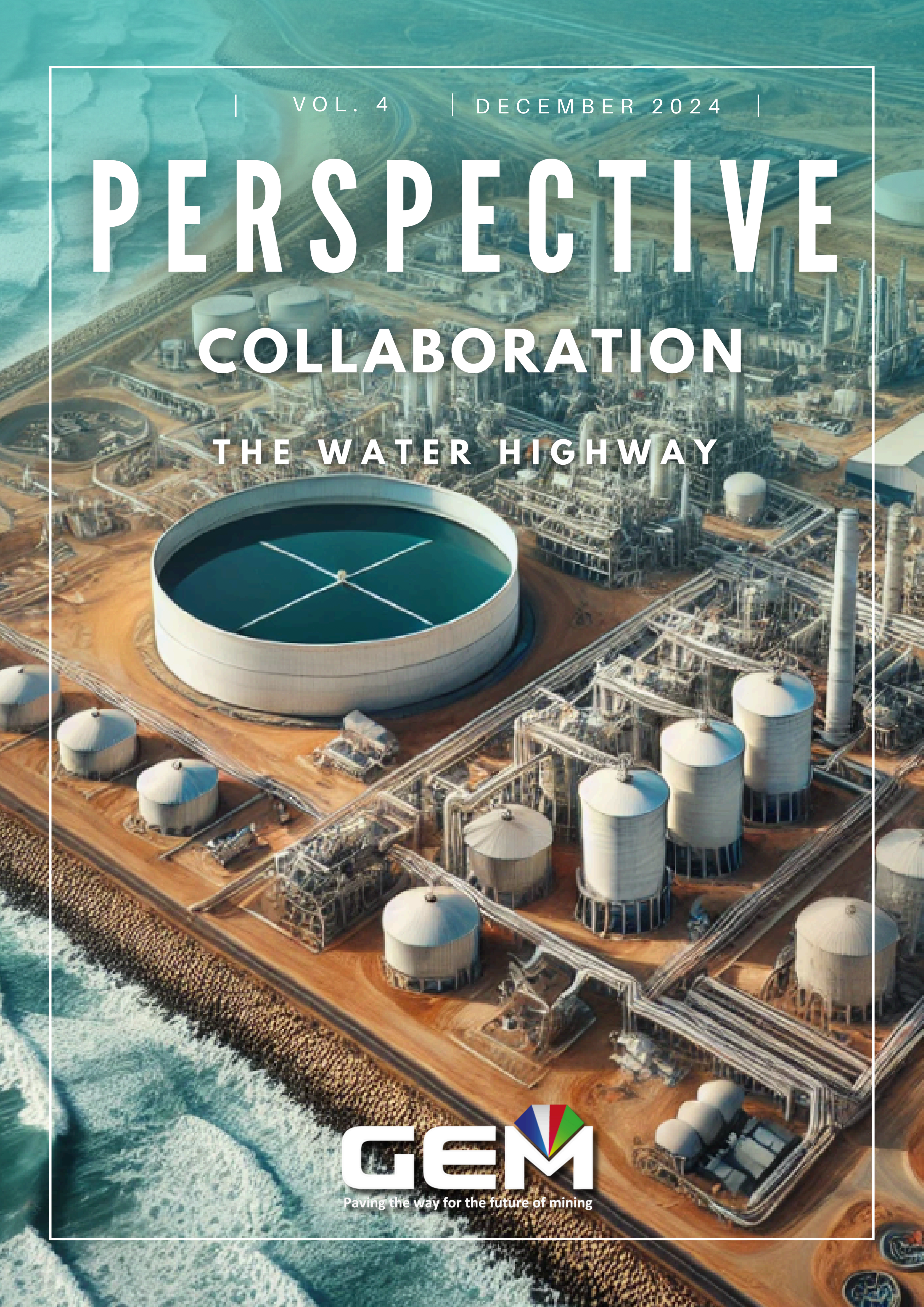


VOL. 4 | DECEMBER 2024

PERSPECTIVE

COLLABORATION

THE WATER HIGHWAY

GEM

Paving the way for the future of mining

INDEX

ABOUT GEM

We are a specialized Industrial Engineering company that provides support to the mining industry in matters related to management and economics. Our expertise covers various fields as we develop the most advanced tools applied in the mining sector. With over 14 years of experience and the successful implementation of more than 400 projects worldwide, we stand out for our solid track record and commitment to excellence in the sector.

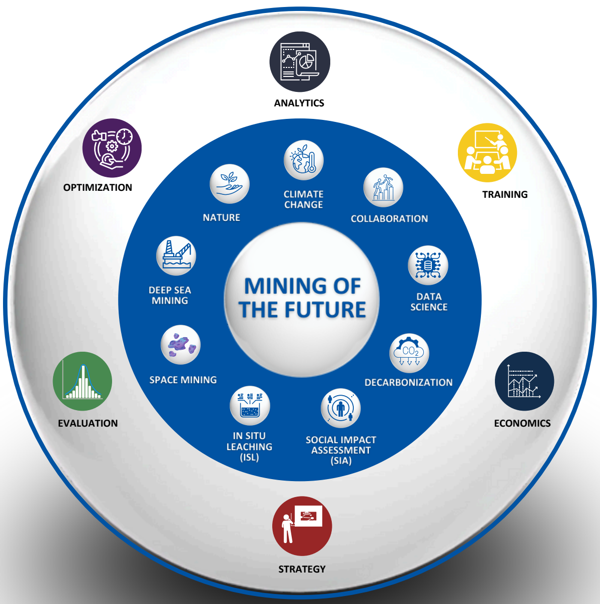
MISSION

We are a company providing products and services in industrial engineering that enable the path for the future of mining while maximizing the business value for our clients.
At GEM, we are committed to becoming a beacon for the global mining industry.

Our core highlights the main service areas of GEM, which include:

Analytics: Use of advanced analytical tools such as machine learning and statistical analysis.
Training: Provision of training on complex topics tailored to specific mining cases.
Economics: Generation of mineral economics studies, market analysis, and econometric analysis.
Evaluation: Identification and quantification of risks with Monte Carlo simulations to evaluate their impact.
Strategy: Support in strategic decision-making to maximize business value.
Optimization: Utilization of tools and programming languages to find optimal solutions.

Additionally, the central image shows GEM's commitment to the future of mining, addressing areas such as climate change, collaboration, social impact assessment, nature, underwater mining, and in-situ leaching.



EDITORIAL

Currently, the mining industry faces increasingly complex challenges, from the depletion of high-grade mineral resources to the growing pressure to minimize the environmental and social impact of its operations. Producing minerals to support an economy requiring low levels of pollutant emissions adds an extra layer of requirements. However, these challenges also present a unique opportunity to innovate within the mining business model, which could lead to substantial savings in regulatory compliance costs.

Within this new framework of requirements, collaboration in the mining industry emerges as an essential need to effectively adressing these challenges. From technological innovation and the development of sustainable practices to meeting international standards and securing social licenses to operate, collaboration fosters knowledge sharing, cost reduction, and accelerates the processes necessary to achieve common sustainability and profitability goals. Collaboration brings value across the entire mining value chain, from mitigating risks in exploring new deposits to enhancing resource management efficiency and reducing environmental impact.

In this Perspective, we showcase examples of partnerships in the mining industry that have achieved significant progress in innovation and sustainability. We also provide a practical example to quantify the economic benefits of collaboration in mining, specifically in the construction of seawater desalination plants. These cases demonstrate that collaboration is essential for tackling 21st-century challenges, from accessing new markets to implementing responsible mining practices.

PABLO FAÚNDEZ
SPECIALIST ENGINEER

At GEM, we are committed to paving the way for the future of mining. We believe that collaboration is crucial for addressing industry's challenges regarding the use of natural resources, especially in terms of water consumption.

Therefore, we are developing the capabilities necessary to support the industry in sustainably meeting this challenge across economic, environmental, and social aspects.

INTRODUCTION

There are countless initiatives aimed at emphasizing the importance and potential of the industry to promote virtuous productive chains that add value to the Chilean productive and export matrix in a more technologized manner. Furthermore, there are several studies covering different methods to foster a more sustainable and competitive mining industry (Cabrera, 2023).

Among the myriad subjects are productive clusters and elements of public policies that can foster the development of the mining industry. In this regard, the most cited term for clusters are: **geographic concentrations of interconnected companies, specialized suppliers, service providers, companies from related sectors, and associated institutions (such as universities, standardization organizations, and trade associations) in specific fields that compete but also collaborate** (Porter, 1998).

Geographic proximity in clusters facilitates the diffusion of knowledge and promotes technological development, driving a virtuous industry that generates growth and economic benefits, not only within the private sector but also in the public sector (Cabrera, 2023).

Collaboration in mining refers to the cooperation and partnership among different stakeholders involved in the mining industry with the aim of achieving mutual benefits and promoting the sustainability of the sector. These stakeholders may include mining companies, governments, local communities, and non-governmental organizations (NGOs). Collaboration can manifest in various forms, such as joint projects, strategic alliances, community initiatives, and sustainable development programs (ICMM, 2024).

Mining in Chile plays a key role in regional economic growth and in the transition to cleaner energy on a global scale. The sustainable development of the country depends on the mining sector optimizing its competitiveness through the adoption of more environmentally friendly processes that also promote the progress of local communities (Gobierno Regional Antofagasta & CORE, 2024).

BACKGROUND

Antofagasta is Chile's main mining region and is projected to continue leading copper production, with an expected contribution of 51.6% of national production by 2034. Additionally, the region is expected to contribute 17.6% of its total production supply in refined copper, equivalent to 583 thousand tons in that same year (Cochilco, 2023). It ranks second in lithium production, which gives it strategic relevance for both the transition to clean energy and its own economic development (OECD, 2023). In 2022, its production in the region exceeded 220,000 tons of lithium carbonate equivalent (LCE). The mining sector in the region has been key in driving economic growth, representing 72% of the regional GDP and 39.4% of the country's total exports. The per capita GDP of the region is the highest in the country and nearly doubles the average of the 50 mining regions in the OECD (OECD, 2023).

The region is home to internationally recognized mining companies, an extensive network of suppliers, and a well-organized productive ecosystem within the Mining Cluster entity (Gobierno Regional Antofagasta & CORE, 2024). In 2009, CORFO (The Production Development Corporation) created the Mining Cluster Program in Antofagasta, one of the first formal efforts to establish a collaborative network, making this region the epicenter of this initiative (CORFO, 2019).

In 2016, the Regional Strategic Program (PER) Mining Cluster of Antofagasta was launched, consisting of a board as a non-profit entity aimed at enhancing the construction of social value and sustainability from the immediate environment of operations (CORFO, 2020).

The most recent initiative is the support from the Regional Government and the Regional Council of Antofagasta in creating the Regional Mining Strategy (EMRA 2030-2050) to ensure that all mining initiatives and activities align with broader goals of sustainable development and territorial planning.

Currently, collaboration is not a central focus in Chile's mining sector, which may affect the country's competitiveness. Competitiveness in mining is linked to the ability to innovate, optimize processes, reduce costs, and increasingly, comply with environmental regulations. Chile faces challenges due to factors such as water scarcity, rising energy costs, and sustainability demands, putting pressure on the mining industry.

Countries that foster collaboration and the adoption of advanced technologies, like Australia, have managed to maintain and increase their competitiveness in the global market, forming mining clusters and public-private partnerships that accelerate the adoption of sustainable technologies, such as green hydrogen and advanced automation systems.

The country's mining industry presents a favorable scenario for strategic collaboration due to its strong cluster. The mining cluster policy is a key management tool to address market failures, raise and leverage resources, access new markets, and connect with larger companies.

EMRA 2030-2050 aims to achieve greater well-being for the region, built on the foundation of a competitive and environmentally responsible mining sector. The EMRA was developed based on the main assessments and recommendations of the Organization for Economic Co-operation and Development (OECD), contained in the "OECD Mining Regions and Cities Case Study: Antofagasta Region, Chile" (2023). The implementation of this strategy seeks to ensure greater participation of communities and indigenous peoples in the governance of the region’s mineral resources.

Short-term strategies (2023-2030) include: "improving collaboration between large, medium, and small-scale mining." Meanwhile, a medium and long-term strategy (2023-2050) is: "facilitating collaboration between mining companies and the public sector in terms of logistics and infrastructure, with an emphasis on road and telecommunications connectivity, as well as the supply of drinking water and electricity throughout the region" (Gobierno Regional Antofagasta & CORE, 2024).

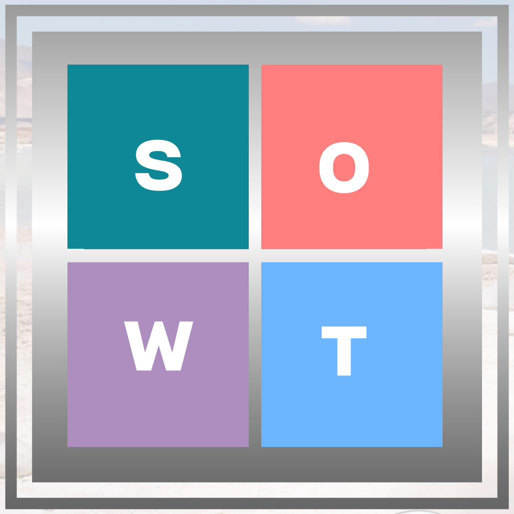
FIGURE 1 SWOT ANALYSIS

STRENGTHS

- Reducing infrastructure costs is crucial in areas such as roads, processing, communications, training, water, energy, joint projects, ports, transportation, logistics, and insurance.
- Collaboration among mining companies in waste management, energy, R&D, emissions, suppliers, and social plans would optimize resources, improve operational efficiency, and reduce costs.
- Collaboration among corporate employees enables information sharing and joint efforts on projects or their execution.
- Collaboration expands capabilities, generates new ideas, adds skills, creates value, maintains competitiveness, and fosters advancements in emerging sectors.
- There is an opportunity to internationalize national companies through overseas projects, aiming to complement resources, expand markets, conduct research, diversify risks, strengthen brands, and share knowledge.

OPORTUNITIES

- The mining cluster is a key strength that allows the concentration of related companies in the same geographic area.
- Chile is the world's largest copper producer, with over 5 million tons annually.
- Mining in Chile contributes nearly 15% of the GDP and accounts for approximately 60% of the country's exports.
- Certain regions, such as Antofagasta, heavily depend on mining and essentially operate as mining clusters.
- Santiago has established itself as the city with the most mining start-ups worldwide.
- Over 8,000 service provider companies for the mining sector operate in Chile.
- Chile possesses the largest reserves of key resources for electromobility, with projected investments exceeding 100 billion USD in the mining sector.



WEAKNESSES

- The risk of confusing genuine collaboration with anti-competitive practices, such as collusion or the formation of a "cartel," can undermine trust between companies and with local communities. This complicates collaborative efforts, hinders the creation of shared value, and jeopardizes the social license to operate.
- Without a proper communication strategy, collaboration can be misinterpreted as collusion, diverting attention from meeting stakeholders' needs. Collusion involves agreements between competitors to fix prices, limit production, divide markets, or manipulate bids, and it carries prison sentences ranging from 3 to 10 years, along with disqualification from holding executive or managerial positions (BCN, 2021).

THREATHS

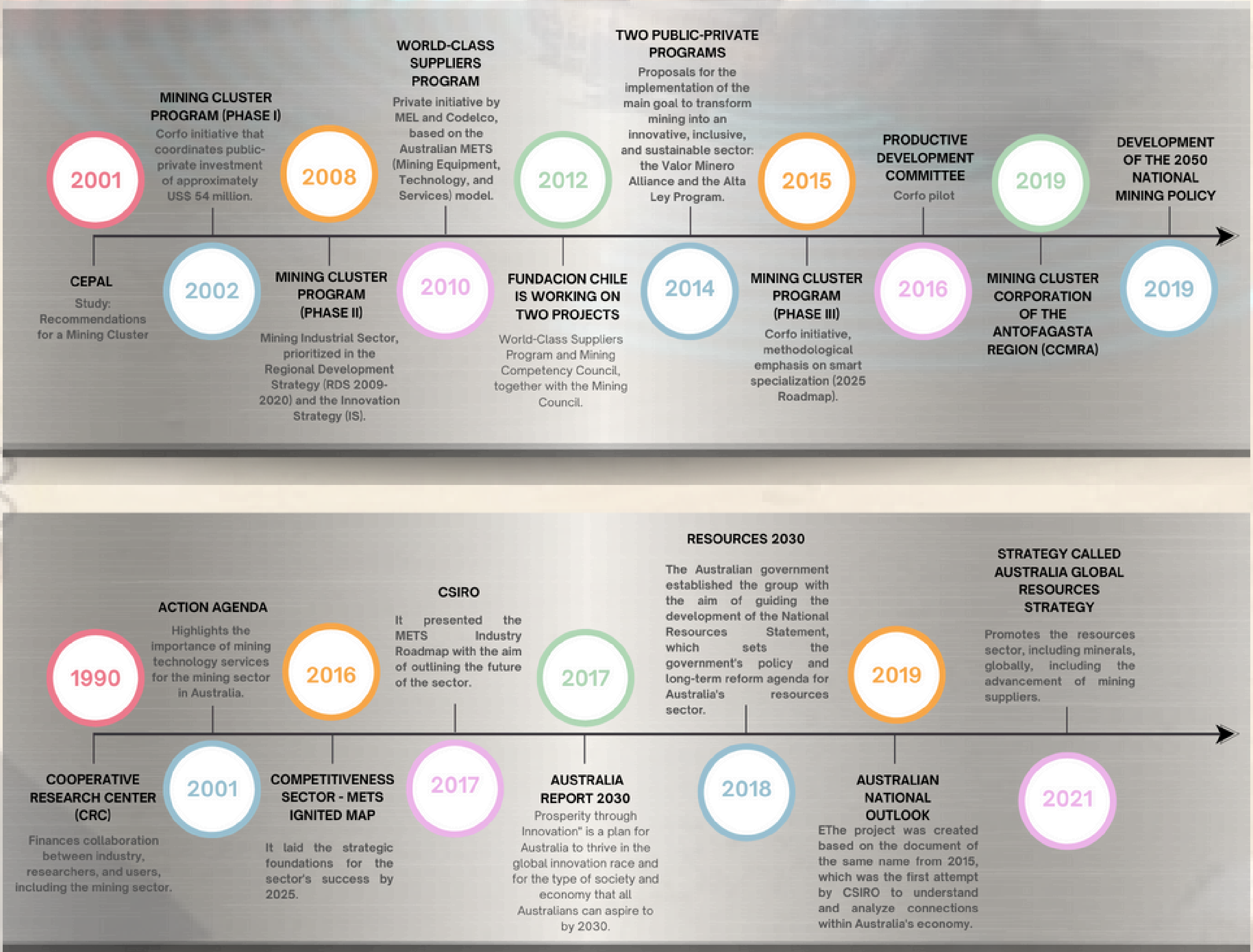
- The deeply ingrained culture of independent industries can hinder full integration.
- The lack of communication and trust between companies makes it difficult to share information, knowledge, and experiences, limiting the productivity, innovation, and competitiveness of the sector.
- Resistance to change and adapting to new technologies and trends prevents companies from seizing growth opportunities.
- Low participation in networks and strategic alliances with stakeholders in the mining ecosystem limits access to resources, financing, advice, and support.

Source: GEM own elaboration

In clusters, both in Chile and in countries like Australia, there are dense networks with diverse participants, including mining companies and other institutions. In both countries, strategies, roadmaps, agendas, and action plans have been developed, driven by both the public and private sectors, and through collaboration.

The following **figure 2** analyzes the existence of public or government policies regarding the creation and functioning of mining clusters. The development of public policies is uneven between the two countries. In Australia's case, it is more advanced than Chile, which is still in a development stage, both in terms of its level of organization, clarity of its objectives, and the use of objective economic indicators (Labó, 2022). Australia began implementing these policies 20 years earlier than Chile, allowing it to establish itself as a model to follow.

FIGURE 2 TIMELINE OF THE AUSTRALIAN AND CHILEAN CLUSTER OF COLLABORATION INITIATIVES AND STRATEGIES



Source: GEM own elaboration

In Australia, strategies have been developed to foster innovation, competitiveness, and sustainability in the mining sector, promoting collaboration among various stakeholders and seeking to capitalize on emerging opportunities. Australian mining companies began to internationalize in the 1990s while retaining local suppliers, which allowed Mining Technology Services (now METS) to expand into other countries. Additionally, the country's mineral diversity encouraged innovation and information exchange as different challenges were faced in various types of mining. There was a need to address periods following the “super cycles” (Cabrera, 2023).

Australia has public-private collaborations, with examples such as CRC and CSIRO, which are R&D centers promoted by the government and generally receive economic support from mining companies to address industry challenges. AUSTMINE and AUSTRADE are private programs with public support that promote METS both locally and internationally. Additionally, they conduct programs, tenders, and competitions to facilitate connections and relationships between mining companies and suppliers (Cabrera, 2023).

The three main consequences of the growth of Australian METS and the strengthening of the cluster are that approximately 1,500 companies generated total revenues of $90,000 [USD] in 2012. About 66% of METS companies exported abroad (2015), with more than 47% exporting over 10% of their sales (2012). Additionally, 78% of METS suppliers are domestic, and 79% have activities outside the mining sector (Hernández, 2015).

Chile, in contrast to Australia, is in an earlier phase of developing its ecosystem despite having made progress in recent years toward its consolidation. Its objectives have primarily focused on the long term, aimed at addressing the future of the mining industry (Labó, 2022).

Various strategies, policies, and programs have been implemented for the development of the mining industry. The origins can be traced back to the creation of ENAMI in 1960 or the National Geological Service in 1970; however, among the most recent initiatives aimed at greater technological development is the establishment of the World-Class Suppliers Program (PPCM) in 2010 by Codelco and BHP Billiton, to which Antofagasta Minerals joined in 2014. The goal of this long-term program, inspired by Australia, was to contribute to regional development, job creation, technological innovation in the country, and export diversification, leveraging the challenges faced by the mining sector. In practice, the largest mining companies would face industry challenges requiring technological solutions from suppliers, aiming for them to subsequently become competitive suppliers in international markets, thus diversifying the export matrix with greater added value.

Predictions regarding the success of the PPCM projected that by 2035 there would be 250 supplier companies with export levels reaching $4 billion annually (Fundación Chile, 2016). However, in 2017, the program was replaced by the "Open Innovation Platform," with its termination being announced by the president of Fundación Chile at the time, Patricio Meller, who stated that the number of potentially innovative companies accounted for only 3% of the total. Furthermore, he noted that it was a mistake to assume that innovating was equivalent to exporting, given that Chile holds 30% of the world's copper and has the potential to capture the local market (Minería Chilena, 2017).

Experience over the years in the European Union and North America indicates that cluster development is linked to higher levels of prosperity. This is reflected, for example, in higher GDP, average wages, employment growth, and an increase in patent development (Europe INNOVA and PRO INNO Europe, 2008; Porter, 2003) (Labó, 2022).

Nueva Unión Project

One of the strongest case of collaboration in Chile is the Nueva Unión project, which arises from the merger of Minera El Morro (GoldCorp) and Minera La Fortuna (Teck), located in the Huasco province of the Atacama Region. It is one of the largest undeveloped copper, gold, and molybdenum projects in the Americas and the largest gold project in Chile. It is expected to produce 209,439 tons of copper and 10,148,000 ounces of gold in its first ten years. The purpose is to extract copper and gold minerals from Minera La Fortuna (located at approximately 13,123 feet above sea level in the Alto del Carmen commune) and copper and molybdenum from Minera Relincho (at about 6,562 feet above sea level in the Vallenar commune), collaborating by transporting the mineral from El Morro and processing it at Teck's concentrator plant (Ej Atlas, 2022).

Study of Seawater Desalination Plants

Chile is a water-rich country when comparing national per capita availability with the average of the Organization for Economic Co-operation and Development (OECD). However, various climatic, regulatory, and management factors present challenges in certain sectors. A clear example is the central-northern region, which is facing a severe water crisis (OECD, 2018). This problem disproportionately affects groups in poverty and rural areas, where water infrastructure is less developed (PUC, 2019) (Naciones Unidas Chile, 2021).

Given this scenario, the present study conducted by GEM explores collaboration projects focused on the development of seawater desalination plants under a cluster model, aiming to optimize the use of aqueducts in these plants and contribute to the country's water sustainability.

At the environmental impact level, the reduction in infrastructure required for supplying mining operations is notable. Through collaboration, the total length of constructed aqueducts could be reduced by up to 41%, using one-third of the desalination plants that would be built without collaboration. This translates to a 41% lesser alteration of the ecosystem (forest and desert).

Most of the aquifers in Chile are overexploited due to the lack of operational hydrogeological models that assist in rationalizing the management of groundwater resources (Apey et al., 2017). The most significant environmental impacts of desalination plants are linked to CO_2 emissions and the effects of brine on the physicochemical characteristics of receiving ecosystems, particularly the increase in salinity and temperature. Additionally, the intake of seawater for desalination also involves the suction of planktonic organisms, fish eggs, larvae, among others, which are harmed or eliminated as they pass through the suction system (BCN, 2021).

Collaboration in the construction of a desalination plant is important from a strategic perspective, as it not only helps reduce operational costs but also generates environmental and sustainability benefits. Moreover, collaboration allows for more efficient compliance with environmental regulations and promotes innovation in impact mitigation technologies, which contributes to improving the economic and environmental viability of the project in the long term.

According to the environmental regulations applicable to the construction of desalination plants, it is essential to consider mitigation, repair, and compensation measures. The plan must include, for each phase of the project or activity, the identification of the environmental component; the associated environmental impact; the type of measure; the name, objective, description, and justification of the corresponding measure, taking into account adaptation to climate change; the location, method, and timing of implementation; and the compliance indicator (BCN, 2023)

1. Explanation of the Cluster Model in the Study of Seawater Desalination Plants

To explain this model along with its assumptions, all operating copper mines and desalination plants were considered in the foundation. Conversely, operations that have existing desalination plants without an expansion project were excluded from the model.

A base with 41 copper operations was thus obtained, considering potential desalination plants where collaboration could or could not occur. It was assumed that each project would require a desalination plant, totaling 39 desalination facilities, given that there are currently three projects evaluating the possibility of sharing a seawater plant. It is important to note that, as of 2024, only 8 out of the 39 projects are under consideration, according to Cochilco. Additionally, for the purposes of simplification, this study used straight lines to calculate distances between the suction plant in the sea and the operations, without considering the feasibility of environmental permits.

To estimate water consumption for copper operations that have a seawater project in the pipeline, it was assumed that the capacity of these projects corresponds to the total consumption of the operation. For the other operations, water consumption was estimated based on the "Projection of Water Consumption in Copper Mining 2018-2029" (Chilean Copper Commission, 2018). It is assumed that a copper concentrate operation consumes 21.267 gallons/ton, while a leaching operation consumes 11.002 gallons/ton.

For the cluster model, an optimization problem was formulated with variables and parameters that allowed for the calculation of the total cost of the system, as well as the capacity required for each desalination plant.

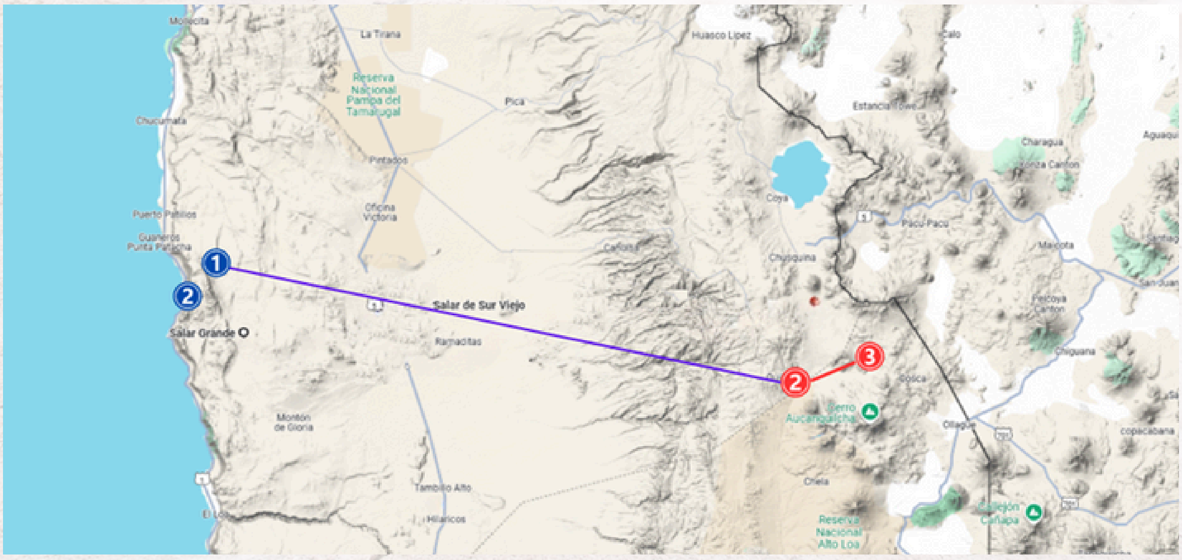
2. Methodology for Resolution

The numerical model developed by GEM optimized the total investment cost resulting from the installation of desalination plants. For this purpose, both the capacity of the plants and the total length of aqueducts needed to meet the water consumption of mining operations were considered. Within the optimization process, the variables to be modified correspond to binary activation indicators that indicate whether it is necessary to construct a pipeline between different entities.

Thus, two types of control variables were considered: desalination plant-mining relationship and mining-mining relationship. The first relationship refers to the direct connection between infrastructures through aqueducts, where the desalination plant supplies water directly to a mining operation. The second relationship represents the flow of water from one mining operation to another, **which is modeled as a collaborative action.**

The **figure 3** shows the desalination plants in blue and the mining operations in red. These two mines are located very close to the Andes Mountains, while the desalinated water is extracted from the coast. If each mining operation were to build its own desalination plant separately, there would be two aqueducts crossing the entirety of Chile. In contrast, if they

FIGUR3 3 MAP HAT INCLUDES BOTH TYPES OF VARIABLES



Source: GEM own elaboration

collaborated, the water would flow from one desalination plant to one of the mines, and from there, an aqueduct would transport the water to the other mine.

Through the tracking conducted, the model calculated costs based on the length of the pipelines and the water consumption of the plants, determining the necessary investment. Subsequently, the model compared a scenario without collaboration to one with collaboration. In more mathematical terms, the model minimized the total investment cost for the country across the 41 copper operations considered.

The model considered this optimization under certain constraints. Specifically, the restrictions relate to the fact that one mining operation can only supply another if it is receiving water. Furthermore, and most importantly, each mining operation must be fed by only one seawater desalination plant. This means that if an operation requires 264 gallons of water, it will not be allowed to have two different plants of 132 gallons each supplying the necessary water to the mine together, as this scenario is deemed unprofitable. Out of 10 mining operations, there may be 5 desalination plants. **A desalination plant can supply multiple mines, but a mine cannot be supplied by multiple desalination plants.**

Although there is an economy of scale that allows for greater benefits to communities by generating less impact with fewer plants, larger operations may encounter greater difficulties in obtaining environmental permits. However, this has happened in specific cases, and according to extensive mining experience, it is not typically a significant problem. In practice, this assumption does not have relevant consequences.

Additionally, technical constraints were incorporated to ensure the model's compliance, such as verifying the water route to calculate costs and distances, as well as the length of the pipelines to assess the model's status.

3.Cluster Results

The results of the cluster model demonstrate that collaboration reduces the Present Value of Costs (PVC) by 14% ($2,856 million), considering the 41 mining operations included in the study. **This would save 19% on investment costs and 7% on operating costs.**

It was concluded that if collaboration is established between the Coquimbo and O'Higgins regions, it could lead to what is called **"the water highway"**. From the Valparaíso region, water could be transported to Rancagua, with a seawater desalination plant supplying 11 mining operations. The model demonstrates that this is feasible and that the water highway could achieve a 24% reduction in costs in the regions where it takes place.

The economic benefits arise from the reduction in the construction of pipeline systems for plants, resulting in lower environmental and social impacts. However, it does not lead to savings in water, as the amount needed remains constant.

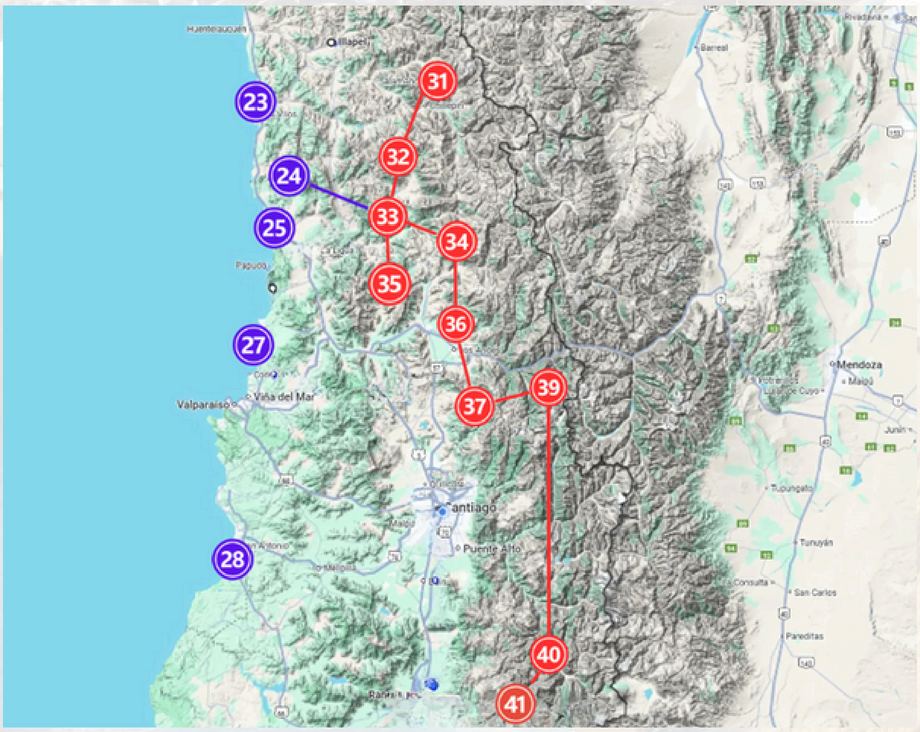
TABLE 1 WITH KPI MODEL

MINE / PLANT	CONSUMPTION [L/s]	CAPEX [MUS$]	OPEX [US$/m3]
31 Los Pelambres	765	523	2,29
32 Las Cenizas	20	98	1,52
33 La Patagua	5	56	1,36
34 Cerro Negro	35	117	1,66
35 El Soldado	108	107	1,45
36 Chagres	268	217	1,39
37 Las Tórtolas	625	444	1,49
38 Los Bronces	735	566	2,32
39 Los Bronces	451	436	2,47
40 El Teniente	1.173	771	1,83
41 Valle Central	38	215	1,47
Base case	4.223	3.522	1,97
Colaboration	4.223	2.666	1,74
Difference	0	856	0,23

- VAC without collaboration: **6.101 [MUS$]**
- VAC with collaboration: **4.943 [MUS$]**
- Savings of **1.158 [MUS$]**
- **19%** of the non-collaboration case

The **table** below demonstrates that it is more cost-effective to undertake a large-scale seawater project rather than have each of the 11 mining operations execute their own separate project. This integration allows for a Net Present Value (NPV) savings of 1.158 [Million US$], which represents a 19% reduction compared to the base case.

FIGURE 4 CLUSTER, THE WATER HIGHWAY: COLLABORATION BETWEEN 11 OPERATIONS ENABLES A 19% COST SAVING AT THE NATIONAL LEVEL (1.158 [MUS$])



Source: GEM own elaboration

CONCLUSION

In the context of the growing need to optimize water resource use in Chile, collaboration among companies emerges as a key strategy to achieve greater sustainability and competitiveness in the mining sector. This study demonstrates that cooperation among 11 mining operations can generate synergies that not only optimize water management but also enable significant economic savings and the implementation of more efficient solutions. The creation of productive clusters, which facilitate the transfer of knowledge and technologies, reinforces the importance of strategic alliances in the Chilean mining industry.

Collaboration among various stakeholders, as suggested by previous studies and the analysis presented here, has the potential to drive industry development, promote sustainability, and contribute to the country's economic growth. By working together, the private sector, public institutions, and communities can consolidate a mining industry that is more competitive, technological, and environmentally respectful, benefiting both the involved parties and the country as a whole.

This collaboration, therefore, is not only an opportunity to enhance efficiency in resource management, such as water, but also a pathway to solidify Chile's position as a global leader in sustainable mining. The implementation of these collaborative projects will strengthen the country's capacity to adapt to future challenges, fostering balanced and more equitable growth that includes all sectors of society.

This study highlights the importance of promoting collaboration among companies to optimize resources and advance towards the mining of the future. It is evident that, in a global context where other countries are already adopting advanced technologies and more sustainable practices, Chile cannot afford to fall behind. Promoting strategic alliances and innovation is essential to maintain competitiveness and ensure that the mining industry continues to be a pillar of the country's economic development in the coming years.

BIBLIOGRAPHY

Apey, A., Ramírez, E., Gumucio, A., & Amunátegui, R. (2017). Agricultura chilena, reflexiones y desafíos al 2030, (1ra ed., pp. 147-178). ODEPA.

BCN. (2021). Colusión de Empresas. Disponible en: https://www.bcn.cl/portal/leyfacil/recurso/colusion-de-empresas.

BCN. (2021). Principales usos del agua desalada a nivel global y estrategias de mitigación de impactos ambientales del proceso de desalinización. Disponible en: obtienearchivo (bcn.cl)

BCN. (2024). Decreto 30 – MINISTERIO DEL MEDIO AMBIENTE. Disponible en: Ley Chile - Decreto 30 01-FEB-2024 MINISTERIO DEL MEDIO AMBIENTE - Biblioteca del Congreso Nacional (bcn.cl)

Cabrera, F. (2023). ClustersMineros en Australia y Chile. Disponible en: https://obtienearchivo.bcn.cl/obtienearchivo?id=repositorio/10221/34387/1/Informe_BCN_Clusters_productivos_en_la_mineri__a_Australia_y_Chile_FINAL.pdf.

Cochilco. (2024). Inversión en la Minería Chilena: Cartera de Proyectos.

COCHILCO. (2024), Proyección de la producción esperada de cobre 2023-2034. Disponible en:https://www.cochilco.cl/Proyeccion_produccion_cobre_2023_2034_vfinal2.pdf.

CORFO. (2019). Alianzas público privada, para el desarrollo servicios especializados en torno al negocio minero. Disponible en: https://www.cepal.org/sites/default/files/events/files/cluster_minero_antofagasta_corfo_0.pdf.

CORFO. (2020). De programa CORFO a Corporación: la nueva ruta del Clúster Minero de la Región de Antofagasta. Disponible en: https://www.corfo.cl/sites/cpp/sala_de_prensa/regional/27_10_2020_nueva_ruta_del_cluster_minero_en_antofagasta.

EjAtlas. (2022). Proyecto Nueva Unión en Vallenar, Chile. Disponible en: Ej Atlas

Fundación Chile. (2016). Disponible en: (Fundación Chile; Roadmap Tecnológico 2015-2035, 2016) az3514.pdf (mecon.gob.ar)

Gobierno Regional Antofagasta, CORE. (2024) Estrategia Minera para el Bienestar de la Región de Antofagasta EMRA 2023-2050. Disponible en: https://www.estrategiamineraantofagasta.cl/web/wp-content/uploads/2024/03/Documento-EMRA.pdf.

Hernández, B. (2015). Mapeo de los Encadenamientos Productivos del Clúster Minero Australiano y Chileno. Universidad de Chile. Santiago

ICMM. (2024). Mining Principles. Disponible en: https://www.icmm.com/website/publications/pdfs/mining-principles/mining-principles.pdf?cb=83767.

Labó, R. (2022) Gobernanza de los clústeres mineros los casos de Australia, Chile y Perú. Disponible en: https://repositorio.cepal.org/server/api/core/bitstreams/f1068bd4-a88c-43d0-96b0-0ec6e71dba1c/content.

Minería Chilena. (2017). En Perspectiva, el programa de Proveedores de Clase Mundial se ve hoy bastante restringido". Disponible en: "En perspectiva, el programa de Proveedores de Clase Mundial se ve hoy bastante restringido" (mch.cl)

Naciones Unidas Chile. (2021). Escasez Hídrica en Chile: Desafíos Pendientes.
Disponible en: https://chile.un.org/sites/default/files/2021-03/PB%20Recursos%20H%C3%ADdricos_FINAL_17%20de%20marzo.pdf.

OCDE. (2023), Mining Regions and Cities in the Region of Antofagasta, Chile: Towards a Regional Mining Strategy, OECD Rural Studies, OECD Publishing, Paris, https://doi.org/10.1787/336e2d2f-en.

OCDE. (s.f.), Nominal Gross Domestic Product (GDP). Disponible en: https://www.OECD.org/en/data/indicators/nominal-gross-domestic-product-gdp.html?OECDcontrol-d7f68dbeee-var3=2021.

Porter, M. E. (1998). Clusters. Innovation, and Competitiveness: New Findings and Implications for Policy.

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