by the same sources or same set of production capabilities. Also, two products that belong to distinct sectors or seems apparently very different might have high relatedness as they share to a great extent the same productive capabilities (for example specialized and skilled work-force, institutions and regulations, financial ecosystem). **Relatedness between products already in the export basket** could provide a measure **of how diverse or concentrated** is the region set of production capabilities. In turn **this information can give an indication for trajectories of future diversification** such as the **ability to add a diverse set of new export specializations.**
- Products with **high degree of relatedness** with products in the current export basket of a region are products where the region is **likely to have the required capabilities** to produce and export them.

Calculation: Following Hidalgo et al (2007), DIVE computes the network of relatedness as the minimum of the pairwise conditional probability of being co-exported with revealed comparative advantage above the unity in the three-year period [t,t+2]. The relatedness between product i and product j at time t is, thus, computed as follows:

$$\varphi_{ijt} = min\{P(EB_{it}|EB_{jt}), P(EB_{jt}|EB_{it})\}$$

where EB_{it} denotes the presence of product i in the export basket at time t. The degree of similarity in the capability required to produce different goods changes over time and, thus, for computing distances in terms of relatedness we adopt year-specific networks.

Source: Country Customs Office and BACI/CEPII

Tool: Diversifying Industries and Value Chains for Exports (DIVE) – UNIDO

For a more detailed explanation about the calculation of key indicators, go to DIVE Tool Manual

Key indicator 2: Product index of path-departure (the inverse of path-dependence)

Indicator logic and interpretation:

- It provides a measure for understanding **how important is the degree of relatedness with the pre-existing export basket for the acquisition of a comparative advantage in the product.**
- A product presents a **high index of path-departure** when is possible to observe that frequently countries develop a specialization in these products even if they were specialized ex-ante in unrelated products.
- **A low index of path-departure** suggest that it is more difficult for a country or region to acquire a new specialization in the product without having ex-ante the necessary productive capabilities (ie without having in the pre-existing export basket highly related products).

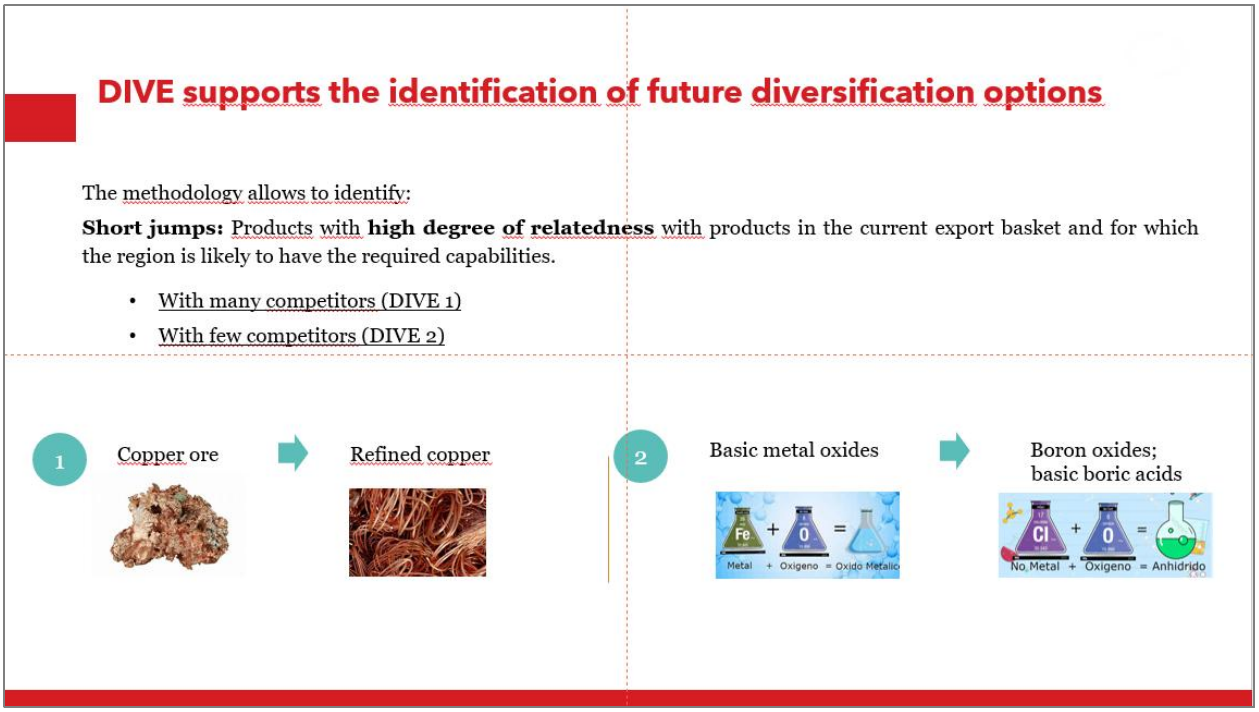
Calculation: To detect the extent to which a product follows 'the path' it is required to focus on the economy-product dimension – in order to capture the territory-specific heterogeneity of product path-dependency. It needs to consider the entire distribution of option set relatedness distribution. Each new entry's inverse measure of distance from the export basket ($dist_{i,EB_{kt}}$) is associated with a percentile in the distribution of the option set ranging from 0 to 100. Higher values denote path-dependent new entries, thus it requires to transform such value in a measure of path-departure as follows:

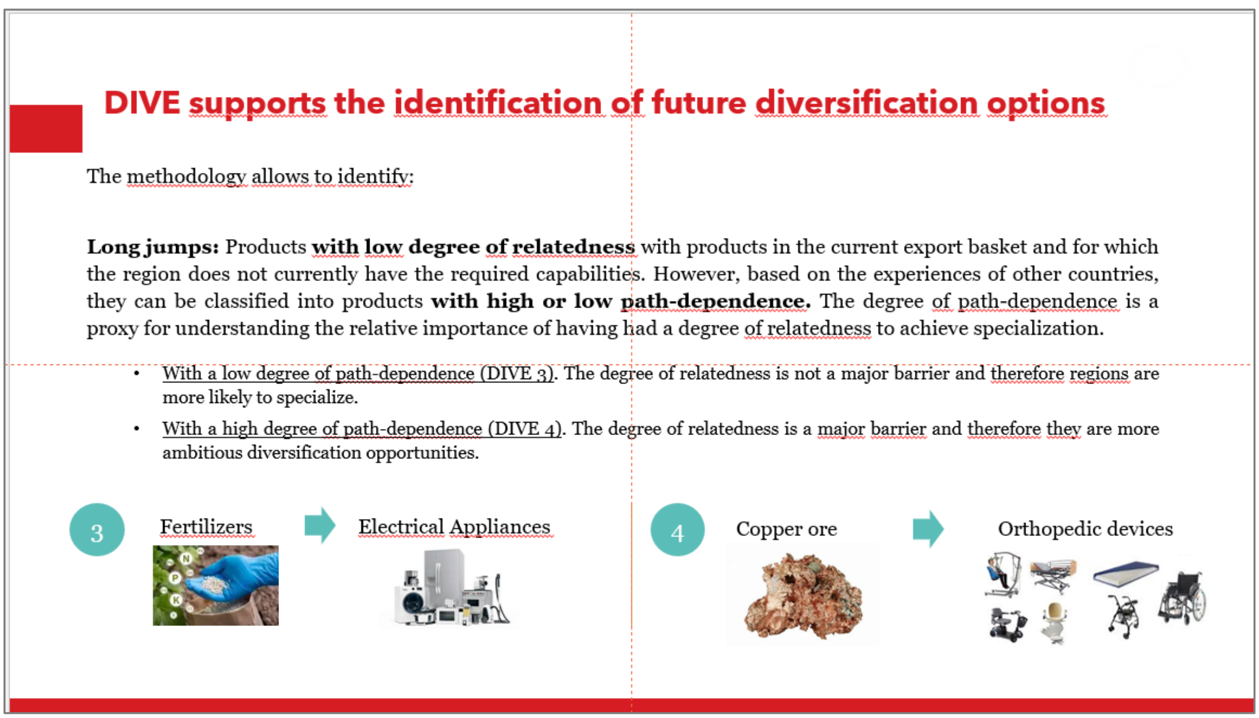
$$percentile_{ikt} = 1 - rank_{OS,ikt}/100$$

Source: Custom Office in a country and BACI/CEPII – HS at 4-digit

Tool: Diversifying Industries and Value Chains for Exports (DIVE) - UNIDO

For a more detailed explanation about the calculation of key indicators, go to DIVE Tool Manual


DIVE supports the identification of future diversification options
The methodology allows to identify:
Short jumps: Products with high degree of relatedness with products in the current export basket and for which the region is likely to have the required capabilities.
• With many competitors (DIVE 1)
• With few competitors (DIVE 2)
1
Copper ore
Refined copper
2
Basic metal oxides
Boron oxides; basic boric acids
Fe
O
Metal + Oxigeno = Oxido Metalico
Cl
O
No Metal + Oxigeno = Anhidrido


DIVE supports the identification of future diversification options
The methodology allows to identify:
Long jumps: Products with low degree of relatedness with products in the current export basket and for which the region does not currently have the required capabilities. However, based on the experiences of other countries, they can be classified into products with high or low path-dependence. The degree of path-dependence is a proxy for understanding the relative importance of having had a degree of relatedness to achieve specialization.
• With a low degree of path-dependence (DIVE 3). The degree of relatedness is not a major barrier and therefore regions are more likely to specialize.
• With a high degree of path-dependence (DIVE 4). The degree of relatedness is a major barrier and therefore they are more ambitious diversification opportunities.
3
Fertilizers
Electrical Appliances
4
Copper ore
Orthopedic devices

Annex 2. Agenda of the workshop "Development of green economic diversification strategies for coal regions" Santiago (9 December 2024)

Agenda

Hora	Actividad	Responsable
8:30 - 9:00	Registro participantes	
9:00 - 9:15	Bienvenida	GIZ
9:15 - 9:30	La Estrategia Nacional de Transición Socio-Ecológica Justa Qué entiende Chile por una transición socio-ecológica justa, justificación y objetivos	Representante del Ministerio del Ambiente
9:30 - 9:45	Propuesta del Plan de Descarbonización - reconversión de centrales a carbón Objetivo, metas propuestas, ejes propuestos	Representante del Ministerio de Energía
9:45 - 10:00	Proyecto GIZ para apoyar la diversificación económica verde en regiones carboníferas a. Elaboración de una guía digital para desarrollar estrategias de diversificación económica verde para regiones carboníferas b. Desarrollo (a modo piloto) de una estrategia de diversificación económica verde para la región de Antofagasta	Global Policy Incubator
10:00 - 10:30	La transición justa en regiones carboníferas y las oportunidades y desafíos que la diversificación económica presenta Marco conceptual para estrategias de diversificación verde El proceso de política basado en evidencia y participativo	Global Policy Incubator
10:30 - 10:45	Coffee break	Todos
10:45 - 11:45	Estado actual de la diversificación económica en Chile: Metodologías y resultados iniciales para Chile y la región de Antofagasta	Global Policy Incubator
11.45 - 12:25	Discusión: Oportunidades y desafíos para Chile y la región de Antofagasta	Todos
12:25 - 12:30	Cierre	Todos

Indicación adicional: Favor de compartir su Nro. de RUT o pasaporte al momento de confirmar su asistencia y considerar llegar a CEPAL aproximadamente 30 minutos antes para pasar por el registro de seguridad.

Annex 3. Agenda of the workshop "Development of green economic diversification strategies for coal regions" Antofagasta (11 December 2024)

Agenda

Hora	Actividad	Responsable
8:45 - 9:00	Registro participantes	
9:00 - 9:15	Bienvenida	GIZ
9:15 - 9:30	La Estrategia Nacional de Transición Socio-Ecológica Justa Qué entiende Chile por una transición socio-ecológica justa, justificación y objetivos	Representante del Ministerio del Ambiente
9:30 - 9:45	Propuesta del Plan de Descarbonización – reconversión de centrales a carbón Objetivo, metas propuestas, ejes propuestos	Representante del Ministerio de Energía
9:45 - 10:00	Proyecto GIZ para apoyar la diversificación económica verde en regiones carboníferas a. Elaboración de una guía digital para desarrollar estrategias de diversificación económica verde para regiones carboníferas b. Desarrollo (a modo piloto) de una estrategia de diversificación económica verde para la región de Antofagasta	Global Policy Incubator
10:00 - 10:30	La transición justa en regiones carboníferas y las oportunidades y desafíos que la diversificación económica presenta Marco conceptual para estrategias de diversificación verde El proceso de política basado en evidencia y participativo	Global Policy Incubator
10:30 - 10:45	Coffee break	Todos
10:45 - 11:45	Estado actual de la diversificación económica en Chile: Metodologías y resultados iniciales para Chile y la región de Antofagasta	Global Policy Incubator
11.45 - 12:25	Discusión: Oportunidades y desafíos para Chile y la región de Antofagasta	Todos
12:25 - 12:30	Cierre	Todos

Annex 4. Workshop agenda "Economic diversification strategies: Applying the IKI JET Guide to the case of Antofagasta with a focus on Mejillones" Mejillones, (1 April 2025)

Agenda

Hora	Actividad	Responsable
15:00 - 15:15	Bienvenida y alcance y contribución del proyecto IKI JET a la diversificación económica verde en regiones carboníferas	GIZ
15:15 - 15:30	a. Contexto sobre la elaboración de una guía digital para desarrollar estrategias de diversificación económica verde para regiones carboníferas b. Desarrollo (a modo piloto) de una estrategia de diversificación económica verde para la región de Antofagasta	Global Policy Incubator
15:30 - 16:45	Presentación de la metodología para identificación de oportunidades de diversificación económica y resultados preliminares para Antofagasta con una mirada a Mejillones: - Resultados de la identificación por medio de herramientas cuantitativas - Diagnóstico por medio de herramientas cualitativas - Lista preliminar de oportunidades con potencial de diversificación para la región	Global Policy Incubator
16:45 - 17:00	Coffee break	Todos
17:00 - 18:00	Taller participativo: - Proponiendo la visión de la estrategia de diversificación económica. - Identificando los objetivos de la estrategia de diversificación económica - Priorización de oportunidades con potencial de diversificación para la región de acuerdo con la visión y objetivos identificados	Todos Moderación: Global Policy Incubator

Annex 5. Agenda of the workshop "Economic Diversification Strategies: Results of the application of the IKI JET Guide to the case of Antofagasta with a focus on Mejillones" Santiago, (3 April 2025)

Agenda

Hora	Actividad	Responsable
9:00 - 9:30	Registro participantes Coffee break de bienvenida	
9:30 - 9:50	Bienvenida	GIZ, Embajada. Alemana en Chile y Delegación de la Unión Europea en Chile
9:50 - 10:05	a. Contexto sobre la elaboración de una guía digital para desarrollar estrategias de diversificación económica verde para regiones carboníferas b. Desarrollo (a modo piloto) de una estrategia de diversificación económica verde para la región de Antofagasta	Global Policy Incubator
10:05 - 11:00	Presentación de la metodología para identificación de oportunidades de diversificación económica y resultados preliminares para Antofagasta con una mirada a Mejillones: - Resultados de la identificación por medio de herramientas cuantitativas - Diagnóstico por medio de herramientas cualitativas - Lista preliminar de oportunidades con potencial de diversificación para la región	Global Policy Incubator
11:00 - 11:20	Coffee break	Todos
11:20 - 12:30	Resultados del taller participativo desarrollado en Antofagasta - Visión y objetivos propuestos para la diversificación económica - Identificación y priorización de oportunidades de diversificación económica.	Global Policy Incubator

Just Energy Transition in Coal Regions