Development pathways for “hydrogen hubs” in Chile

DEVELOPMENT PATHWAYS FOR "HYDROGEN HUBS" IN CHILE

AN EXPERTISE FOR THE INTER-AMERICAN DEVELOPMENT BANK

Project #: RG-T3725

FINAL REPORT

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R E P O R T

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Contents

TABLES

FIGURES

ACRONYMS AND ABBREVIATIONS

CGH_2	Compressed Gaseous Hydrogen
ECMPO	Marine Coastal Spaces for Indigenous Peoples
ECMPO	Marine Coastal Spaces for Indigenous Peoples
FCEV	Fuel Cell-Electric Vehicle
GDP	Gross Domestic Product
GH2	Green Hydrogen
GHS	(National) Green Hydrogen Strategy
GIZ	Gesellschaft für Internationale Zusammenarbeit (German development organization)
H_2	Hydrogen
HRS	Hydrogen Refueling Station
HV line	High Voltage Line
LGUC	General law of urbanism and construction
LH_2	Liquified Hydrogen
MoE	Ministry of Energy (Chile)
MoNA	Ministry of National Assets (Chile)
NH_3	Ammonia
OGUC	General ordinance on urban planning and construction
PELP	Planificación Energética de Largo Plazo (Long-term Energy Planning)
PNOT	National land-use planning policy
PROT	Regional land management plan
RES	Renewable Energy Sources
SEIA	Environmental Impact Assessment System
SII	Servicio de impuestos internos (Internal Revenue Services of Chile)

EXECUTIVE SUMMARY

Chile has set itself ambitious goals for the development of a green hydrogen industry in the **National Green Hydrogen Strategy**. Six prioritized sectors have been identified to play a key role in a strongly growing domestic demand. At the same time, Chile plans to provide hydrogen and its derivatives to a dynamically growing world market.

Establishing so-called **hydrogen hubs – H_2 hubs** – will allow Chile to unlock synergies in serving both the domestic and the world market. H_2 hubs are "ecosystems" of hydrogen production, distribution, utilization, innovation and potentially export. Renewable energy production for hydrogen generation will be spread-out over larger areas to form, together with the hydrogen hub, a wider hydrogen valley.

This study identifies criteria for the selection of suitable locations and exemplifies development pathways for two H_2 hubs. To profit from Chile's world-record levelized costs of energy, the locations should preferably be selected from two regions: the **Antofagasta** region and the wider Atacama desert in the north with solar potentials as high as 1400 GW, and the **Magallanes** region in the south with on-shore wind potentials of some 130 GW. The selection of H_2 hub locations should be based on existing infrastructure (e.g. ports), proximity to domestic demand, synergies with existing industries, local capacities (e.g. availability of skilled workers), hazard risks and the local development of hydrogen projects, among others. In the Antofagasta region, it may proof advantageous to establish corridors of two or several H_2 hubs along the coast, for example in Mejillones and Tocopilla, offering synergies and advantages with regards to regional participation and infrastructure requirements as long as the critical mass for a self-sustaining development of the hubs can be achieved.

Mejillones bay offers very good potential for a H_2 hub according to the criteria assessed and is picked in this study as a promising potential location for examination of a development pathway in the Antofagasta region. Cabo Negro bay is selected for this study in the Magallanes region.

In close alignment with the National Green Hydrogen Strategy, the **local hydrogen demand** in the two regions to be served from the potential H_2 hubs is estimated. Specifically, the mining sector as well as the explosives and fertilizer industries are identified as major potential hydrogen demand sectors in the Antofagasta region. In contrast, the hydrogen demand in the Magallanes region will remain low and should thus be positioned for export from the beginning of H_2 hub development.

Upon consideration of **hydrogen and derivatives export** scenarios, both H_2 hubs can provide large hydrogen quantities for export to world markets in Asia, North America and Europe. In a high export scenario, the Magallanes region will be able to fully exploit its green hydrogen potential, while the Antofagasta renewable potential is far greater than hydrogen production scenarios require.

Development pathways until 2050 are detailed for the two H_2 hubs in Antofagasta and Magallanes based on the low-export scenario of the National Green Hydrogen Strategy. 38 GW of **electrolyzer capacity** will be installed in Antofagasta until 2050 in this development pathway, requiring some 77 GW of installed **solar power generation**. The Magallanes region at the same time reaches 31 GW of electrolyzer capacity and 61 GW of installed **wind power generation**. In Antofagasta about 2.8 million tons of **hydrogen** will be produced per year, while Magallanes reaches production volumes of 3.1 million tons per year. Hydrogen derivatives such as ammonia, methanol or synthetic fuels may be interesting export products from the start, while the technology for safe and cost-effective transport of liquefied hydrogen – LH_2 – is anticipated to become relevant on a large-scale at the beginning of the next decade. For the sake of simplicity, this study calculates export volumes of ammonia and LH_2. However, other derivatives may be attractive as well replacing some of the LH_2 and ammonia quantities estimated here. Production is estimated at 5.6 million tons of **ammonia** per year in Antofagasta in 2050, and 6.9 million tons of ammonia in Magallanes.

Table 1: Development of renewable power and electrolyzer capacities

		2022-2025	2025-2030	2030-2035	2035-2040	2040-2045	2045-2050	
Renewable capacity	Antofagasta	1.993	15.306	43.259	63.314	70.224	77.667	MW
	Magallanes	1.189	10.207	30.190	39.929	48.875	61.417	MW
	Total	3.182	25.513	73.449	103.243	119.099	139.084	**MW**
Electrolyzer capacity	Antofagasta	996	7.653	21.629	31.657	35.112	38.834	MW
	Magallanes	595	5.104	15.095	19.964	24.437	30.708	MW
	Total	1.591	12.757	36.724	51.621	59.549	69.542	**MW**

For achieving this, a strong expansion of the existing **infrastructure** will be required. Especially the current electrical grid faces strong growth to transport the required renewable electricity to the H_2 hubs. These infrastructure developments have significant potential for synergies, notably in the north of Chile, with the existing grid and expansions to serve existing as well as additional electricity demand from renewable energies.

The development of a green hydrogen industry bears great opportunities, but also risks. Based on the development pathways, cumulative **investments** of over 70 billion US Dollars by 2050 in Antofagasta and over 100 billion US Dollars in Magallanes are required to establish and develop the H_2 hubs to the anticipated capacities. Investments are strongly driven by renewable capacities, which represent 40-65% of total investments depending on the location and the year of installation. Hydrogen generation requires some 13-32% of total investments, hydrogen conditioning and derivatives synthesis 9-17%, electrical infrastructure 3-13%, export ships 2-11%.

In both regions, an investment peak is to be observed at around 2035 based on further decreasing investment costs of renewable electricity plants and hydrogen technologies, and a peak in new installations around that time.

By 2050, the hydrogen generation alone will create yearly **tax revenues** in the order of around 700 million US Dollars in each of the two regions of Antofagasta and Magallanes. Additionally, further value will be created by companies involved in the green hydrogen value chain, comprising equipment logistics, electricity generation, water supply, electrolysis, conditioning and national as well as international transport. In both, Antofagasta and Magallanes, at least a quarter of existing **companies** can potentially profit from green hydrogen production. In the emerging industry, the highest job creation potential has been identified for the construction of renewable energy generation plants, electrical infrastructure and hydrogen generation, reaching some 200,000 **jobs** around 2035 and thereafter. This includes indirect job creation through support activities. While construction-related jobs follow the trend of new installations of capacities, operation and maintenance jobs continuously grow over time with growing fleet of capacities in operation. The number of full-time equivalents is estimated to be beyond 130,000 in Antofagasta by 2050 and beyond 80,000 in Magallanes.

Chile provides several instruments for **territorial planning**, being important for both lay-out of the H_2 hubs and renewable energy generation. The National Land Use Planning policy (PNOT) will provide for a strategic framework at national level (not publicly available yet), the Regional Land Use Plan (PROT) at regional level. Municipal level planning is provided by the Intercommunal Regulatory Plan (PRI) and Municipal Regulatory Plan (PRC). The General Law of Urbanism and Construction (LGUC) and the General Ordinance of Urbanism and Construction (OGUC) provide for the related legislative framework. In the areas of interest, Mejillones provides for a level of planning detail down to dedicated zones for industrial development, also highlighting potential synergies with the phase-out of coal-fired power plants. For the Cabo Negro bay area, in contrast, only communal planning is published, not covering the H_2 hub site. The existing planning instruments need to be adjusted to meet the requirements for H_2 hubs. Especially the strong expansion of renewable energy production for supplying the H_2 hubs needs to be incorporated into the respective planning instruments, such as the long-term energy plan (PELP), specifically dealing with Chile's renewable energy transition.

Social and environmental risks are assessed for the exemplified locations, which revealed certain dimensions and aspects to be taken into account. In Antofagasta, one concrete aspect to manage carefully are nesting sites of the protected Gaviotín Chico (*Sternula lorata*), which are located at the coast; among others, this is relevant for the construction of desalination plants. Moreover, the Chango ethnic group has recently been recognized as indigenous group and is active as artisanal fishers, thus making it important to balance port infrastructure and interests of that people. Archaeological sites may surface during construction activities and should be closely monitored.

In Magallanes, availability of **skilled workers** may become a challenge for the ambitious development of H_2 hubs, while on the other hand this provides opportunities for training local personnel. Additional opportunities emerge for the municipalities of the H_2 hubs and the respective regions, from the large investments in local infrastructure, such as roads and ports. Furthermore, careful planning of H_2 hub(s) in Antofagasta should allow for effective synergies for water supply through new desalination capacities. Magallanes, in turn, can profit from the required electrical infrastructure expansion, potentially interconnecting the isolated grids currently existing.

Attracting **component manufacturing** to Chile, such as electrolyzers or components for wind power plants or solar PV plants, for the green hydrogen industry would represent major additional development potential for Chile, and especially the regions of the emerging green hydrogen industry.

From the findings of this study, a number of **recommended actions** can be derived the next steps for the roll-out of the National Green Hydrogen Strategy that would help advance Chile in its objective of developing a green hydrogen economy and thereby achieve both environmental and economic goals. The recommendations are of five major categories and cover actions at national, regional, or municipal government levels:

- **Incentives** at national and regional level support attracting green hydrogen and renewable energy component manufacturing to Chile; vocational and academic training; worker mobility; etc.
- **Planning** at all government levels relate to specific industrial zones for hydrogen industry, and at national level to the regular reassessment of the National Green Hydrogen Strategy; etc.
- **Communication & Consultation** at all government levels includes obligations on project developers to inform the population; open round tables for hydrogen industry stakeholders; etc., keeping in mind that a hydrogen industry remains a national opportunity and will not be limited to H_2 hubs; etc.
- **Studies**, notably at national government level, are recommended on further topics such as technical and safety standards; detailed world market demand and competition; detailed domestic demand; etc.
- **Administrative** action at regional government level is related to monitoring of archaeological sites; monitoring of Gaviotín Chico/ Little tern nesting sites; etc.

1 INTRODUCTION, MOTIVATION AND METHODOLOGY

1.1 General background

The strong surge in interest by internationally recognized organizations, governments, non-governmental organizations, researchers, and companies in renewable hydrogen (H_2) as an energy carrier is based on its enabling role for a rapid, sustained, and cost-effective reduction of emissions of greenhouse gases throughout the economy and, in particular, in hard-to-abate sectors such as energy-intensive industries, heavy transport or high-grade heat. Countries representing almost 90% of global GDP have policies or initiatives for public support of hydrogen.

Hydrogen is key for an effective mitigation of the effects of man-induced climate change and provides a solution for jurisdictions to achieve their emissions reduction commitments in a timely and cost-effective manner.

The National Determined Contribution for Chile for 2030 has recently been updated with a more ambitious goal of reaching a peak of national Greenhouse Gas emissions by 2025 and a target of 95 $Mton_{CO2eq}$ by 2030 – a reduction of approximately 30% in per GDP terms from 2016 emissions. By 2050, Chile aims at carbon neutrality.

The National Green Hydrogen Strategy (GHS) published by the Government of Chile in late 2020 lays out the pathway for Chile to tap the potential of renewable hydrogen, based on its vast and world-class solar and wind resources, to promote green H_2 production for both domestic use and export.

The GHS establishes three main targets:

(i) to produce the cheapest green H_2 on the planet by 2030, below 1.5 USD/kg_{H2},

(ii) to be within the top 3 exporters of green H_2 and its derivatives by 2040, and

(iii) to have 5 GW of electrolyzer capacity under development by 2025.

These goals seek to tap into the over 160 million tons per year of green H_2 production potential that has been recognized in Chile, which correlates with over 1.75 TW of untapped renewable electricity generation potential mapped in the country.

If market and development projections defined by the GHS come to unfold, then a new clean industry of the size of the mining sector will emerge in Chile. The Strategy estimates cumulative investments of over 200 billion USD in the next 20 years on hydrogen's value chain, as well as 200 GW of new renewable power capacity.

Green hydrogen creates significant opportunities for sustainable and inclusive regional economic development, especially in areas in which there is large renewable resource potential, such as the North of Chile, and the South of Chile (Magallanes region).

"Ecosystems" of hydrogen production, distribution, utilization, innovation and potentially export are termed in global discussions as "hydrogen valleys" or "hydrogen hubs" – H_2 hubs.

1.2 Objective

The targets defined in the GHS are ambitious, and entail new challenges related to a transformational industrial development in these areas.

The study aims to develop and provide key information and recommendations for public and private stakeholders, including local and national authorities, companies, communities, and researchers, on the opportunities and challenges that the development of hydrogen hubs could entail to specific areas.

This may be useful as a basis for further discussions on the future local challenges of green hydrogen deployment, as well as on the means to adequately capture the opportunities it offers.

The objective of this study thus is to assess the deployment of hydrogen hubs in specific regions in Chile.

- Possible pathways for the deployment of hydrogen hubs in Chile are determined including the required infrastructure and installations as well as the required resources.
- Macroeconomic impacts of the development of green hydrogen in each hydrogen hub, including new investments, tax revenues, and job creation are described.
- Local challenges arising from the development of the hydrogen hubs, including territorial planning as well as opportunities for local value creation and growth, are outlined.
- Recommendations for action at national, regional and local government levels to mitigate the risks arising from the outlined challenges, as well as to capture the outlined opportunities are developed.

1.3 Methodology

1.3.1 Definition for H_2 Hubs in Chile

Internationally, the terms “hydrogen valley” and “hydrogen hub” are not consistently and precisely defined. Nonetheless, there is a common general understanding that they are “ecosystems” of hydrogen production, distribution, utilization, innovation and potentially export.

It may be useful to differentiate between hydrogen valleys and hydrogen hubs as done for example in the South Africa Hydrogen Valley study [SA 2021]: “These hubs have been identified based on locations with potential for a high concentration of future hydrogen demand, the possibility to produce hydrogen (e.g., access to sun/wind, water infrastructure), and contributions to the just transition – an economic development plan that brings positive social impact particularly to more fragile groups and communities. These hubs […] – will host pilot projects and contribute to the launch of the hydrogen economy in the Hydrogen Valley.” Here, a hydrogen valley is a larger area, or region, while hydrogen hubs are locally defined “ecosystems”.

In this sense the first step for the definition of hydrogen hubs in Chile is the definition of the terms “hydrogen hub” and “hydrogen valley” in order to provide for a common understanding for this study.

On the basis of well-defined terms, the boundaries of two regions that will be considered the H_2 valleys to be studied here, will be defined in close collaboration with the Ministry of Energy (MoE) and the Inter-American Development Bank (IDB). These regions shall not have a size smaller than one of the 16 administrative regions of Chile (e.g. II Región de Antofagasta, XII Región de Magallanes y de la Antártica Chilena).

As the next step, potential locations for hydrogen hubs are identified within the hydrogen valleys. A list of criteria will be developed including the potential for green hydrogen production, transportation, utilization, and export. The potential for green hydrogen production is essentially linked to the potential for renewable electricity production. Additionally, water supply to hydrogen production by electrolysis, both for cooling purposes and for feeding the water splitting reaction, will be considered, taking into account existing facilities for seawater desalination and related infrastructure. Energy transportation, both of electricity for feeding electrolysis, and of hydrogen towards national consumption centers and to export facilities (ports) will be covered. Export facilities notably relate to ports from where ships would transport hydrogen to markets in Asia, North America and Europe. The criteria will be validated with the MoE and the IDB. This set of criteria will then be applied to potential locations to identify hydrogen hubs for this study.

1.3.2 Development pathways of H_2 hubs

The potential domestic demand has been evaluated and projected until the year 2050 in the GHS for the whole of Chile. Additionally, the GHS has identified enormous opportunities for the export of H_2 and derivatives to the world markets. The development of H_2 hubs will ensure covering domestic demand at all times and will tap opportunities for export.

The development pathways for the H_2 hubs will thus be designed along the lines of the GHS by estimating domestic demand related to each of the two H_2 hubs in a first step, and by estimating the export quantities provided by each of the H_2 hubs in a second step.

The hydrogen production volumes in each of the two H_2 hubs sufficient to serve the identified domestic and export demand will be the basis for the two H_2 hub development pathways.

1.3.3 H_2 hub development indicators

Based on the H_2 production volume estimates in 5-years intervals up to 2050 of the previous steps, the development indicators will be estimated. Assumptions made will be validated with the MoE and the IDB. As a result, relevant development indicators will be estimated for each H_2 hub, including electrolyzer installed capacity and footprint, renewable energy installed capacity and footprint, desalination capacity and footprint, high voltage electricity line capacity and length, electricity substation capacity and footprint, H_2 storage footprint and volume, NH_3 production capacity and footprint, NH_3 storage footprint and jetties, LH_2 storage capacity and footprint, LH_2 liquefaction capacity, LH_2 tank storage, number of hydrogen refueling stations (HRS), trailers required to supply the HRS, rail cars and trains, length of new pipelines, roads and railways.

As a result, conceptual figures of the development pathway of each H_2 hub clearly describing the quantitative sizing of infrastructure and installation development in 5-year intervals, from 2025 to 2050, will be available.

Referential locations of installations and infrastructure will be made provided on an exemplary basis and will be visualized on local maps of the H_2 hubs, guided by infrastructure and RES potential.

1.3.4 Macroeconomic impacts: Investments, tax revenues, company and employment structure, job creation

On the basis of the conceptual figures achieved for the H_2 hubs, relevant financial indicators will be estimated over time up to 2050 allowing to calculate the required investments broken down by value chain element and by region.

Tax revenues are estimated based on current regulations relevant to hydrogen hub projects and their derivatives in Servicio de impuestos internos – SII (Internal Revenue Services of Chile). Relevant bases are the estimated hydrogen production volumes over time, and the anticipated hydrogen production costs. Furthermore, import duties and contribution to regional development tax provisions are taken into account.

In order to establish the regional status quo of economic activity and the labor market, regional economic activity will be characterized based on the current structure of businesses and employment in the selected two regions. The collection of the information includes most notably publicly available statistics.

Job potentials of the identified investments will be assessed based on literature values for employment factors for Chile of the relevant elements of the value chain. This includes construction-related job and operation & maintenance-related jobs as well as indirect jobs.

1.3.5 Regulatory restrictions and challenges

Research will be carried out on the national regulations in relation to urban and regional regulatory and construction plans that are relevant to hydrogen hubs. Most notably, territorial planning instruments that govern the areas of interest in this study, in the regions of Antofagasta and Magallanes, will be identified for the assessment of regulatory challenges the development of H_2 hubs may be facing.

1.3.6 Environmental, archaeological, heritage and cultural profile

The environmental profile of the municipalities of Mejillones, Antofagasta and Punta Arenas, Magallanes, will be developed considering environmental aspects of flora & fauna and vegetation, archaeological or heritage sites, and relevant cultural activities or sites.

For all these areas, a general analysis will be made based on secondary sources of information, and conclusions will be drawn on the existence of relevant aspects to take into account in the development of H_2 hubs in the defined locations.

1.3.7 Opportunities of growth for the regions

The different parts of the hydrogen value chain from renewable electricity production to domestic consumption or to export will be evaluated to identify opportunities to utilize local industry resources or project the production needed to meet the requirements of the development pathways studied.

Also, certain elements of the supply chains will be analyzed for which it might be advisable to build up local or national supply, as for example in the case of water supply from a desalination plant or the manufacturing of electrolyzers.

For this analysis, meetings will be held with the regional authorities of Antofagasta and Magallanes, with the participation of their respective Regional Governments and Ministerial Energy Secretariats. Inputs gathered from these exchanges will be taken into account in determining the opportunities for the development of local value and growth of the region in the implementation of the H_2 hubs.

1.3.8 Recommendations

Recommendations for action at national, regional and local government levels to mitigate the risks arising from the outlined challenges, as well as to capture the outlined opportunities will be developed based on the results achieved in the course of the study.

2 EVALUATION OF POTENTIAL LOCATIONS

2.1 Definition of terms

This study aims to develop a pathway for the deployment of "hydrogen hubs" in Chile. A definition of relevant terms is provided in the following paragraphs to align with previously published studies [FCH 2 JU 2021], [SA 2021], [ISPT 2020] and state clearly how such terms are used in this study.

H_2 Hub:

The term H_2 hub comprises the electrolyzers, electricity substation, H_2 storage, loading facilities, compressors, derivative production, port facilities, industrial roads & easements, transportation facilities and the like. It refers to a compact industrial complex, with the aim to reduce transport distances and tap economies of scale.

H_2 Valley:

The term H_2 valley covers a larger geographic area and may comprise one or several H_2 hubs, including the renewable energy production. Due to the nature of solar and wind energy plants, these usually spread out with considerable land-use and are best placed in locations with high potential capacity factors.

H_2 Nucleus:

The term H_2 nucleus is introduced here to specifically describe the H_2 hub in its starting years, which in the case of Chile is planned to be around 2025.

H_2 Satellite:

In some cases, decentralized production of H_2 makes sense to avoid, for example, long-distance H_2 transport or allow stakeholders to choose a preferred site. The term satellite, hence, describes smaller scale H_2 production facilities. A satellite may be related to an H_2 hub, where the distance is moderate.

H_2 Corridor:

A corridor is an H_2 hub stretched out along an axis with several individual locations with synergies such as being close enough together to allow for service companies to serve both locations, reducing the electrical grid infrastructure, reducing hydrogen transport distances, notably for domestic consumption, etc.

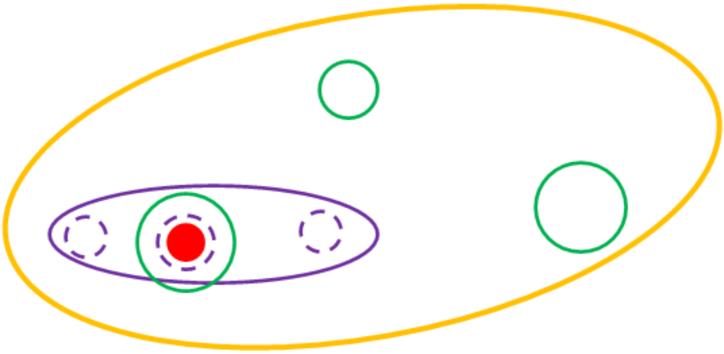

Figure 1: Definition of terms – schematic

Figure 1 gives a schematic representation of the terms: The H_2 valley (yellow) includes several H_2 hubs (green). The corridor (purple) is elongated along one axis and includes the nucleus (red) for at least one H_2 hub (green), with several potential locations for satellites (dashed purple).

2.2 Identification of regions as H_2 Valleys

Chile has two of the best areas for renewable energy generation in the world. The Atacama Desert stretching several administrative regions in the north of Chile provides a combined solar energy potential of over 1,400 GW allowing for world-leading capacity factors, while the Magallanes region reaches a total on-shore wind potential of 130 GW allowing for world-leading capacity factors.

The GHS concluded that these renewable energy sources (RES) potentials will lead to world-record levelized costs of energy. As a consequence, also the levelized costs of H_2 production are projected to reach around 1 USD/kg_{H2} by 2030.

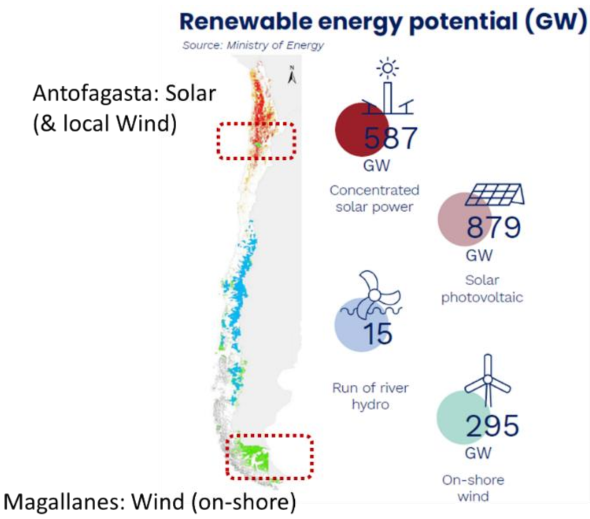

Figure 2: Renewable electricity potentials in Chile, according to the National Green Hydrogen Strategy (GHS)

As large areas of this renewable energy potential lie in the administrative regions of Antofagasta (II) and Magallanes (XII), they are perfectly suited for the establishment of H_2 valleys. By tapping the economies of scale, the GHS projects enormous potential for export of green H_2 and its derivatives. The Antofagasta H_2 valley adds the advantage of high domestic demand from fertilizer and mining industries. Therefore, the H_2 hub will start-off as Archetype 2[1], as defined by [FCH 2 JU 2021] and with growing export opportunities further is set to develop into Archetype 3[2]. In contrast, the Magallanes H_2 hub will likely be export focused and thus of Archetype 3, as defined by [FCH 2 JU 2021].

By selection of the Antofagasta and Magallanes region other administrative regions in Chile are not excluded from the emerging hydrogen economy. Especially in areas of high industrial density, another H_2 hub may develop and providing green H_2 without the additional costs of H_2 transport over longer distances.

2.3 H_2 Hub Nucleus in Antofagasta: Decision matrix

In Antofagasta three potential locations were analyzed in more detail: Tocopilla, Mejillones and Taltal, all of which have overseas ports making them eligible for export of H_2 derivatives.

In order to narrow down the potential locations for the implementation of H_2 hubs within the identified regions, factors belonging to six categories were analyzed. The categories comprised infrastructure (e.g. ports or electricity grid), domestic demand (e.g. proximity to ammonia end users), scaling opportunities (e.g. potential synergies for desalination), local capacities (e.g. availability of skilled workers and academics) and hazards (e.g. the assumed experience regarding handling of high risk products). Moreover, the sixth category comprises the status of currently developed projects. All potential locations in Antofagasta were categorized in either very good, good or fair with regards to each factor, and the best location was marked with an asterisk, where applicable (Table 2). No quantitative thresholds were defined, due to a focus on relative comparison of the different potential locations.

In Figure 3 the basis for the assessment in Table 2 is provided. Additionally, we used publicly available information on solar and wind potentials[3], RES projects[4] as well as data provided on Chilean government websites, on e.g. regulatory intercommunal plans (PRIs)[5].

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1 Local, medium-scale & industry-focused: Local hydrogen production projects centered around 1-2 large off-takers as "anchor load" (industry or energy sector, e.g. refineries), smaller mobility off-takers as add-on; Making use of existing infrastructure around industrial plants, often replacing grey H_2 supply; Mostly led by private sector.

2 Larger-scale, international and export-focused: Large-scale projects with low-cost production, ultimately aiming for long-distance hydrogen transport to large off-takers abroad (but typically starting with local supply); Focus on connecting supply and demand internationally; Mostly led by private sector

3 https://globalsolaratlas.info/map and https://globalwindatlas.info/

4 https://acera.cl/mapa/#/map

5 https://ide.minvu.cl/datasets/9b91533e9a2942f897ea6b62b7e64a49/explore

Table 2: **Decision matrix for a potential nucleus location in the Antofagasta region**

Category	Factor	Mejillones	Taltal	Tocopilla
Infrastructure	Port	very good ★	good	very good
Infrastructure	Train connection	very good ★	fair	fair
Infrastructure	Proximity to high capacity factor PV	very good	good	very good ★
Infrastructure	Proximity to high capacity factor wind	good	very good ★	fair
Infrastructure	Electricity grid	very good ★	good	very good
Infrastructure	Gas grid	good ★	fair	good
Infrastructure	Airport	very good ★	fair	fair
Domestic demand	Proximity to local demand mining	very good ★	good	very good
Domestic demand	Proximity to local demand ammonia	very good ★	good	good
Domestic demand	Proximity to bus/HDT	good	good	good
Scaling opportunities/synergies	Industrial development zone, PRI (ecorisk zones, ZEICs)	very good ★	fair	fair
Scaling opportunities/synergies	Synergies with local industry thermoelectric plants	very good ★	good	very good
Scaling opportunities/synergies	Synergies with local industry desalination	very good ★	good	good
Local Capacities	Skilled workers and academics	very good ★	good	good
Local Capacities	Availability of service companies	very good ★	good	good
Hazards	NH3 crash or similar, amount of affected persons	good ★	good	fair
Hazards	Industry with experience / "ecosystem" for high risk products	very good ★	fair	good
Project development	HyEx	good	fair	very good ★
Project development	San Pedro de Atacama	good ★	fair	good
Project development	HOASIS	good ★	fair	fair

Legend: very good | good | fair best: ★

Mejillones was identified to offer the best opportunities for establishment of the H_2 hub nucleus. All major criteria are met or reach at least medium quality. However, we have to emphasize that this is a preliminary assessment, which cannot replace a detailed and thorough assessment including further factors. The purpose of this study is to identify a suitable potential H_2 hub, and lay out a plausible development pathway for it, which may be transferred to other potential locations. It should be highlighted that an H_2 Corridor may also be a suitable concept for the Antofagasta region, which is developed in section 2.5 below.

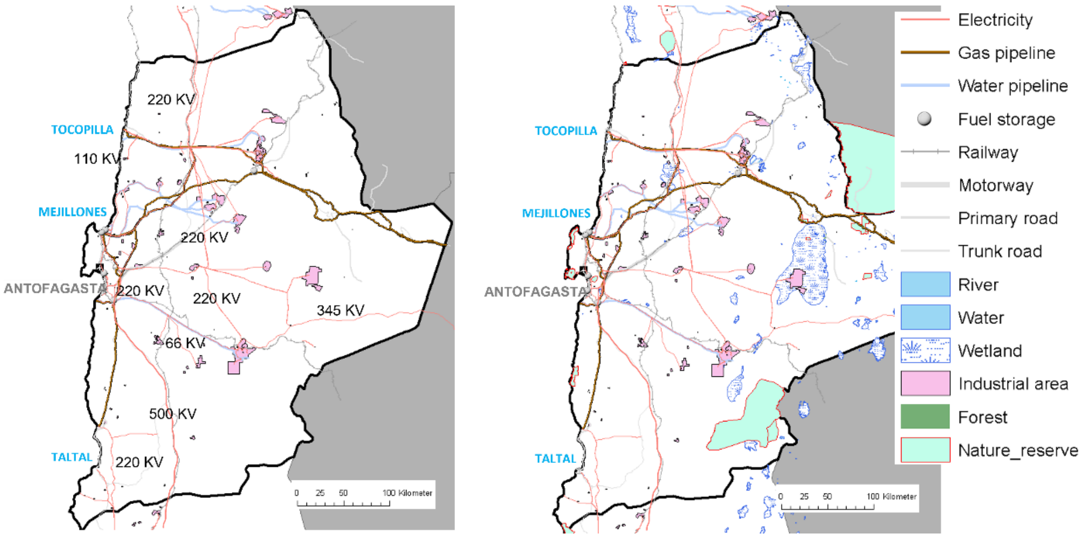

Figure 3: **Antofagasta region: industrial infrastructure (left), plus land-use (right)**

2.4 H_2 Hub Nucleus in Magallanes: Infrastructure overview

Infrastructure data for the Magallanes region are provided in Figure 4. Here, the region around and north of the bay between Cabo Negro in proximity to Punta Arenas, the largest city in Magallanes, and San Gregorio along the Strait of Magellan offers the best opportunities for the H_2 hub nucleus. All other locations can be excluded for the purpose of this study, either due to their remoteness or other factors, such as natural reserve areas or lower expected wind capacity factors.

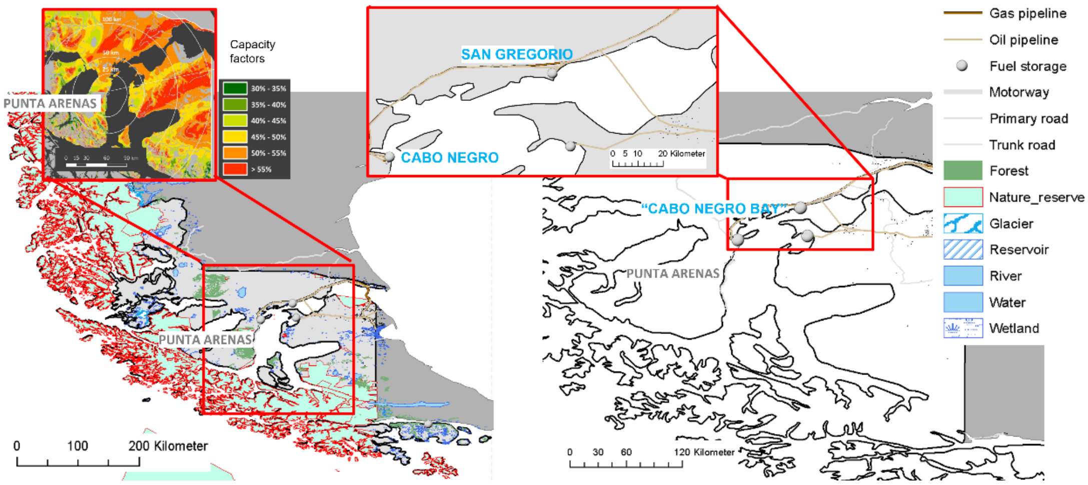

Figure 4: Magallanes region: Land-use (left) and Wind capacity factors (inset, [MoE 2021]) and infrastructure details between Cabo Negro and San Gregorio(right and inset)

2.5 Consideration of corridors in Antofagasta

In order to also consider the potential combination of different sites we further considered the concept of a corridor. In Table 3 various pros and cons of a corridor along the coast are collected.

While corridors offer some advantages with regards to regional participation, these may be outweighed by the expected export orientation of the hubs. The centralization of H_2 and subsequent derivatives (NH_3, etc.) production are essential to reach the economies of scale and thus the goals defined in the GHS. However, if the rather expensive, large-scale transport of H_2 is required to provide H_2 to all regions in Chile, the targeted price of below 1.5 USD/kg$_{H2}$ will not be met. Therefore, a balance between centralization, notably for export, and decentralization, notably for domestic consumption, needs to be struck. Importantly, the renewables' production, being by far the most land intensive part of potential H_2 valleys, will be spread over a large area in Antofagasta.

It is thus most feasible to start developing the H_2 hub at a specific location and incorporate smaller satellites, where applicable. Especially the potential location of Tocopilla might be such a satellite and could be connected to the Mejillones hub through ammonia transport (cf. HyEx project).

Table 3: Pros and cons of an H_2 corridor in Antofagasta

Pro	Con
+ Distance **Tocopilla – Mejillones** (130 km) may allow for some synergies, cf. HyEX project (transport of derivatives instead of H_2)	– Distance **Taltal – Mejillones** (300 km) too large for synergies
+ **Regional development / Synergies** More than one industrial area covered, several locations get „share of the cake"	– **Critical mass** Critical mass for self-sustaining development may only be achieved later
+ **Regional development / energy transition from fossil to sustainable** Phasing out of thermoelectric coal plants in more than one location in the Antofagasta region, thus better „reuse" of existing infrastructure and skilled workers	– **Decentralization** Higher regulatory/ administrative effort
+ **Regional participation / Synergies** Higher acceptance in population of the wider area	– **Regional participation** PV/ CSP/ Wind production will be spread out anyway to tap best resource opportunities
+ **Project development** Companies can develop projects at their own favorite location	– **Infrastructure** Higher infrastructure requirements: more substations, HV lines, water pipelines, etc.
+ **Local capacities** Depending on size, one location may not be able to provide enough skilled workers or service companies	– **Scaling opportunities - Electrolysis and Derivatives synthesis** electrolysis has scaling characteristics, NH_3 synthesis even stronger; „RES-to-X" efficiency drops because of local H_2 storage and transport vs. direct further processing
+ **Domestic demand** Also smaller, decentralized consumers may be convered	– **Scaling opportunities - Export** Scaling is essential to meet world market price, higher export volume than domestic
	– **Hazards** Ecological & health risks more difficult to assess, risk area larger, potentially affected population larger

The decision matrix in Table 2 indicates a number of strengths for Tocopilla, notably the proximity to high-capacity solar PV potentials, which relate, among others, to the Maria Elena solar PV development area ("polo de desarrollo"). This proximity could significantly reduce the length of new electricity lines compared to a single H_2 Hub in Mejillones, in addition to further opportunities.

Also, Taltal has strengths including the proximity to high-capacity wind potentials. Combining solar with wind power would further allow increasing the utilization factor of electrolyzers providing for a welcome economic advantage.

3 H2 Production by Valley

3.1 Domestic demand

The potential domestic demand has been evaluated and projected until the year 2050 in the GHS for the whole of Chile. In an accelerated case, through strategic policy making, significant numbers are to be expected before the year 2030. Especially six prioritized sectors are projected to break-even in the next decade and thus create the basis for the development of the H_2 hubs. These prioritized sectors are Heavy Duty Trucks and Buses/Coaches (both for long distance purposes), copper-mining trucks (CAEX), ammonia use in the fertilizer and explosives industry, replacement of grey H_2 in oil refineries as well as gas blending into residential grids. Other sectors, such as shipping and aviation, are not yet ready to implement H_2 technologies and thus will not create significant demand in the mid-term. For this study, we therefore focused on the evaluation of the domestic demand in the prioritized sectors consistent with the GHS.

The transport of H_2 is adding significantly to the achievable market price, as stated in the GHS for the export case and also known for domestic transport [e.g. DeliverHy 2013]. It is thus important to evaluate the fraction of domestic demand expected for each of the prioritized sectors on a regional level. To approach this, we assumed probable indicators correlating with each of the prioritized sectors. Heavy Duty Trucking correlates with the overall gross domestic product (GDP) by region, while personal transport in buses and coaches correlates with the population density. Copper-mining trucks are used for the transport of the copper ore within the mines and their expected H_2 demand thus correlates with the location and yearly extraction volume of the copper mines. Ammonia use in Chile is correlated strongly with the company ENAEX and their production site(s). Use of H_2 in refining processes correlates with the overall crude oil amounts processed at the respective sites and gas blending, again, correlates with the population density.

All indicators are to be understood as approximates and may vary in detail.

The selected regions of Antofagasta and Magallanes are compared with a central region (see Table 4), taking together all other regions. The center thus includes, for example, the large industrial areas around Santiago de Chile. It is likely that another H_2 hub may develop there, mostly serving a domestic market, its development pathway is, however, out of the scope of this study. Recently, industry stakeholders have announced green H_2 production in Valparaíso.[6] and also the MoE’s recent update on the long-term energy planning include H_2 hubs in Valparaíso and Biobío [PELP 2021].

Table 4: Correlating indicators for division of the projected demand by region

Prioritized sector	Correlating indicator	Percentage	“Region”
Heavy Duty Trucks	GDP per region	89 %	Center
		10 %	Antofagasta
		1 %	Magallanes
Buses / Coaches	Population density per region	95 %	Center
		4 %	Antofagasta
		1 %	Magallanes
Mining copper –	Copper mined	25 %	Center

[6] https://www.gnlquintero.com/2021/12/13/proyecto-hidrogeno-verde-bahia-quintero-logra-acuerdos-de-entendimiento-con-empresas-de-la-region-de-valparaiso-por-el-70-de-su-produccion-inicial/; last accessed: 23. December 2021.

Prioritized sector	Correlating indicator	Percentage	"Region"
Trucks	per region	75 %	Antofagasta[(a)]
		0 %	Magallanes
Ammonia	ENAEX	0 %	Center
		100 %	Antofagasta
		0 %	Magallanes
Oil refineries	Amount of crude oil processed per region	82 %	Center
		0 %	Antofagasta
		18 %	Magallanes
Gas blending	Population density per region	95 %	Center
		4 %	Antofagasta
		1 %	Magallanes

(a) Including mining activities in Tarapacá and Atacama.

3.1.1 Antofagasta

The results for the Antofagasta region obtained by application of the described indicators are listed in Table 5.

Table 5: Domestic H_2 demand for the Antofagasta region in thousand tons / year based on the GHS

Prioritized applications as defined in GHS	Antofagasta – Domestic H_2 demand in thousand tons / year					
	2025	**2030**	**2035**	**2040**	**2045**	**2050**
	33	***181***	***681***	***828***	***9242***	***1,024***

Most prominently the ammonia demand is identified as a key factor in successfully developing the H_2 hub of Antofagasta. Being the largest single point consumer of H_2 in Chile until 2035, the ENAEX plant in Mejillones will play a crucial role in rolling out the H_2 hub of Antofagasta. Relatively advanced projects published in the context of H_2 hubs in Antofagasta confirm this approach. Prominently, the HyEx project aims to provide NH_3, produced in Tocopilla, to the ENAEX plant already by the year 2025.[7]

Not surprisingly, the mining sector will create the largest H_2 demand by 2030 and will, by far, be the biggest consumer of H_2 in 2050 in Antofagasta (for this analysis, mines close to Antofagasta, in the Tarapacá and Atacama region were added to the potential demand).

Gas blending data included here are to be understood as a low-end consumption scenario as they exclude gas consumption in power plants, which roughly represents some 50% of gas

[7] HyEx project: https://renewablesnow.com/news/engie-enaex-plan-green-hydrogen-to-ammonia-projects-in-chile-751727/; last accessed: 23. December 2021.

consumption in Chile. Recently, the MoE and GIZ published a report stating that gas-powered thermoelectric plants may run on a 5% H_2 in natural gas mixture without any further hardware modifications. [GIZ 2021] This would create significant further demand in Antofagasta, with gas power blocks with a combined generation capacity of above 2,000 MW installed. [GIZ 2021]

Additional demand may also emerge from other sources. The GHS discusses aviation applications for synfuels, container ship propulsion and construction industry. Conceivable are also application in FCEVs, such as passenger cars and fork lifts. The respective technologies are, however, likely not commercially available before the mid of the next decade. Yet, if the demand rolls-out from 2035 on, it can be expected to find an additional domestic demand in Antofagasta of up to 400,000 tons H_2 per year in 2050, starting at 50000 tons H_2 in 2035. These numbers are based on the current trade and passenger volume of Antofagasta’s port and airport, as well as the indicators used before (GDP per region, and population density).

3.1.2 Magallanes

The results for the Magallanes region obtained by application of the described indicators are listed in Table 6.

Table 6: Domestic H_2 demand for the Magallanes region in thousand tons / year based on the GHS

Prioritized applications as defined in GHS	Magallanes – Domestic H_2 demand in thousand tons / year					
	2025	**2030**	**2035**	**2040**	**2045**	**2050**
	7	***15***	***24***	***28***	***30***	***31***

It becomes clear that no large H_2 demand is expected for the Magallanes region. The largest potential consumer identified is the ENAP refinery at San Gregorio, not exceeding a consumption of 20,000 tons / year in 2050. Moreover, the largest application area of H_2 in refining is the desulfurization process, which strongly depends on the quality (sulfur content) of used crude oil input and desired product quality and may thus vary to even smaller absolute amounts required in Magallanes. Only the Methanex plant at Cabo Negro may potentially represent a significant domestic H_2 demand for producing green methanol (for export nonetheless) and thus add significantly to the currently projected demand, if the stakeholders are ready to invest into an adaptation of the currently applied processes. Assuming a complete transition of the current yearly production of about 2 million tons of methanol, this would reach up to 400,000 tons of additional yearly H_2 demand.

Further demand projected for the Magallanes region in the sectors given for Antofagasta will remain below 15,000 tons H_2 until 2040, but then may exceed the currently projected demand with close to 58,000 tons H_2 additional demand in 2050; mostly through application of synfuels in the aviation sector. These numbers are, similar to Antofagasta, based on the current trade and passenger volume of Punta Arena’s port and airport, as well as the indicators used before (GDP per region, and population density). Potentially, further demand emerges from the additional shipping traffic caused by the H_2 hub and supply of isolated grids through fuel cell or synfuel technologies.

3.1.3 Conclusions from regional division of domestic demand

The two H_2 hubs of Antofagasta and Magallanes will develop around the largest single point consumers, respectively. In order to satisfy the domestic H_2 demand from the start, the created H_2 hub capacities (i.e. electrolysis) at least should cover the demand identified for the year 2025. Especially in Antofagasta, the relatively spread-out mining sector may additionally lead to the creation of satellites, if H_2 transport costs exceed the assets required to establish a smaller H_2 production facility on site. Furthermore, production driven satellites will appear, where project stakeholders prefer another location over Mejillones Bay. An example for this is the HyEx project, which plans to transport green ammonia from Tocopilla to the ENAEX plant.[8]

3.2 Export

The domestic H_2 demand plays a significant role for the development of the H_2 hub nuclei and is to be covered by the hubs permanently. Additionally, the GHS has identified enormous opportunities for the export of, first, H_2 derivatives (i.e. NH_3, methanol, etc.) and, second, a subsequent roll-out of liquid H_2 (LH_2) export on the world market. The world-record capacity factors for both solar and wind plants are creating very low levelized costs of energy and hence H_2, especially in the two regions localized in this study. The overall H_2 export activities will thus almost exclusively be covered by the hubs in Antofagasta and Magallanes. To understand which relative fraction of export will be covered by each of the two H_2 hubs respectively, two different scenarios were applied.

For the sake of simplicity, the focus here is on ammonia and liquid hydrogen in these scenarios. However, this does not imply any preference for these compared to methanol or synfuels. Both ammonia and liquid hydrogen quantities could be substituted by equivalent quantities of methanol or synfuels. A detailed assessment differentiating between different types of derivatives is not a focus here.

In one assumption scenario the targeted market share (as calculated in the GHS) is divided between Antofagasta and Magallanes based on known project stakeholders, e.g. Total EREN and Siemens in Magallanes and e.g. Engie in Antofagasta, as well as transport distances to the oversea destination ports (Table 7). Note, this division between the regions may fluctuate strongly and is to be read as an approximation.

[8] HyEx project: https://renewablesnow.com/news/engie-enaex-plan-green-hydrogen-to-ammonia-projects-in-chile-751727/; last accessed: 23. December 2021.

Table 7: Assumption scenario 1 – Breakdown between Antofagasta and Magallanes of hydrogen production for the different target markets, based on involved stakeholders and distances to destination ports

	Antofagasta	Magallanes
Europe	50%	50%
LATAM	50%	50%
USA	100%	
China		100%
Japan		100%

In another assumption scenario the division between Antofagasta and Magallanes is based on the respective overall renewable energy potential (Table 8).

Table 8: Assumption scenario 2 - Division of target markets between Antofagasta and Magallanes, based on RES potential

	RES potential (GW)	Capacity factor	Target market share
Antofagasta	1288	35% (solar)	88%
Magallanes	130	50% (wind)	12%

3.2.1 Antofagasta

Application of the different scenarios on the absolute export potential as defined in the GHS, results in absolute amounts as listed in Table 9 and Table 10.

Table 9: Antofagasta, assumption scenario 1 - Absolute H_2 export potential of NH_3 and LH_2 for both the low and high export scenario (GHS), based on involved stakeholders and distances to destination ports

Export	Antofagasta – H_2 export in thousand tons / year					
	2025	**2030**	**2035**	**2040**	**2045**	**2050**
Ammonia – low GHS scenario	38.13	320.66	647.57	739.29	802.28	870.92
Assumed % of total	42%	41%	41%	41%	41%	42%
Ammonia – high GHS scenario	67.29	564.54	1,137.13	1,295.67	1,404.38	1,524.03
Assumed % of total	40%	40%	40%	40%	40%	41%
LH_2 – low GHS scenario	0.00	46.17	518.40	697.09	786.00	883.49
Assumed % of total	0%	51%	47%	42%	37%	32%
LH_2 – high GHS scenario	0.00	126.03	1,775.77	2,996.11	4,238.25	5,976.16
Assumed % of total	0%	31%	33%	34%	34%	35%

Table 10: Antofagasta, assumption scenario 2 - Absolute H_2 export potential of NH_3 and LH_2 for both the low and high export scenario as described in the GHS, based on RES potential

Export	Antofagasta – H_2 export in thousand tons / year					
	2025	**2030**	**2035**	**2040**	**2045**	**2050**
Ammonia – low GHS scenario	64.31	547.74	1,102.68	1,254.45	1,355.97	1,465.48
Assumed % of total	70%	70%	70%	70%	70%	70%
Ammonia – high GHS scenario	117.18	999.32	2,000.19	2,263.77	2,436.07	2,623.21
Assumed % of total	70%	70%	70%	70%	70%	70%
LH_2 – low GHS scenario	0.00	63.53	776.80	1,159.36	1,483.04	1,937.46
Assumed % of total	70%	70%	70%	70%	70%	70%
LH_2 – high GHS scenario	0.00	280.11	3,813.76	6,250.15	8,625.81	11,910.35
Assumed % of total	70%	70%	70%	70%	70%	70%

3.2.2 Magallanes

For the Magallanes region application of the different scenarios on the absolute export potential as defined in the GHS, results in absolute amounts as listed in Table 11 and Table 12.

Table 11: Magallanes, assumption scenario 1 - Absolute export potential of NH_3 and LH_2 for both the low and high export scenario as described in the GHS, based on involved stakeholders and distances to destination ports

Export	Magallanes – H_2 export in thousand tons / year					
	2025	2030	2035	2040	2045	2050
Ammonia – low GHS scenario	53.75	461.83	927.68	1,052.77	1,134.82	1,222.62
Assumed % of total	58%	59%	59%	59%	59%	58%
Ammonia – high GHS scenario	100.12	863.05	1,720.29	1,938.28	2,075.72	2,223.41
Assumed % of total	60%	60%	60%	60%	60%	59%
LH_2 – low GHS scenario	0.00	44.59	591.30	959.14	1,332.63	1,884.31
Assumed % of total	0%	49%	53%	58%	63%	68%
LH_2 – high GHS scenario	0.00	274.13	3,672.46	5,932.67	8,084.33	11,038.63
Assumed % of total	0%	69%	67%	66%	66%	65%

Table 12: Magallanes, assumption scenario 2 - Absolute export potential of NH_3 and LH_2 for both the low and high export scenario as described in the GHS, based on RES potential

Export	Magallanes – H_2 export in thousand tons / year					
	2025	2030	2035	2040	2045	2050
Ammonia – low GHS scenario	27.56	234.75	472.58	537.62	581.13	628.06
Assumed % of total	30%	30%	30%	30%	30%	30%
Ammonia – high GHS scenario	50.22	428.28	857.23	970.19	1,044.03	1,124.23
Assumed % of total	30%	30%	30%	30%	30%	30%
LH_2 – low GHS scenario	0.00	27.23	332.91	496.87	635.59	830.34
Assumed % of total	30%	30%	30%	30%	30%	30%
LH_2 – high GHS scenario	0.00	120.05	1,634.47	2,678.63	3,696.77	5,104.44
Assumed % of total	30%	30%	30%	30%	30%	30%

3.2.3 Conclusions from the export scenarios

Already in the early stages of H_2 hub development, export is expected to play a significant role in Antofagasta. Only for the low export scenario, based on the involved stakeholders and distances to destination ports (Table 9), ammonia export will remain on the order of domestic ammonia demand until 2050. All other scenarios show that export of NH_3 exceeds the domestic demand significantly already during the early years of H_2 hub development and thus emphasizes the importance of export infrastructure, even in Antofagasta.

As discussed before, the Magallanes region does not supply H_2 to large domestic consumers. Considering the large export potential from the region, however, the development of an H_2 hub with export focus remains a crucial point in the roll-out of the GHS. Moreover, several large-scale export projects have been announced with commissioning dates before 2030.

Table 13: Combined H_2 demand for Magallanes and Antofagasta, for the GHS low export scenario and the export assumption scenario 1

	H_2 combined export and domestic demand in thousand tons / year					
	2025	**2030**	**2035**	**2040**	**2045**	**2050**
Domestic (Antofagasta)	33.15	180.66	681.40	828.36	923.62	1,023.74
Export from Antofagasta (NH_3)	38.13	320.66	347.57	739.29	802.28	870.92
Export from Antofagasta (LH_2)	0.0	46.2	518.4	697.1	786.0	883.5
Sum (Antofagasta)	**71.3**	**547.5**	**1,547.4**	**2,264.7**	**2,511.9**	**2,778.2**
Domestic (Magallanes)	7.03	15.17	23.75	28.46	30.04	31.46
Export from Magallanes (NH_3)	53.75	461.83	927.68	1,052.77	1,134.82	1,222.62
Export from Magallanes (LH_2)	0.00	44.59	591.30	959.14	1,332.63	1,884.31
Sum (Magallanes)	**60.78**	**521.59**	**1,542.73**	**2,040.37**	**2,497.49**	**3,138.39**

As soon as technology for safe and cost-effective transport of LH_2 becomes relevant on a large-scale (at the beginning of the next decade), additional capacities emerge from LH_2 production. Especially in the high export scenarios, these capacities would become the most important pillars for the H_2 hubs. Due to the major uncertainties with regards to the development of the LH_2 market, however, the H_2 hubs are expected to primarily focus on H_2 derivatives, such as NH_3 or methanol, in the early phases. While the GHS does not provide exact projections for other H_2 derivatives such as synthetic fuels, these may become an important additional product provided by the H_2 hubs to the world markets. Prominently, the HIF project[9] in Magallanes plans to export green methanol in the order of 750,000 liters per year by 2022, reaching 1,000,000 liters per year in 2026.

Table 13 summarizes the combined export and domestic demand to be expected for the two H_2 hubs in the Antofagasta and the Magallanes region.

4 H_2 HUB DEVELOPMENT INDICATORS

In a first step we calculated the required electrolyzer capacities. For this it was assumed that these run at 70% efficiency (related to the lower heating value) and with renewable electricity only. The respective capacity factors applied are listed in the respective subchapters. The required H_2 output is based on the results of the low export GHS scenarios plus the regional domestic demand obtained for Antofagasta and Magallanes, respectively. We did not specify the electrolyzer type (alkaline vs PEM), yet expect that the H_2 hub will be run on a combination of both technologies, thus taking advantage of the flexibility of PEM and the robustness of alkaline electrolyzers. It is conceivable that the PEM electrolyzers are used to mitigate fluctuating energy supply and ramp-up, and alkaline electrolyzers only run during stable electricity provision times.

In a subsequent step we assumed that the installed solar and wind capacities are in line with the recently published “National Plan for the Promotion of Green Hydrogen Production in public land” [MoNA 2021], which is requiring the installation of a 2:1 ratio of RES capacity to installed electrolyzer capacity. The capacity given through this regulatory framework easily covers the complete additional energy consumption of the H_2 hub, caused by ammonia synthesis, gas compression, air separation, desalination, and in the future H_2 liquefaction. A detailed optimization of installed RES capacity vs. electrolyzer capacity is out of scope of this study, but may reduce the PV and wind footprint considerably.

Based on the obtained RES values, it was possible to deduce a maximum or worst-case requirement of HV lines to be installed, if the required RES potential is installed only in separated 500 MW solar parks at maximum distance from the H_2 hub. Through intelligent grid design these requirements can be optimized. Especially if the renewable energy production is clustered, the required HV line assets can be decoupled from the RES production growth. For example, mega solar parks will likely use higher voltage lines, than the currently assumed 220 kV and thus increase the nameplate capacity per installed HV line kilometer. A detailed grid capacity analysis will be required to determine a threshold for higher voltage HV lines.

For water consumption, we assumed that only process water is to be provided by desalination plants, any cooling water will be provided through once-through pumping of sea water. The process water needed includes all processes present at the H_2 hub. In the first years the relatively small amount of water will likely be covered through spare capacities of

[9] https://www.haruoni.com/#/en; last accessed: 23. December 2021.

the desalination plants already existing. As soon as the water consumption exceeds these assumed spare capacities, the H_2 hub will get its own desalination plant.

To assess the amount of NH_3 produced and thus the required production capacities, we calculated the percentage of H_2 projected for derivative production. For example, in the year 2025 93% of H_2 produced in the Antofagasta H_2 hub is used for NH_3 production. With the emergence of LH_2 export and demand from mines, this figure drops to 36% of total H_2 produced in 2050.

Noteworthy, the ammonia production is a continuous process (if the Haber-Bosch process is used). The provided H_2 should thus be available reliably and adequate temporary H_2 storage is essential. We assumed as first approximation the storage of half an average daily H_2 production, which depends on the flexibility of the installed ammonia plant. It is anticipated that for an optimum operation of the ammonia production the peak output may be reduced to a base load, such that the daily H_2 production suffices to run the plant overnight [ISPT 2017, Armijo-Philibert 2020]. With growing demand for H_2 itself the continuation of the ammonia production becomes better manageable, as the ratio of installed electrolyzer to ammonia production increases significantly (from 1:1 to about 3:1).

LH_2 storage projections are based on current technology, it is, however, very likely that with the emerging global markets larger storage tanks will be developed and hence also available for the H_2 hubs in Chile. For determination of the required capacities, we assume that at least the frequency of approaching ships needs to be bridged. Ship capacities were based on currently available technology (NH_3) and projections by ship manufacturers such as Kawasaki and Hyundai for technology advances.

It is to be mentioned that the liquefaction technology requires continuous cooling and thus an on-spot fuel cell to provide energy.

For calculation of the numbers of HRS and trailers to supply the HRS, it is anticipated that with the larger amounts of FCEVs present on Chile’s roads (2035) large-scale HRS are going to be installed. Based on the assumption that the HRS will be equally distributed along the coast and the main roads in the hinterland it was possible to obtain average distance from Mejillones/San Gregorio to the HRS. Then applying current CGH_2-capacities for trailers until 2030 and subsequently LH_2-trailers, as well as eight working hours per day we determined the required trailers to supply each HRS on a daily basis.

It is assumed that by 2030 LH_2 rail cars will be available commercially, based on LH_2 technologies known for trailers.

The required modules are listed below (Table 14) with their typical capacities and footprint. For each module, an estimation of the footprint was based on literature, and reality-checked through data of currently planned or existing facilities in Chile, where available. Please note we assume that for all given modules the required piping (to collect H_2 from electrolyzers), as well as offices or electricity collection grids (at RES fields) are included, although not explicitly calculated. These numbers strongly depend on the exact lay-out of the industrial sites and need to be looked at during later stages of planning.

Table 14: Modules for development of H_2 Hub and their typical capacities and footprints

Modules	Assumptions	Capacity		Footprint	
PV	1 MWp/ha	100	MW	1,000,000	m²
Wind	0.5 MW/ha	100	MW	2,000,000	m²
Electrolyzer		100	MW	4,000	m²
Substation	220 kV – 6.9 kV	1	#/1,000 MW_{RES}	25,000	m²
HV lines Antofagasta	Max. 150 km	500	MWp/line		
HV lines Magallanes	Max. 80 km	500	MWp/line		
Desalination plant	Process water max. (25 L/kg_{H2})	1,000	L_{H2O}/sec	50,000	m²
Cooling cycle	Once-through (saline water)	2200	L/kg_{H2}	<5,000	m[(a)]
H_2 Storage (CGH_2)	1/2 day production	1	kg_{H2}	0.125-0.33	m²
NH_3 plant		3,000	t_{NH3}/day	110,000	m²
Compressor	Fully scalable	1	Compressor	25	m²
Liquefaction	Scalable	150	t/d	500	m²
NH_3 storage	one shipload	54,400	tons in max. tank size	2,500	m²
LH_2 storage	Technology will advance	170	$tons_{LH2}$	50	m²
LH_2 storage (2040)		1000	$tons_{LH2}$	-	
Export facility	NH_3 jetty	Up to 8,000	t_{NH3}/hour	500	m
Export ship (NH_3)	Largest current technology	54400	t_{NH3}/ship	80000	m³
Export ship (LH_2) 2030		1416	t_{LH2}/ship	20000	m³
Export ship (LH_2) from 2035		11326	t_{LH2}/ship	160000	m³
Trailer until 2030	@ 50 MPa	1.3	t_{CGH2}/trailer		
Trailer from 2035	LH_2	4	t_{LH2}/trailer		
Rail car	LH_2	3.5	t_{LH2}/rail car		
Train length		35	Rail cars/train		
HRS until 2030		1	t/day		
HRS from 2035		2.5	t/day		

(a) If H_2 hub is positioned at waterfront.
(b) Optional: not included in hub development projections.

4.1 Antofagasta

For our calculations only photovoltaic power generation is assumed for Antofagasta. It is, however, expected that concentrated solar[10], as well as wind power, may offer the chance to smooth out the fluctuating power supply and thus increase the utilization rate of installed electrolyzers.

Finally, 3066 full load hours (35% capacity factor) are expected to be achieved for the installed solar power plants, if they are positioned in high capacity-factor locations in the Atacama Desert.

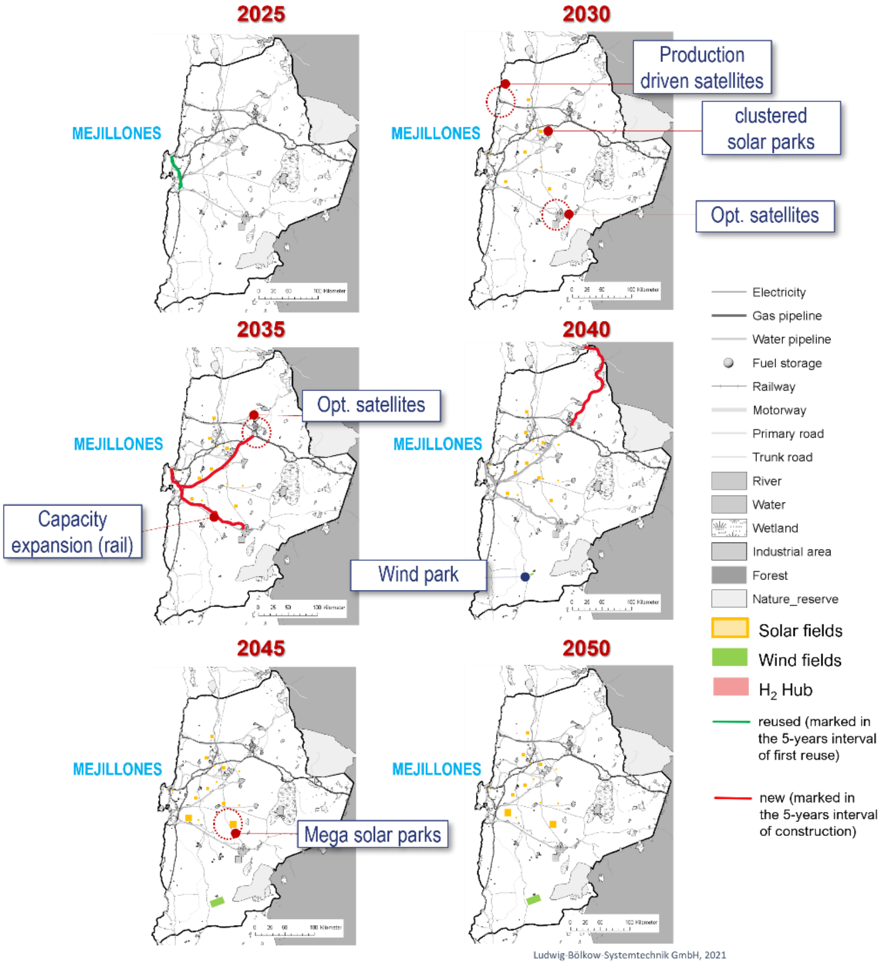

Figure 5: Schematic development pathway of Antofagasta H_2 valley, based on numbers projected in Table 15. The required footprints are drawn to scale; exact locations are, however, for illustration purpose only. Detailed images of each 5-years interval are attached in Annex A to this report

10 http://www.cspfocus.cn/en/market/detail_799.htm, last accessed on 23 December 2021.

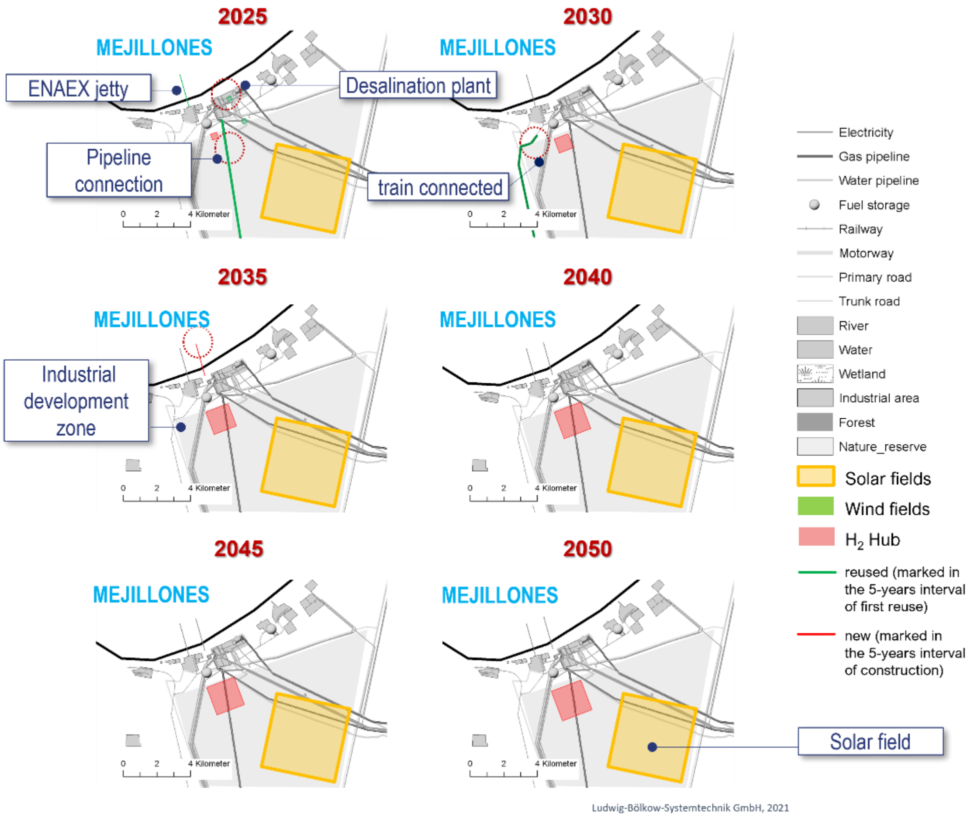

Figure 6: **Schematic development pathway of Mejillones H_2 hub, based on numbers projected in Table 15. The required footprints are drawn to scale; exact locations are, however, for illustration purpose only**

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Table 15: Development pathway for Antofagasta H_2 hub based on low GHS export scenario; assuming 70% electrolyzer efficiency and 3066 full load hours and the target market share assumption scenario 1 (reused infrastructure in green)

Module	2025		2030		2035		2040		2045		2050	
Electrolyzer	996	MW	7,653	MW	21,629	MW	31,657	MW	35,112	MW	38,834	MW
Electrolyzer footprint	39,853	m²	306,116	m²	865,176	m²	1,266,281	m²	1,404,476	m²	1,553,344	m²
Installed PV (capacity)	1,993	MW	15,306	MW	43,259	MW	63,314	MW	70,224	MW	77,667	MW
Installed PV footprint	19,926,593	m²	153,057,948	m²	432,587,963	m²	633,140,254	m²	702,237,949	m²	776,671,939	m²
H_2 output	195	tons/d	1,500	tons/d	4,239	tons/d	6,205	tons/d	6,882	tons/d	7,611	tons/d
H_2 output	71,277	tons/yr	547,488	tons/yr	1,547,366	tons/yr	2,264,740	tons/yr	2,511,903	tons/yr	2,778,153	tons/yr
Desalination	4,882	m³/day	37,499	m³/day	105,983	m³/day	155,119	M³/day	172,048	m³/day	190,284	m³/day
(capacity)	57	L/sec	434	L/sec	1,227	L/sec	1,795	L/sec	1,991	L/sec	2,202	L/sec
Desal. Footprint			50,000	m²	50,000	m²	100,000	m²	100,000	m²	150,000	m²
HV lines (capacity)	2	#/500 MWp	15	#/500 MWp	43	#/500 MWp	63	#/500 MWp	70	#/500 MWp	78	#/500 MWp
HV line length (worst case)	300	km	2,250	km	6,450	km	9,450	km	10,500	km	11,700	km
No. of Substations	1	# subs.	8	# subs.	22	# subs.	32	# subs.	35	# subs.	39	# subs.
Substation footprint	25,000	m²	200,000	m²	550,000	m²	800,000	m²	875,000	m²	975,000	m²
H_2 Storage footprint (CGH_2)	12,205	m²	93,748	m²	264,960	m²	387,798	m²	430,120	m²	475,711	m²
H_2 Storage volume (geom., 50 MPa)	29,194	m³	224,244	m³	633,782	m³	927,609	m³	1,028,844	m³	1,137,897	m³
NH_3 production (capacity)	1,028	tons/d	5,829	tons/d	6,634	tons/d	12,994	tons/d	14,203	tons/d	15,496	tons/d
NH_3 production (capacity)	375,382	tons/yr	2,127,764	tons/yr	2,421,326	tons/yr	4,742,919	tons/yr	5,183,954	tons/yr	5,655,865	tons/yr
NH_3 production footprint	110,000	m²	220,000	m²	330,000	m²	550,000	m²	550,000	m²	660,000	m²

Table 15 (cont.): Development pathway for Antofagasta H_2 hub based on low GHS export scenario; assuming 70% electrolyzer efficiency and 3066 full load hours and the target market share assumption scenario 1 (reused infrastructure in green)

Module	2025		2030		2035		2040		2045		2050	
Storage NH_3	54,400	t	54,400	t	54,400	t	54,400	t	54,400	t	54,400	t
NH_3 jetty	1	# jetties	1	# jetties	1	# jetties	1	# jetties	1	# jetties	1	# jetties
LH_2 jetty	-	# jetties	1	# jetties	1	# jetties	1	# jetties	1	# jetties	1	# jetties
Storage LH_2 (capacity)	170	t_{H2}/tank	170	t_{H2}/tank	170	t_{H2}/tank	1000	t_{H2}/tank	1000	t_{H2}/tank	1000	t_{H2}/tank
Storage LH_2 tanks	0	# tanks	8	# tanks	8	# tanks	11	# tanks	11	# tanks	11	# tanks
Compressors	scalable		scalable		scalable		scalable		scalable		scalable	
LH_2 liquefaction	-		126	t/d	1420	t/d	1910	t/d	2153	t/d	2421	t/d
pipeline (mix natural gas + H_2)	15	km										
ships (NH_3)	1	# ships	1	# ships	1	# ships	1	# ships	1	# ships	2	# ships
ships (LH_2)	-	# ships	3	# ships	6	# ships	7	# ships	8	# ships	8	# ships
refuelling stations	1	# HRS	27	# HRS	89	# HRS	123	# HRS	128	# HRS	130	# HRS
trailer (LH_2 trailer from 2035)	1	# trailers	12	# trailers/d	37	# trailers/d	61	# trailers/d	64	# trailers/d	64	# trailers/d
rail cars			78	# rail cars/d	354	# rail cars/d	421	# rail cars/d	473	# rail cars/d	530	# rail cars/d
number of trains	-		2	# trains/d	10	# trains/d	12	# trains/d	14	# trains/d	15	# trains/d
capacity expans.					500	km	750	km	750	km	750	km

Antofagasta, as discussed before, offers effective synergies with both, existing infrastructure, as well as from the phase-out of coal-fired thermoelectric power plants and mining activities running-out The nucleus in Mejillones will be able to reuse significant amounts of HV lines, substations and desalination capacities. The respective modules are marked in green in Table 15. The currently installed and projected solar power capacities for 2025 exceed the needed power input for the H_2 hub. Possibly, some of the projects will thus be able to provide energy to the hub. Another alternative is to build a solar field close to the H_2 hub in Mejillones, which may, however, not reach the high capacity factors of fields installed in the Atacama Desert, yet have the advantage of being independent of grid capacities and HV lines. The export and transport infrastructure in Mejillones is expected to be sufficient throughout the next decades, especially considering for example the train connection to three of the largest mining complexes, namely Escondida and Chuquicamata in Antofagasta and additionally to Collahuasi in Tarapacá. Importantly, as soon as the number of trains projected reaches 10 per day, it is expected that some sort of capacity expansion is required for the railway (siding tracks to allow for trains to pass each other). Although in this study we assumed H_2 supply by train for the mines, it may at some point be more cost-efficient to decentralize the production or install a hydrogen pipeline. As this, however, depends a detailed cost analysis it lies out of the scope of this study.

From 2030 onwards, the H_2 hub in Antofagasta will exceed the capacity of the currently installed infrastructure. It is expected that with the growing solar capacities in the Atacama Desert, investments especially into further electric grid capacities are required. A detailed analysis of grid capacities is, however, out of the scope of this study.

Additional H_2 hub features, such as Hydrogen Refueling stations (HRS) to meet the local demand of fuel cell-electric vehicles (FCEV), may be added to the hub at any time and are negligible (with regards to footprint) compared to the industry complex developing around electrolyzing capacities and ammonia production. Further HRS will be placed in positions of high traffic frequency.

The ships required to export LH_2 will arrive with frequencies of around 1 ship every 1 to only 11 days in 2030, thus making significant amounts of storage already important in the years of LH_2 ramp-up.

The concentrated H_2 hub approach makes investments into a H_2 pipeline infrastructure unlikely, due to the lower costs of electricity transport over short distances [MA 2021]. Only a small NG-pipeline extension is anticipated to connect the large pipeline to the Antofagasta gas grid.

4.2 Magallanes

The Magallanes region does not provide large opportunities for the reuse of existing infrastructure. Neither the gas nor the electricity grid offers chances for effective synergies. Only the network of existing gas drilling pads north of San Gregorio may offer the reuse of existing (gravel) road infrastructure. Any assets required for construction (cranes etc.) will arrive through Punta Arenas port. Moreover, no phase-out of large-scale fossil-based industries is anticipated. We thus assume the development of the H_2 hub at locations with proximity to the highest capacity factors for the wind parks. This would be around the bay of Cabo Negro, or along the coast as laid out by Total Eren in the H2 Magallanes project[11]. Positioning the H_2 hub such that the assets for newly built HV lines become minimal is one key design factor in the region of Magallanes.

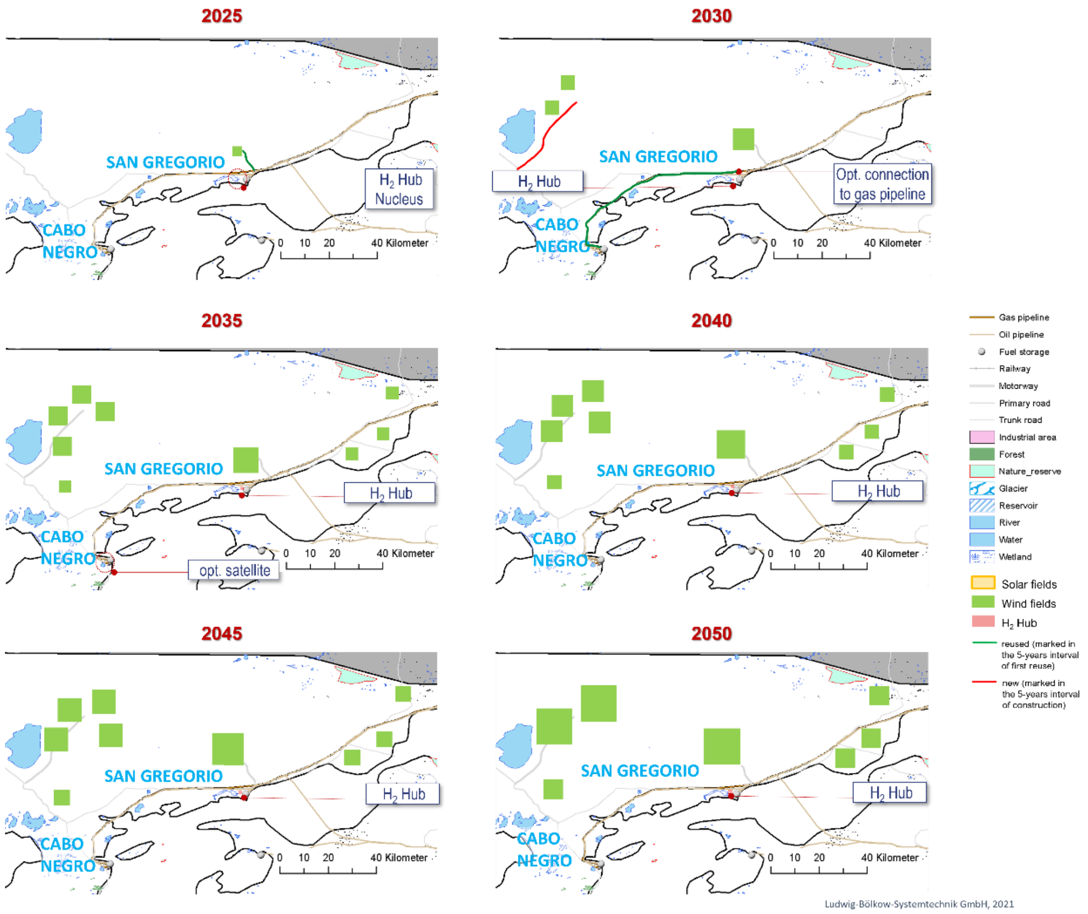


Figure 7: **Schematic development pathway of Magallanes H_2 valley, based on numbers projected in Table 16. The required footprints are drawn to scale; exact locations are, however, for illustration purpose only. Larger versions of each 5-years interval are given in annex A to this report**

[11] https://www.total-eren.com/wp-content/uploads/2021/12/PR-Chile_H2_02122021_EN_FINAL-TC_pp_V2.pdf; last accessed: 23. December 2021.

Table 16: Development pathway for Magallanes H_2 hub based on low GHS export scenario; assuming 70% electrolyzer efficiency and 4380 full load hours (capacity factor 50%) and the target market share assumption scenario 1

Module	2025		2030		2035		2040		2045		2050	
Electrolyzer	595	MW	5,104	MW	15,095	MW	19,964	MW	24,437	MW	30,708	MW
Electrolyzer footprint	23,789	m²	204,146	m²	603,810	m²	798,579	m²	977,491	m²	1,228,333	m²
Installed Wind (capacity)	1,189	MW	10,207	MW	30,190	MW	39,929	MW	48,875	MW	61,417	MW
Installed Wind footprint	23,788,646	m²	204,145,588	m²	603,809,750	m²	798,578,907	m²	977,490,875	m²	1,228,333,340	m²
H_2 output	167	tons/d	1,429	tons/d	4,227	tons/d	5,590	tons/d	6,842	tons/d	8,598	tons/d
H_2 output	60,780	tons/yr	521,591	tons/yr	1,542,732	tons/yr	2,040,367	tons/yr	2,497,487	tons/yr	3,138,389	tons/yr
Desalination	4,163	M³/day	35,725	m³/day	105,666	m³/day	139,751	m³/day	171,060	m³/day	214,958	m³/day
(capacity)	48	L/sec	413	L/sec	1,223	L/sec	1,617	L/sec	1,980	L/sec	2,488	L/sec
Desal. Footprint			50,000	m²	50,000	m²	100,000	m²	100,000	m²	100,000	m²
HV lines (capacity)	1	#/500 MWp	10	#/500 MWp	30	#/500 MWp	40	#/500 MWp	49	#/500 MWp	61	#/500 MWp
HV line length (worst case)	80	km	800	km	2,400	km	3,200	km	3,920	km	4,880	km
No. of substations	1	# subs.	5	# subs.	15	# subs.	20	# subs.	24	# subs.	31	# subs.
Substation footprint	25,000	m²	125,000	m²	375,000	m²	500,000	m²	600,000	m²	775,000	m²
H_2 Storage footprint (CGH_2)	10,408	m²	89,314	m²	264,167	m²	349,378	m²	427,652	m²	537,395	m²
H_2 storage volume (geom., 50 MPa)	24,895	m³	213,637	m³	631,884	m³	835,709	m³	1,022,939	m³	1,285,445	m³
NH_3 production (capacity)	834	tons/d	7,170	tons/d	14,402	tons/d	14,891	tons/d	17,618	tons/d	18,981	tons/d
NH_3 production (capacity)	304,568	tons/yr	2,617,023	tons/yr	5,256,861	tons/yr	5,435,117	tons/yr	6,430,665	tons/yr	6,928,203	tons/yr
NH_3 production footprint	110,000	m²	330,000	m²	550,000	m²	550,000	m²	660,000	m²	770,000	m²

Table 16 (cont.): Development pathway for Magallanes H_2 hub based on low GHS export scenario; assuming 70% electrolyzer efficiency and 4380 full load hours and the target market share assumption scenario 1 (reused infrastructure in green)

Module	2025		2030		2035		2040		2045		2050	
Storage NH_3	54,400	t	54,400	t	54,400	t	54,400	t	54,400	t	54,400	t
NH_3 jetty	1	# jetties	1	# jetties	1	# jetties	1	# jetties	1	# jetties	1	# jetties
LH_2 jetty	-	# jetties	1	# jetties	2	# jetties	2	# jetties	2	# jetties	2	# jetties
Storage LH_2 (capacity)	170	t_{H2}/tank	170	t_{H2}/tank	170	t_{H2}/tank	1000	t_{H2}/tank	1000	t_{H2}/tank	1000	t_{H2}/tank
Storage LH_2 (tanks)	0	# tanks	8	# tanks	8	# tanks	11	# tanks	11	# tanks	11	# tanks
Compressors	scalable		scalable		scalable		scalable		scalable		scalable	
LH_2 liquefaction	-		122	t/d	1620	t/d	2628	t/d	3651	t/d	5162	Lt/d
ships (NH_3)	1	# ships	1	# ships	2	# ships	2	# ships	2	# ships	2	# ships
ships (LH_2)	-	# ships	3	# ships	8	# ships	11	# ships	13	# ships	18	# ships
refuelling stations	1	# HRS	3	# HRS	9	# HRS	13	# HRS	14	# HRS	14	# HRS
trailers	0	# trailers/d (CGH_2)	1	# trailers/d (CGH_2)	3	# trailers/d (LH_2)	5	# trailers/d (LH_2)	5	# trailers/d (LH_2)	5	# trailers/d (LH_2)
roads (length)			50	km								

5 NEW GROSS INVESTMENT

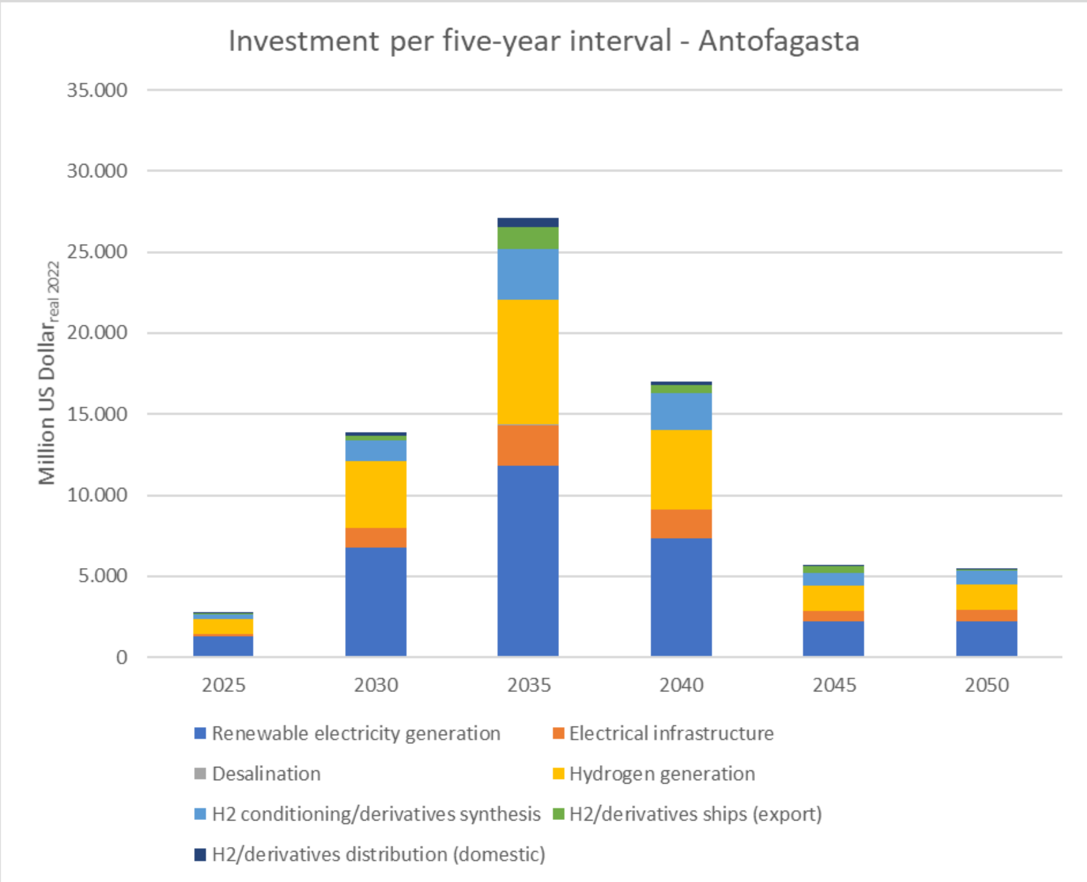
New gross investment is estimated separately for Antofagasta and Magallanes based on the production scenario developed in Report 1. The individual components of the value chain in Chile are assigned to seven groups: (1) renewable electricity generation, (2) electrical infrastructure (high voltage lines and substations), (3) desalination, (4) hydrogen generation, (5) hydrogen conditioning and derivatives synthesis (hydrogen compression, hydrogen liquefaction, hydrogen storage, ammonia synthesis and storage, etc.), (6) hydrogen and derivatives ships, and (7) hydrogen and derivatives distribution within Chile.

Investment estimates do not include investments for port infrastructures as these may vary significantly depending on whether existing port facilities can be used, or new investments are needed. Also, investments in consumption technologies such as vehicles (buses, coaches, mining trucks, etc.) creating domestic demand are not included. Furthermore, indirect investment needs possibly arising from indirect effects such as indirect job creation (see section 8) with associated need for investments for related businesses, infrastructure, buildings, etc. are not included. Finally, investments required in education and training for skilled workers and academics are not included. Such aspects could be covered in future studies. The ramp-up of hydrogen production in Chilean hydrogen hubs as described in Report #1 requires significant investments. These, in turn, lead to tax revenues (see section 6) and job creation (see section 8), and provide market opportunities for Chilean companies (see section 7).

Investments as shown in this chapter are estimated based on the ramp-up of production capacities, but no systematic optimization has been done. Optimization potentials exist on various levels (hub concept, renewables mix (PV, solar concentrated, wind), renewable power plant concepts, etc.). As a consequence, actual investments could be somewhat lower based on optimized developments. Investment figures are in real terms of 2022.

5.1 Antofagasta Region

The ramp-up of hydrogen production in Antofagasta as described in chapter 4 requires significant investments, as shown in Figure 8. Investments are shown for each 5-year-interval until 2050; average annual investments within each 5-year-interval can be calculated by dividing the figures shown by 5. In Antofagasta, investments clearly follow the trends of ramping up hydrogen production value chains with a peak in 2035, and declining investments thereafter with very low investments after 2040. While some elements of the value chain are conventional, well-established technologies, e.g. high-voltage electricity lines, which are not expected to decline in investment costs, other elements are anticipated to show relevant investment cost reductions over time until 2050. Prominent examples are solar PV and electrolyzers, specific investment costs of which are anticipated to decrease by some 50% until 2050. For this reason, the decline in investments after 2035 is more pronounced than the decline in new installations of facilities in terms of technical capacities as shown in the table below the figure.



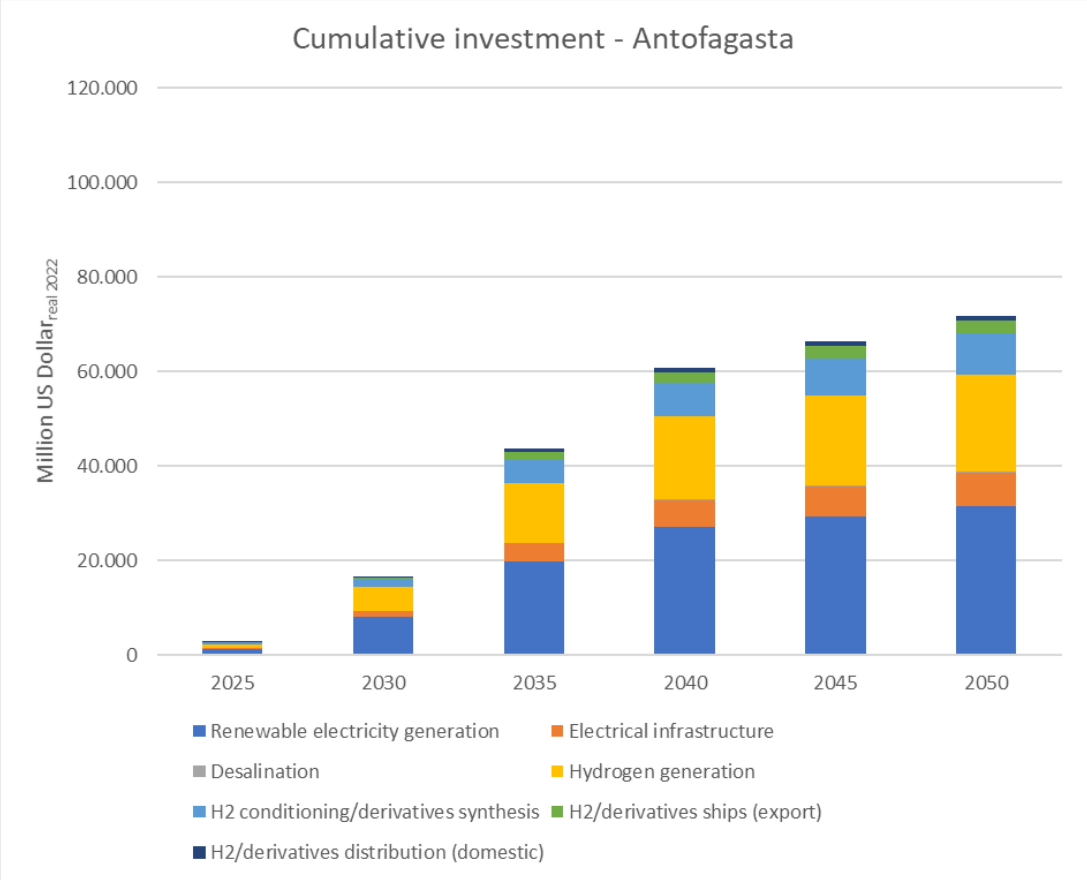
Associated new renewable capacity	1.993	13.313	27.953	20.055	6.910	7.443	MW
Associated new electrolyser capacity	996	6.657	13.977	10.028	3.455	3.722	MW
Associated new eq. H_2 production	71.277	476.210	999.878	717.375	247.162	266.250	tons/yr
Associated new ammonia export	216.070	1.601.003	152.490	2.219.747	356.943	388.960	tons/yr
Associated new LH_2 export	0	46.170	472.230	178.690	88.910	97.490	tons/yr
Desalination capacity	4.882	32.617	68.485	49.135	16.929	18.236	m³/day

Figure 8: **New (gross) investment in each 5-year interval in Antofagasta (low export scenario) by value chain stage**

Table 17 shows that solar electricity generation has the largest share of total investments in the range of 39% to 49%. The second largest contribution to investments stems from hydrogen generation at a range of 27% to 32%. Hydrogen conditioning and derivatives synthesis is next at 9% to 16%. Electrical infrastructure has a share of 6% to 13%, which is increasing over time as the most important contributors show decreasing investment costs while electrical infrastructure is not expected to decline in investment costs. Also, investments in ships for international hydrogen or derivatives transport require significant investments of 2% to 8%.

Table 17: Investment shares by value chain stage in Antofagasta

Antofagasta investment shares	min	max
Renewable electricity generation	39%	49%
Hydrogen generation	27%	32%
H_2 conditioning/derivatives synthesis	9%	16%
Electrical infrastructure	6%	13%
H_2/derivatives ships (export)	2%	8%
H_2/derivatives distribution (domestic)	1%	2%
Desalination	0.2%	0.3%



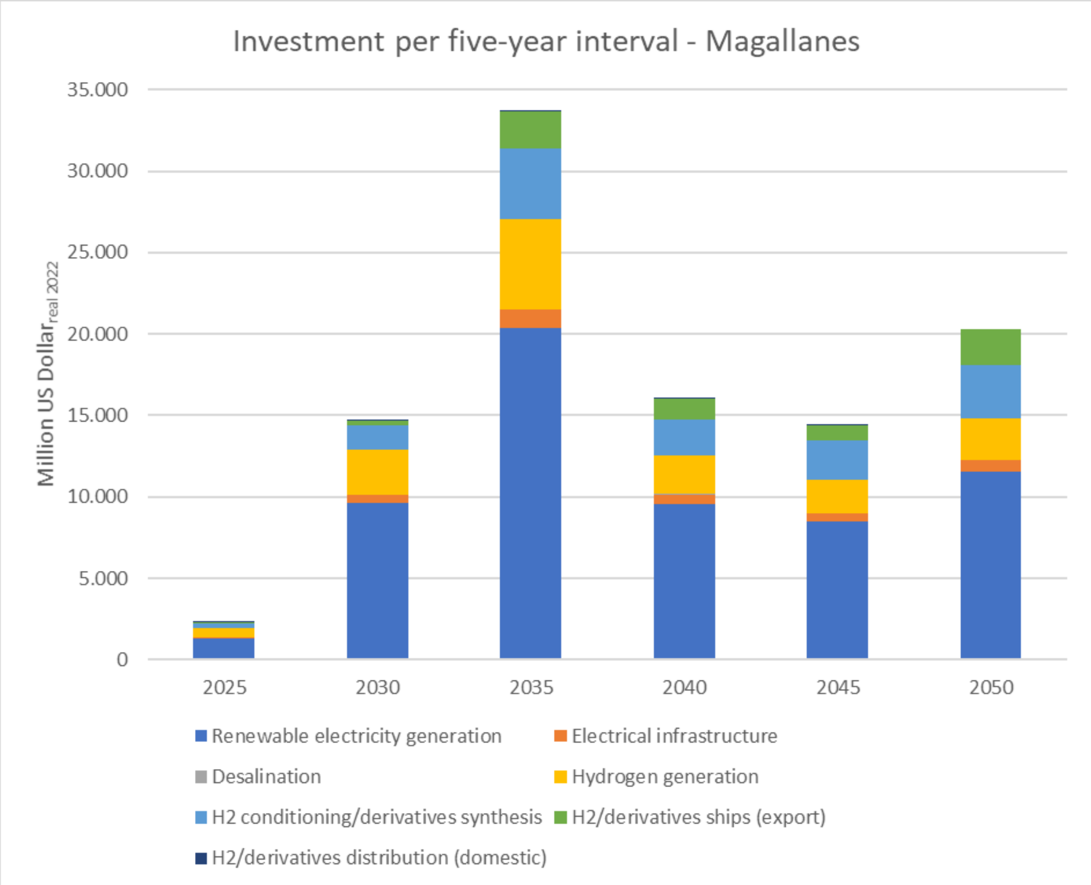
Associated renewable capacity	1.993	15.306	43.259	63.314	70.224	77.667	MW
Associated electrolyser capacity	996	7.653	21.629	31.657	35.112	38.834	MW
Associated eq. H_2 production	71.277	547.488	1.547.366	2.264.740	2.511.903	2.778.153	tons/yr
Associated ammonia export	216.070	1.817.073	1.969.563	4.189.310	4.546.253	4.935.213	tons/yr
Associated LH_2 export	0	46.170	518.400	697.090	786.000	883.490	tons/yr
Desalination capacity	4.882	37.499	105.984	155.119	172.048	190.284	m³/day

Figure 9: Cumulative new (gross) investment in Antofagasta (low export scenario) by value chain stage

Figure 9 shows the investments as cumulative figures summing up all investments over time until 2050. The steep increase until 2035 with gradual relaxation thereafter shows the significant changes anticipated over the coming two decades. It reflects the anticipated international market breakthrough between 2030 and 2035.

5.2 Magallanes Region

The ramp-up of hydrogen production in Magallanes as described in chapter 4 requires significant investments as shown in Figure 10. Investments are shown for each 5-year-interval until 2050; average annual investments within each 5-year-interval can be calculated by dividing the figures shown by 5.



Associated new renewable capacity	1.189	9.018	19.983	9.738	8.946	12.542	MW
Associated new electrolyser capacity	595	4.509	9.992	4.869	4.473	6.271	MW
Associated new eq. H_2 production	60.780	460.812	1.021.141	497.635	457.120	640.902	tons/yr
Associated new ammonia export	304.568	2.312.454	2.639.838	708.840	464.963	497.538	tons/yr
Associated new LH_2 export	0	44.591	546.714	367.834	373.489	551.681	tons/yr
Desalination capacity	4.163	31.562	69.941	34.085	31.310	43.897	m³/day

Figure 10: New (gross) investment in each 5-year interval in Magallanes (low export scenario) by value chain stage

In Magallanes, investments clearly follow the trends of ramping up hydrogen production value chains with a pronounced peak in 2035, and lower, but rather stable investments thereafter at a significantly higher level than in Antofagasta. This is based on assumptions on global target markets being served from Antofagasta and from Magallanes, respectively. While some elements of the value chain are conventional, well-established technologies, e.g. high-voltage electricity lines, which are not expected to decline in investment costs, other elements are anticipated to show relevant investment cost reductions over time until 2050. A prominent example are electrolyzers, specific investment costs of which are anticipated to decrease by some 50% until 2050. Cost reductions of wind power as are less pronounced at almost 20% by 2050. For this reason, the decline in investments after 2035 is more pronounced than the decline in new installations of facilities in terms of technical capacities as shown in the table below the figure.

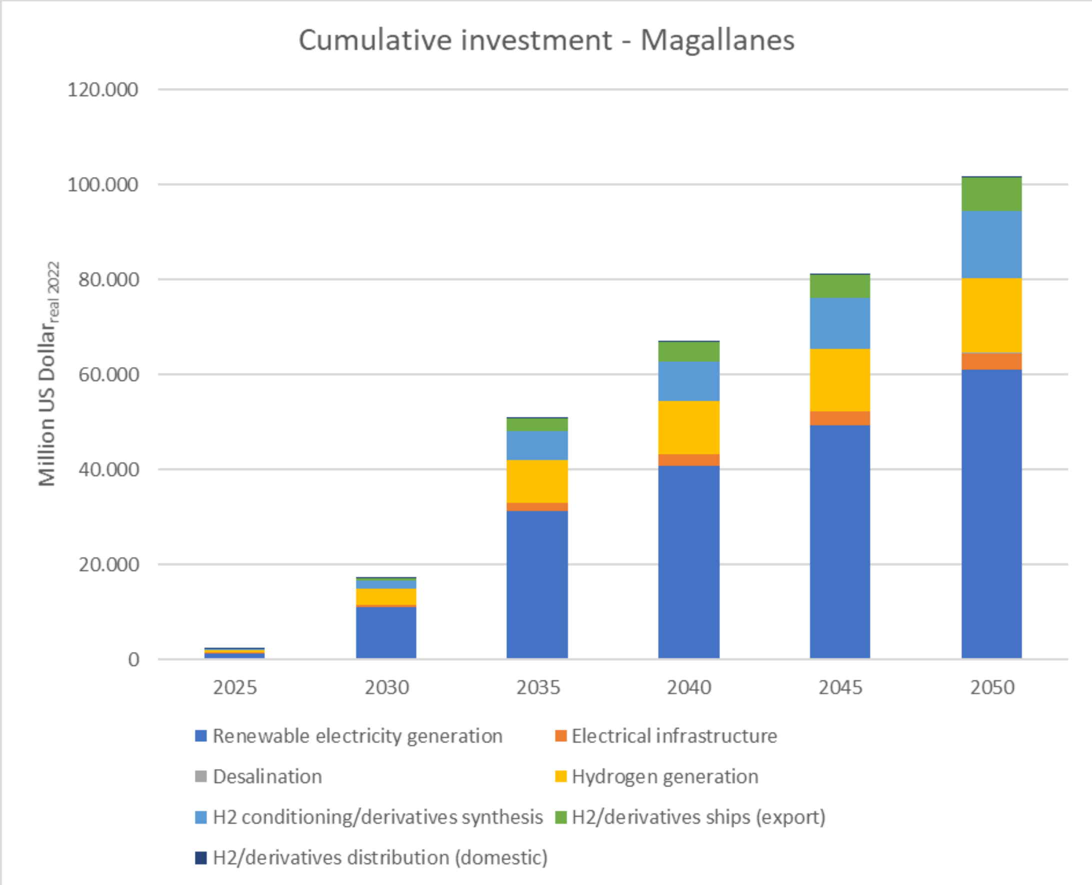
Investments are higher in Magallanes than in Antofagasta based on two effects: In the long run, hydrogen production capacities are higher in Magallanes than in Antofagasta, and future investment cost reductions in solar PV are anticipated to be much stronger than in wind power, which in turn results in investments in Magallanes increasing more strongly than in Antofagasta.

Table 18 shows that wind power generation has the largest share of total investments in the range of 57% to 65%. The second largest contribution to investments relates to hydrogen generation at a range of 13% to 23%. Hydrogen conditioning and derivatives synthesis is next at 10% to 17%. Investments in ships for international hydrogen or derivatives transport require significant investments of 2% to 11%. Electrical infrastructure has a share of 3% to 4%, which reflects the shorter high voltage line lengths required in Magallanes than required in Antofagasta.

Table 18: Investment shares by value chain stage in Magallanes

Magallanes investment shares	min	max
Renewable electricity generation	57%	65%
Hydrogen generation	13%	23%
H_2 conditioning/derivatives synthesis	10%	17%
Electrical infrastructure	3%	4%
H_2/derivatives ships (export)	2%	11%
H_2/derivatives distribution (domestic)	0%	1%
Desalination	0.2%	0.2%

Figure 11 shows the investments as cumulative figures summing up all investments over time until 2050. The steep increase until 2035 with a certain reduction thereafter shows the significant changes anticipated over the coming two decades. It reflects the anticipated international market breakthrough between 2030 and 2035.



Associated renewable capacity	1.189	10.207	30.190	39.929	48.875	61.417	MW
Associated electrolyser capacity	595	5.104	15.095	19.964	24.437	30.708	MW
Associated eq. H_2 production	60.780	521.591	1.542.732	2.040.367	2.497.487	3.138.389	tons/yr
Associated ammonia export	304.568	2.617.023	5.256.861	5.965.701	6.430.665	6.928.203	tons/yr
Associated LH_2 export	0	44.591	591.304	959.138	1.332.627	1.884.308	tons/yr
Desalination capacity	4.163	35.725	105.667	139.751	171.061	214.958	m³/day

Figure 11: Cumulative new (gross) investment in Magallanes (low export scenario) by value chain stage

6 TAX REVENUE

In Chile, tax revenues related to economic activity have several classifications, a summary of the types of taxes[12] is presented below:

- Direct taxes:
    - First Category Income Tax.
    - Single Second Category Tax that affects Wages, Salaries and Pensions.
    - Global Complementary Tax
    - Additional Tax
- Indirect taxes:
    - First Category Income Tax or Single Second Category Tax affecting Wages, Salaries and Pensions
    - Single Second Category Tax on Wages, Salaries and Pensions o Global Complementary Tax on Wages, Salaries and Pensions
    - Global Complementary Tax
    - Additional Tax
- Other Taxes
    - Property tax

The types of industry that will develop in the green hydrogen value chain, and thus are included for this study, will correspond mainly to the economic sectors of Energy Generation, Fuels, Transport and Export.

In alignment with the regulations established by the Chilean Internal Revenue Service (SII in Chile), the types of companies that operate in the economic sectors described above are mainly affected by First Category Taxation.

The other direct taxes listed have an impact on the income of individuals and not companies, while the “additional tax” on the other hand affects only individuals or legal entities that have no residence or domicile in Chile.

With regards to indirect taxes, only the fuel tax has some relevance, which for the purposes of this analysis is, however, not included since it establishes a tax on the first sale or import of automotive gasoline and diesel oil (the products to be replaced by H_2).

The First Category Income Tax is applied to income from capital by commercial, industrial, mining and service companies. This tax is collected from companies that determine their

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[12] SII Web Site, taxes description;
Source: https://www.sii.cl/aprenda_sobre_impuestos/impuestos/descripcion.htm

effective income by means of full or simplified accounting, spreadsheets or contracts on the basis of the profits received or accrued.

As of tax year 2019, business year 2018, and thereafter, the general rate of the First Category Income Tax is 27%, and will be applied to any income classified in such category (SII Circular: No. 52, 10.10.2014)[13].

An estimate of the taxes generated by the projected hydrogen hubs considering only hydrogen generation for module from tables 14 and 15 of report 1 and taking as price the cost of production projected by the national hydrogen strategy is as follows.

Table 19: Tax generated for Antofagasta H_2 Hub development pathway

Module	2025	2030	2035	2040	2045	2050
H_2 output tons/year Antofagasta	71,277	547,488	1,547,366	2,264,740	2,511,903	2,778,153
production cost USD/kg H_2	2.00	1.40	1.20	1.10	1.10	1.00
Generated MUSD/year	142.55	766.48	1,856.84	2,491.21	2,763.09	2,778.15
Taxes generated MUSD/year	38.49	206.95	501.35	672.63	746.04	750.10

Table 20: Tax generated for Magallanes H_2 Hub development pathway

Module	2025	2030	2035	2040	2045	2050
H_2 output tons/year Magallanes	6,078	521,591	1,542,732	2,040,367	2,497,487	3,138,389
production cost USD/kg H_2	1.70	1.30	1.10	1.00	0.90	0.80
Generated MUSD/year	10.33	678.07	1,697.01	2,040.37	2,247.74	2,510.71
Taxes generated MUSD/year	2.79	183.08	458.19	550.90	606.89	677.89

6.1 Imports

Imports are subject to payment of ad valorem duty (6%) which is calculated on the CIF value (cost of goods + insurance premium + freight value). The VAT "Value Added Tax" (19%) is calculated on the CIF value plus the ad valorem duty.

In some cases, depending on the nature of the merchandise, for example: luxury goods, alcoholic beverages and others, special taxes are required.

Used goods, in cases where their importation is authorized, pay an additional surcharge of 3% on their CIF value, in addition to the taxes to which they are subject, depending on their nature.

In the case of goods originating in a country with which Chile has signed a trade agreement, the ad valorem duty may be free or subject to a percentage reduction.

[13] SII Web Site, First Category Income Tax.
Source: https://www.sii.cl/ayudas/aprenda_sobre/3072-1-3080.html

The control of these operations and the collection of the indicated duties and taxes corresponds to the National Customs Service.

6.2 Contribution to regional development of investment projects

Law No. 21,210 was published in the Official Gazette on February 24, 2020, which introduces various amendments to the tax legislation, and whose thirty-second article establishes the so-called “contribution for regional development” with respect to investment projects executed in Chile that meet the requirements established by the same Law.

The requirements that must all be met in order to projects to be subject to the tax are:

- Involving the acquisition, construction or importation of fixed assets with a total value equal to or exceeding US$10 million.
- That must be submitted to the environmental impact assessment system (Evaluacion de impacto Ambiental EIA) in accordance with the provisions of Article 10 of Law No. 19,300, on general bases of the environment, and its regulations.

In the case of goods acquired on the domestic market, the acquisition value of the aforementioned goods is made up of the value effectively invested in their acquisition or construction. Including those disbursements that have had a direct incidence on the acquisition or construction of the aforementioned goods, such as freight or insurance, contracted transport, assembly or installation expenses and revaluations provided by law.

In the case of goods acquired abroad, the CIF value according to the invoice or contract, import duties and customs clearance expenses will be considered.

Independent from the goods acquirement on the local or foreign market, the acquisition value will be converted into US dollars at the exchange rate (value currently reported by the Central Bank of Chile) in effect on the date of the supplier's invoice or, if no invoice is issued, on the date of execution of the respective contract with the supplier.

The contribution is accrued at the end of the first fiscal year in which the project generates operating income. Depreciation is not considered, provided that the definitive reception of works has been obtained by the Directorate of Municipal Works. In the event this is not applicable to the project, the Superintendence of Environment must have been informed about the minimum management, act or work of the project or activity that shows the start of its execution, according to the stipulations of the respective Environmental Qualification Resolution and Article 25 ter of Law No. 19,300.

Considering the following typical investment values per hydrogen plant with respect to electrolyzer capacity, the following is obtained:

Table 21: **Investment cost for hydrogen plants, in electrolyzer capacity, which would not be taxed by “contribution for regional development”**

Module	2025	2030	2035	2040	2045	2050
Electrolyzer USD/MW	900,000	600,000	550,000	500,000	450,000	400,000
Maximum plan capacity whitout paying this tax MW	11.11	16.67	18.18	20.00	22.22	25.00

7 CHARACTERIZATION OF COMPANIES AND EMPLOYMENT IN THE SELECTED REGIONS

7.1 Identification of companies potentially participating in the value chain

On the basis of the planning from the energy generation capacity shown in the "Long Term Energy Planning" (PELP)[14] from the Ministry of Energy, hydrogen demand will be projected.

The Ministry of Energy also made projections of the installed renewable energy capacity required over the next few decades to meet projected hydrogen demand, along with the capacity and investment needed for backbone transmission of such energy.

In a first step, using this demand, the respective infrastructure, and the technologies associated with this new market were quantified.

Secondly, the goods and services associated with the green hydrogen value chain were identified based on a bibliographic review of studies published by consulting firms and agencies dedicated to sustainable development. The following stages were considered: planning; equipment acquisition; manufacturing; transportation; installation and assembly; operation and maintenance; and decommissioning.

Thirdly, we proceeded to identify the items, sub-items and economic activities related to the industrial linkage of GH_2, filtering by company size and company name, thus excluding those that are not linked to the industry and considering only medium and large firms.

7.2 Participation of the identified companies in sales and employment at the national level

The emerging H_2 industry would mainly affect the secondary (construction and electricity supply as well as advanced manufacturing) and tertiary sectors of the Chilean economy (trade, especially if manufacturing in Chile is not included and imported; transportation and warehousing; professional services and administrative services). Details of the economic activities linked to the GH_2 value chain can be found in Annex I.

The total number of medium-sized and large companies detected in the relevant areas is 817 nationwide, representing 0.2% of the total number of companies in the country. Approximately 75% of these companies are registered in the Metropolitan Region and the remaining 25% are distributed among the other regions of the country. It should be noted

[14] Projections were taken from scenario E of the PELP, which represents the case with the highest penetration of renewable energies among the five scenarios included in the document.

that none are located in the Magallanes Region. In the Antofagasta region 23 companies (2.8%) are situated.

In order to incorporate smaller companies that can potentially participate in the GH_2 value chain, the 2019 GIZ, HINICIO Chile study uses the ratio between selected companies and the total number of companies in the Medium 1 bracket (more than 25,000.01 a 50,000.00 UF annual revenue) identified as potential. Using this approach, it was obtained that of the 9,421 small companies identified nationally, 2,016 (21.4%) could potentially be involved in the GH_2 value chain (Quantification of industrial and labor linkages for hydrogen development in Chile, 2019, p. 46).

The country has also seen an increase in renewable projects. The entry of new players in solar and wind power generation in the country has led to PYMEs capturing an increasing percentage of sales. This will continue to be accentuated because 100% of new power generation projects under construction are renewable and, secondly, because a green hydrogen industry could further enhance this development by benefiting new players interested in entering the market.

"With this background, it is possible to argue that a green hydrogen industry could lead to a deconcentration of sales in this area, considerably decreasing the sales gaps between large companies and the rest". (Quantification of the industrial and labor linkage for the development of hydrogen in Chile, 2019, p. 45).

With the information available at the regional level provided by SII, it is not possible to more differentiation on the economic activity and size of the company.

7.3 Antofagasta Region

The GH_2 production value chain involves 40 economic activities in 7 branches of the economy (see Annex I). In Antofagasta, the companies that potentially form part of this chain make up 25.4% of the total number of companies in the region, and their sales volume covers 30% of the total of the branches considered. They are also an important source of employment, as they employ 39% of the workers in the industries considered.

Professional, scientific, and technical activities account for 63% of the companies and 86% of the sales and professionals hired, respectively.

In 2020, the Antofagasta region had a total of 6,601 companies potentially participating in the GH_2 value chain.

In the region, most of the companies participating in the GH_2 value chain are in the transportation sector, followed by professional activities, commerce, and construction. The same occurs in relation to the number of workers hired, except in commerce, where the percentage is much lower in relation to the number of existing companies, similar to that of the manufacturing industry.

Table 22: Companies, annual sales, and dependent workers in GH_2 value chain activities, by industry, Antofagasta Region, 2020.

Item	Number of companies	Percentage	Annual sales (UF)	Percentage	Dependent workers	Percentage
Manufacturing industry	395	6.00	6,521,634	10.70	2,981	11
Supply of electricity and gas	17	0.30	Not reported	-	837	3
Construction	936	14.20	7,197,658	11.80	536	19
Commerce	1,276	19.30	11,520,054	18.90	2,956	10
Transport	2,205	33.40	24,024,146	39.50	6,327	22
Professional activities	133	20.10	9,308,156	15.30	627	22
Administrative and support activities and services	442	6.70	2,237,836	3.70	3,585	13
Total Region	6,601	100.00	60,809,484	100.00	28,315	100

Source: Own elaboration based on SII 2020

The evolution in the region shows that the companies that can participate in the green hydrogen value chain have grown in terms of number, sales volume and workers hired, as shown in the following graph. However, each of the items considered have dissimilar behaviors, as shown in Table 23.

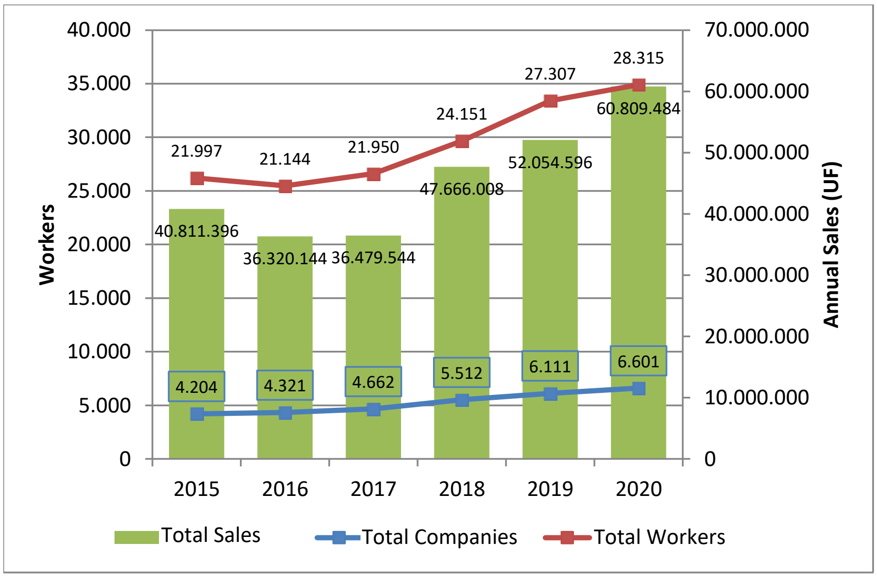


Figure 12: Companies, annual sales, and dependent workers of GH_2 value chain activities, Antofagasta Region, 2015-2020. Source: Own elaboration based on SII 2020

Strong growth is observed between 2015 and 2020 in the number of companies engaged in construction, administrative activities and services, professional activities, and transportation, while manufacturing and electricity and gas have remained stable or decreased sharply.

Table 23: Growth rates in the number of companies in GH_2 value chain activities, Antofagasta Region, 2015-2020

Item	Average annual growth 2015-2019	Total growth 2015-2019	Average annual growth 2015-2020	Total growth 2015-2020
Manufacturing industry	-0.51	-2.04	0.10	0.51
Supply of electricity, gas	-15.19	-48.28	-10.13	-41.38
Construction	17.11	88.09	24.02	193.42
Commerce	6.41	28.22	3.72	20.04
Transport	8.55	38.82	8.55	50.72
Professional activities	16.34	83.19	13.06	84.72
Administrative and support activities and services	16.37	83.41	15.29	103.69
Total Region	9.80	45.36	9.44	57.02

Source: Own elaboration based on SII 2020[15]

The economy of the Antofagasta Region is heavily dependent on mineral exports, with little productive linkage to other sectors that could diversify the productive sector. According to the Regional Government, the development of small and medium-sized companies has been very weak, despite the efforts undertaken through state development instruments.

These factors are decisive in explaining the decline in the number of workers hired in the manufacturing industry potentially participating in the H_2 value chain. Indeed, according to INE 2022, as of November 2021, the Mining (metallic mining) and Energy (electricity distribution) sectors recorded decreasing variations compared to November 2020. On the other hand, the Supermarket Sales Index (ISUP) at constant prices in the region registered a growth of 8.0% compared to the same month of 2020.

Complementing the above, the decreases in electricity supply are routed to the closure of two thermoelectric plants during 2019 and the decrease in demand for electricity from the mining sector. Indeed, in June 2019, units 12 and 13 in Tocopilla were disconnected by Engie Chile. Likewise, according to INE, the Mining economic sector is the one that represents and consumes the highest relative proportion of electric energy with 81.8%, which registered during November 2021 a variation of -23.1% compared to November 2020.

7.3.1 Specific economic activities of the GH_2 value chain Antofagasta region

The Antofagasta region has a relevant mining industry, which represented 52.7% of the regional GDP in 2019 (Central Bank). This phenomenon has a strong impact on the

[15] The particular situation of the year 2020 and the effect of COVID on economic activity should be considered for the analysis of the data.

development and economic characteristics of the region. The mining industry boosts all those sectors that are able to meet the demand generated by the industry. All those sectors' development is closely tied to the development of the mining sector.

Contractions in the mining production index - especially metallic and copper - such as those observed between 2018 and 2021 (INE, IPM 2018-2021) compromise the possibilities for expansions and even existence of numerous companies linked to this sector. As will be described below, it appears that those linked to phases or processes of operation, such as metal manufacturing or those linked to electronic and computer equipment and components, have suffered the highest impact due to the decline in mining activity.

On the other hand, the development of new industries (e.g. ammonium, methane, etc.) and the exploitation of new resources (i.e. lithium), open spaces for the development of service companies. This is what seems to be observed in the growth of services and engineering services companies, which has had an explosive growth in the region during 2015-2020.

Manufacturing Industry in Antofagasta

In the manufacturing industry, the economic activities selected are those related to the manufacture of metal products, specifically for construction and other purposes. The companies engaged in this activity typically incorporate, in addition to manufacturing, metal structure assembly processes and integrate preventive and corrective maintenance services for metal structures.

In the Antofagasta region, they are integrated into the mining industry, for example through the manufacture of light, medium, heavy, and extra heavy metal structures, offering machining of parts and pieces for mining equipment such as shovels, drills, etc. Assembly of stainless steel, carbon and HDP piping. Companies engaged in these activities in the Antofagasta region have decreased since 2015, with a slight recovery observed since 2019.

Table 24: Companies and weighted workers in the metal products manufacturing industry (Economic activities 251100 and 259900)

Year	Number of companies	Workers weighted by months worked
2015	342	3,801
2016	307	3,408
2017	305	3,236
2018	319	3,053
2019	343	3,046
2020	355	2,802

Source: SII

The same has happened with the hiring of labor force, which has notoriously decreased in the 2015-2020 period. Probably its strong linkage with the mining industry has caused this decrease, suggesting that these economic activities could be seen as an opportunity for diversification of demand in the GH_2 industry.

A second relevant activity in the manufacturing industry of the GH_2 value chain is the production of components, electronic boards, computers, and peripheral equipment (Economic activities 261000 and 262000). As can be seen in the following table, there are not many companies engaged in these activities.

Likewise, the number of workers hired is small, which suggests a strong use of alternative mechanisms to permanent hiring (project work, etc.).

Similarly, a close link with the demand of the mining sector can be intuited, so that, as in the case of the metal products industry, the opening of a market derived from the production of GH_2 is an opportunity for companies engaged in these activities.

Table 25: Companies and weighted workers in the electronic components and boards and computers and peripheral equipment industry (Economic activities 261000 and 262000)

Year	Number of companies	Workers weighted by months worked
2015	19	30
2016	18	143
2017	19	18
2018	13	2
2019	10	25
2020	13	6

Source: SII

Finally, within manufacturing, the manufacture of electric motors, generators and transformers, distribution and control apparatus and the manufacture of other types of electrical equipment are considered as part of the GH_2 value chain (Economic activities 271000 and 279000).

Table 26: Companies and weighted workers in the manufacturing industry of electric motors, generators, and transformers (Economic activities 271000 and 279000)

Year	Number of companies	Workers weighted by months worked
2015	24	251
2016	25	290
2017	22	255
2018	12	66
2019	21	96
2020	19	169

Source: SII

This group of companies has experienced a downward trend in both their number and the number of workers hired. It is assumed that this phenomenon is linked to the decrease in demand from the mining industry.

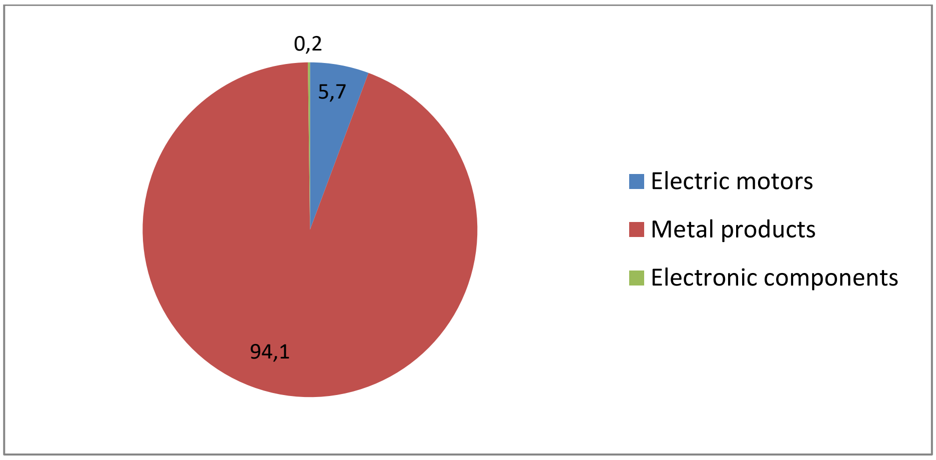


Figure 13: **Dependent workers of Manufacturing Industry in Antofagasta, 2020, Source: Own elaboration based on SII 2020**

Industrial service sector in Antofagasta

The activities considered as part of the GH_2 value chain in the service category is those related to professional, scientific, and technical activities and administrative and support service activities.

A relevant subset of service categories is that of legal advisory and representation services as well as management consulting activities. These activities have had a sustained increase until 2019, if the number of companies is considered, and until 2018, if the number of hired workers is considered. After those years, both variables decrease.

Table 27: **Companies and weighted employees in legal advisory and representation services and management consulting activities (Economic activities 691001 and 702000)**

Year	Number of companies	Workers weighted by months worked
2015	509	2,177
2016	546	2,462
2017	548	2,637
2018	698	2,868
2019	733	1,396
2020	680	1,352

Source: SII

In contrast, services and engineering services companies and related technical consulting activities have had a strong and sustained increase in the Antofagasta region between 2015 and 2020.

Table 28: Companies and weighted employees in engineering and related technical consulting services and services activities (Economic activities 711002 and 711003)

Year	Number of companies	Workers weighted by months worked
2015	211	1,095
2016	267	951
2017	332	1,095
2018	524	2,144
2019	586	2,732
2020	650	4,918

Source: SII

In the case of security, facility support and cleaning services, considerable growth is observed between 2015 and 2020.

Table 29: Companies and weighted employees in security, facility support and cleaning services (economic activities 801001, 811000, 812100 and 812909)

Year	Number of companies	Workers weighted by months worked
2015	193	1,351
2016	222	989
2017	283	1,386
2018	310	2,443
2019	334	3,432
2020	376	3,483

Source: SII

Finally, with regard to combined office administrative services activities, photocopying, document preparation and other specialized office support activities, sustained growth is observed between 2015 and 2020.

Table 30: Companies and weighted workers in office administrative services Photocopying, document preparation and other specialized office support activities (economic activities 821100 and 821900)

Year	Number of companies	Workers weighted by months worked
2015	24	53
2016	32	71
2017	41	74
2018	52	99
2019	64	117
2020	66	102

Source: SII

Within the group of companies dedicated to manufacturing, those related to metal products are the most relevant in terms of number of companies and workers hired.

On the other hand, the services sector concentrates companies and workers in legal advice and representation, security services, support services for facilities and cleaning, but especially in engineering services and related technical consulting activities, which have experienced strong growth in the last five years.

7.4 Magallanes Region

In Magallanes, the companies that potentially participate in the GH_2 value chain account for 26.4% of the items considered (Manufacturing industry, Supply of electricity & gas, Construction, Commerce and Transport) and employ 25% of the total number of employees in this group. They account for 20% of sales in the group of items considered.

In 2020 in Magallanes there are 2,587 companies that could potentially participate in the GH_2 value chain, mainly linked to transportation, commerce, and construction. In terms of workers hired, transportation, commerce and administrative activities and services are the most relevant.

In this region, the companies supplying electricity and gas are most to the GH_2 value chain because they account for 93.4% of the workers in this branch of activity.

Table 31: Companies, annual sales, and dependent workers in GH_2 value chain activities, by industry, Magallanes Region, 2020

Item	Number of companies	Percentage	Annual sales (UF)	Percentage	Dependent workers	Percentage
Manufacturing industry	92	3.6	169,907	1,4	143	2,3
Supply of electricity, gas	9	0.3	0	0,0	124.5	2,0
Construction	443	17.1	975,070	8,3	861	13,7
Commerce	528	20.4	4,796,168	40,8	1,400	22,2
Transport	1,118	43.2	4,768,811	40,5	2,102	33,3
Professional activities	256	9.9	919,188	7,8	446	7,1
Administrative and support activities and services	141	5.5	138,716	1,2	1,231	19,5
Total Region	2,587	100.0	11,767,859	100,0	6,306	100,0

Source: Own elaboration based on SII 2020

The following graph (Figure 14) shows that there is a growth in the number of companies, sales and hired workers in companies potentially contributing to the GH_2 value chain.

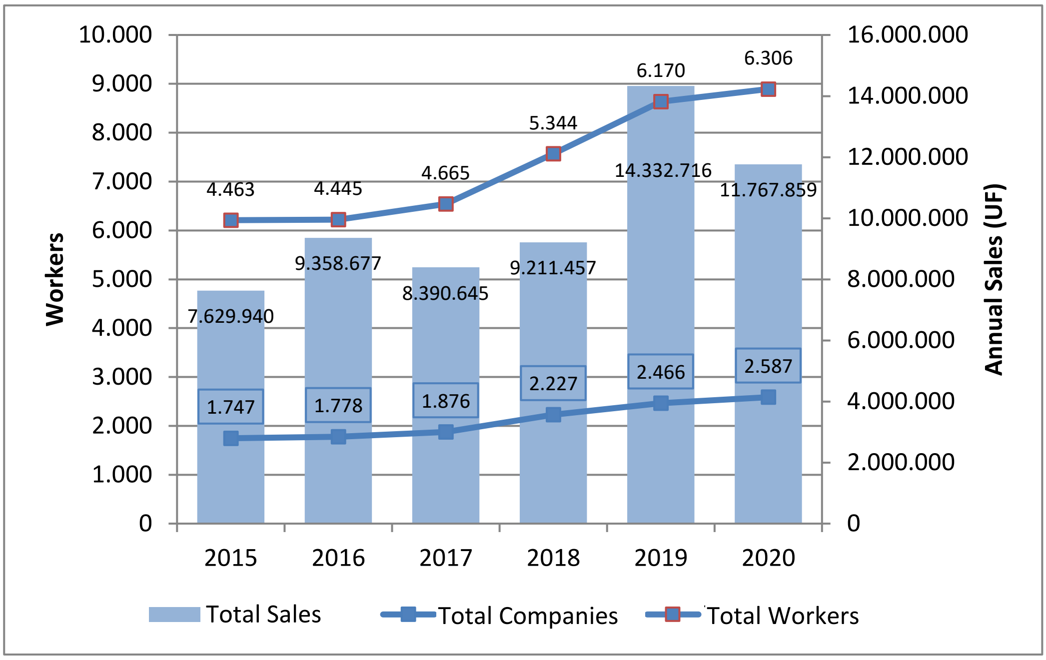


Figure 14: **Companies, annual sales, and dependent workers of GH_2 value chain activities, Magallanes Region, 2015-2020. Source: Own elaboration based on SII 2020**

However, not all sectors experienced growth in the same way in terms of growth in the number of companies, with construction, administrative and support service activities, and professional, scientific, and technical activities standing out above the rest.

Table 32: **Growth rates in the number of companies involved in GH_2 value chain activities, Magallanes Region, 2015-2019 and 2015-2020**

	Average annual growth 2015-2019	Total growth 2015-2019	Average annual growth 2015-2020	Total growth 2015-2020
C - Manufacturing industry	1.2	4.8	1.8	9.5
D - Supply of electricity, gas, steam, and air conditioning	4.7	20.0	12.5	80.0
F - Construction	22.1	122.2	28.6	251.6
G - Wholesale and retail trade	4.0	16.8	1.8	9.3
H - Transport and storage	6.9	30.7	5.2	29.0
M - Professional, scientific, and technical activities	21.1	115.2	15.4	104.8
N - Administrative and support services activities	21.9	121.1	19.9	147.4
Total	9.0	41.2	8.2	48.1

Source: Own elaboration based on SII 2020

In line with the growing number of companies, the number of workers hired has increased sharply in administrative and support service activities and construction, as well as, although at a slower pace, in professional, scientific, and technical activities and transportation.

Table 33: Growth rates in the number of workers hired in GH_2 value chain activities, Magallanes Region, 2015-2019 and 2015-2020

	Average annual growth 2015-2019	Total growth 2015-2019	Average annual growth 2015-2020	Total growth 2015-2020
C - Manufacturing industry	6.2	27.3	-6.3	-27.7
D - Supply of electricity, gas, steam, and air conditioning	-2.7	-10.5	-2.7	-12.6
F - Construction	13.8	67.5	17.1	120.2
G - Wholesale and retail trade	-3.1	-11.9	-4.2	-19.2
H - Transport and storage	10.4	48.4	8.2	48.0
M - Professional, scientific, and technical activities	14.1	69.4	7.6	44.1
N - Administrative and support services activities	38.0	262.8	35.5	356.1
Total	8.4	38.3	7.2	41.3

Source: Own elaboration based on SII 2020

According to regional information, Magallanes is in a process of transition with regards to the importance of its productive sectors (Center for the study of energy resources of the Universidad De Magallanes (CERE - UMAG), Proposed Energy Matrix for Magallanes by 2050). The energy mining sector, hydrocarbons, metallic and non-metallic mining went from representing close to 50% of the GDP in 1985, almost down to 22% in 2020. In contrast, tourism and its related services, such as commerce, restaurants, and hotels, as well as transport and communications, grew from 12.7% to close to 20% relative value generation. (Central Bank, 2021)

7.4.1 Specific economic activities of the GH_2 value chain Magallanes region

Magallanes has a relatively distributed productive structure, where no sector is as predominant as mining activities in Antofagasta. Nevertheless, and according to the Central Bank, the manufacturing sector is the one that has the greatest weight in the regional GDP, reaching 22.4% of the total in 2019.

From the analysis of the exports made in the region, within the industry, food production has special relevance, which constitutes almost 50% of region's exports, followed far behind by basic chemical products and refined petroleum products and by-products.

Manufacturing Industry in Magallanes

In the manufacturing industry, the economic activities selected are those related to the manufacture of metal products, specifically for construction and other purposes.

As noted, the companies dedicated to this activity typically incorporate, in addition to manufacturing, assembly processes of metallic structures and integrate preventive and corrective maintenance services for metallic structures. As can be seen in the following table, there is an increase in the number of companies dedicated to these activities maintaining the number of contracted workers.

Table 34: Companies and weighted workers in the metal products manufacturing industry (Economic activities 251100 and 259900)

Year	Number of companies	Workers weighted by months worked
2015	68	136
2016	64	139
2017	71	131
2018	73	109
2019	73	196
2020	81	133

Source: SII

A second relevant activity in the manufacturing industry of the GH_2 value chain is the production of electronic components and boards and computers and peripheral equipment (Economic activities 261000 and 262000).

As can be seen in the table below, few companies are engaged in these activities. Likewise, the number of workers hired is low, which suggests a strong use of alternative mechanisms to permanent hiring (project work, etc.) or family businesses.

Table 35: Companies and weighted workers in the electronic components and boards and computers and peripheral equipment industry (Economic activities 261000 and 262000)

Year	Number of companies	Workers weighted by months worked
2015	8	14
2016	7	12
2017	9	10
2018	3	0
2019	3	5
2020	2	0

Source: SII

Within manufacturing, the manufacturing of electric motors, generators and transformers, distribution and control devices and the manufacture of other types of electrical equipment (Economic activities 271000 and 279000) are considered as part of the GH_2 value chain.

Table 36: Companies and weighted workers in the manufacturing industry of electric motors, generators, and transformers (Economic activities 271000 and 279000)

Year	Number of companies	Workers weighted by months worked
2015	5	7
2016	6	7
2017	9	7
2018	6	7
2019	6	1
2020	6	7

Source: SII

This group of companies has maintained both their number and the number of workers hired. However, it is a rather small subset of companies.

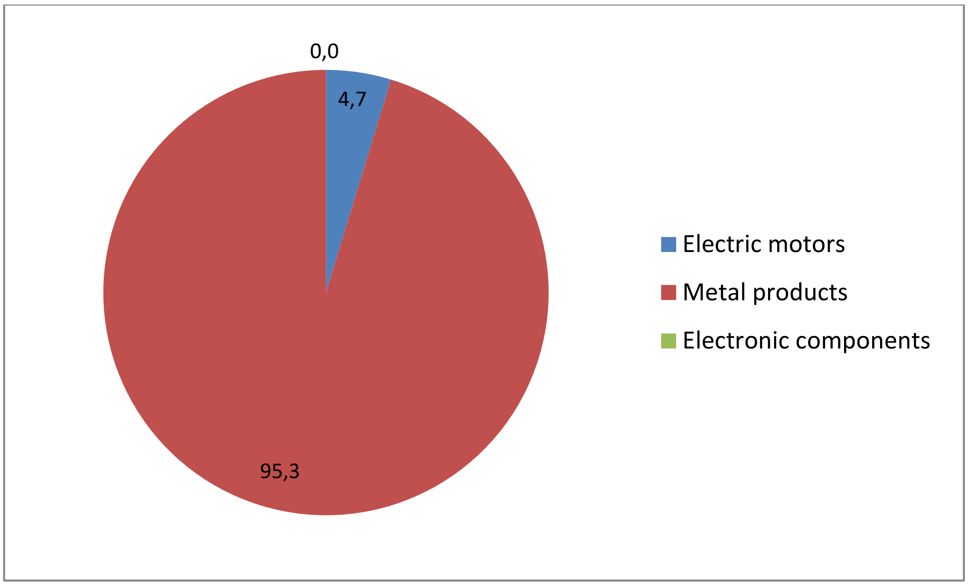


Figure 15: Dependent workers of Manufacturing Industry in Magallanes, 2020, Source: Own elaboration based on SII 2020.Industrial service sector in Magallanes

The activities considered as part of the GH_2 value chain in the services category are those related to professional, scientific, and technical activities and administrative and support service activities.

A relevant subset of service activities is that of legal advisory and representation services as well as management consulting activities. These activities have had an increase both in the number of companies and in relation to the number of workers hired.

Table 37: Companies and weighted employees in legal advisory and representation services and management consulting activities (Economic activities 691001 and 702000)

Year	Number of companies	Workers weighted by months worked
2015	89	276
2016	94	257
2017	94	252
2018	126	318
2019	151	272
2020	148	286

Source: SII

On the other hand, engineering services and services firms and related technical consulting activities have had a strong and sustained increase in the Magallanes region between 2015 and 2020

Table 38: Companies and weighted employees in engineering and related technical consulting services and services activities (Economic activities 711002 and 711003)

Year	Number of companies	Workers weighted by months worked
2015	36	33
2016	43	38
2017	55	36
2018	101	226
2019	118	251
2020	108	159

Source: SII

In the case of Security, Facility Support and Cleaning Services, considerable growth is observed between 2015 and 2020.

Table 39: Companies and weighted employees in Security, facility support and cleaning services (economic activities 801001, 811000, 812100 and 812909)

Year	Number of companies	Workers weighted by months worked
2015	52	268
2016	63	317
2017	73	454
2018	96	939
2019	104	950
2020	121	1,213

Source: SII

Finally, to the combined sector office administrative services activities, photocopying, document preparation and other specialized office support activities, both the number of companies and workers engaged in these activities has increased significantly, although when compared to the volumes in the Antofagasta region, they are considerably lower.

Table 40: Companies and weighted workers in office administrative services Photocopying, document preparation and other specialized office support activities (economic activities 821100 and 821900)

Year	Number of companies	Workers weighted by months worked
2015	5	2
2016	5	2
2017	8	1
2018	18	9
2019	22	29
2020	20	18

Source: SII

In the group of companies dedicated to manufacturing, those related to metal products are the most relevant in terms of number of companies and workers hired, although the market is considerably smaller compared to the Antofagasta region.

7.5 Conclusions

For both regions, the information from the SII shows the existence of companies in all the required categories (Manufacturing industry, Supply of electricity & gas, Construction, Commerce and Transport).

The comparative analysis of the selected regions shows significant differences with respect to:

1. The universe of companies potentially participating in the value chain of Green Hydrogen production is significantly larger in the region of Antofagasta compared to Magallanes, this is mainly related to the mining industrial activity and its potential linkages (ENGIE, ENAEX).
2. Related to the above, there are advantages in Antofagasta, especially in the availability of skilled labor. The Magallanes region has, due to the small number of companies that can form part of the production chain, a potentially insufficient pool of skilled labor.

8 ESTIMATED GROSS EMPLOYMENT IN THE GREEN HYDROGEN INDUSTRY

We use employment factors discussed in the study "Cuantificación del encadenamiento laboral para el desarrollo del hidrógeno en Chile bajo un escenario de exportación" from GIZ, HINICIO Chile.

Direct employment: refers to employment generated directly by basic activities and includes project planning, equipment manufacturing, equipment transportation, construction, plant installation and assembly, plant operation and maintenance, and decommissioning activities.

Indirect employment: includes employment in industries that supply and support the basic activities required for the development of the projects. These are those related to the manufacture of raw materials (e.g. steel, plastics or other materials), financial services, legal services, architectural and industrial design services, research and development activities, among others.

The employment factors, which provide the number of jobs per MW or Km, etc. for each technology, were adapted to obtain full-time equivalents (FTE).

Regional employment multipliers are also used, considering the different stages of economic development and productivity of the country.

Likewise, decline factors are considered for each technology, related to automation and the reduction of employment in a given percentage per year[16]. With these parameters, the following employment factors were obtained:

Table 41: Direct employment factors for green hydrogen production

Phase	H_2 Production by Electrolysis			
	2030	2040	2050	Indirect jobs
Construction	112.8	101.2	89.7	0.9
Operation and maintenance	52.5	47.1	41.7	0.9

Source: GIZ, HINICIO Chile, 2021

Considering an FTE/100 MW factor, employment generation ranges between 1.12 and 0.89 between 2030 and 2050 in the construction stage, while these values are lower by half in operation and maintenance, which, however, stretches over a much longer period than construction.

[16] The employment reduction factors were only used for wind, photovoltaic and hydrogen energy production. They were not used in the other segments of the value chain, since the information found by the GIZ study, HINICIO Chile, 2021, came from studies in other regions (Middle East and Asia), which could generate distortions in the results when applied to Chile.

Table 42: Employment factors for electricity generation with solar plants. Based on a 50 MW plant

Phase	Photovoltaic solar plants 50MW			
	2030	2040	2050	Indirect jobs
Construction (per MW)	1.86	1.67	1.48	0.8
Operation and maintenance	0.63	0.57	0.5	0.8
Other[17]	0.34	0.31	0.27	0.8

Source: GIZ, HINICIO Chile, 2021

Considering an FTE/MW factor, employment generation ranges between 1.86 and 1.48 between 2030 and 2050 in the construction stage, while these values are at one third during operation and maintenance and one sixth during planning and decommissioning.

Table 43: Employment factors associated with electricity transmission

Phase	Electricity transmission			
	2030	2040	2050	Indirect jobs
Construction (per km)	12.7	12.7	12.7	2.1
Operation and maintenance Factor per km	0.15	0.15	0.10	2.1

Source: GIZ, HINICIO Chile, 2021

Considering a per km factor, employment generation is 12.7 between 2030 and 2050 in the construction stage, while this value reduced to 0.15 in operation and maintenance.

Table 44: Employment factors for Ammonia. Based on a plant with a production of between 450 to 900 kton NH_3 /year, equivalent to an EZ between 1 and 2 GW

Phase	Ammonia Production			
	2030	2040	2050	Indirect jobs
Construction	0.85	0.85	0.85	0.2
Operation and maintenance	0.03	0.03	0.03	0.2

Source: GIZ, HINICIO Chile, 2021

In the case of ammonia production plants, considering an FTE/ton factor, the generation of employment is 0.85 between 2030 and 2050 in the construction stage, while these values are at 0.03 in operation and maintenance.

17 Project Planning + Decommissioning

Table 45: Employment factors for hydrogen storage (gas)

Phase	Hydrogen Storage (Gas)			
	2030	**2040**	**2050**	**Indirect jobs**
Construction	0.32	0.32	0.32	0.86
Operation and maintenance	0.29	0.29	0.29	0.86

Source: GIZ, HINICIO Chile, 2021

Table 46: Employment factors for hydrogen storage (liquefied)

Phase	Hydrogen Storage (Liquefied)			
	2030	**2040**	**2050**	**Indirect jobs**
Construction	0.30	0.30	0.30	0.16
Operation and maintenance	0.02	0.02	0.02	0.16

Source: GIZ, HINICIO Chile, 2021

Finally, for the storage of Green Hydrogen in gaseous form the employment factor of FTE/1,000 m^3 is considered.

While for the second one, the employment factor calculated for the operation and maintenance phase of the liquefaction ports was considered, in this case, estimated based on the FTE/kton factor.

8.1 Job creation in Antofagasta

According to Report_V1-2_2022-02-10 the following production figures are considered in the various components of the Green Hydrogen value chain for the years 2025-2050:

Table 47: Production figures in the various components of the GH_2 value chain for the Antofagasta region

Antofagasta	*Unit*	*2025*	*2030*	*2035*	*2040*	*2045*	*2050*
Electrolysis	MW	199	1,331	2,795	2,006	691	744
Photovoltaic Plant	MW	398	2,663	5,591	4,011	1,382	1,489
Electrical transmission	km	60	390	840	600	210	240
H2 Storage (Gas)	1000 m^3	6	39	82	59	20	22
Production NH_3	(kt/year)/year	75	350	59	464	88	94
LH_2 liquefaction	(kt/year)/year	0	9	94	36	18	20

Source: Report_V1-2_2022-02-10

These values provide, according to the employment factors indicated above for each of the segments of the value chain, the following amounts of employment:

8.1.1 Direct employment[18]

Table 48: Number of direct jobs in green hydrogen production, Antofagasta[19]

Phase	*Unit*	*2025*	*2030*	*2035*	*2040*	*2045*	*2050*
Construction	Jobs	225	1,502	2,829	2,030	620	668
Operation and maintenance	Jobs	523	4,018	10,187	14,910	14,642	16,194
Total Electrolysis	Jobs	748	5,520	13,016	16,940	15,262	16,862

Source: Own elaboration based on GIZ, HINICIO Chile, 2021.

Table 49: Number of direct jobs in solar photovoltaic plants, Antofagasta

Phase	*Unit*	*2025*	*2030*	*2035*	*2040*	*2045*	*2050*
Construction	Jobs	741	4,953	9,336	6,698	2,045	2,203
Operation and maintenance	Jobs	1,255	9,643	24,658	36,089	35,112	38,834
Other[20]	Jobs	135	905	1,733	1,243	373	402
Total Photovoltaic Plant	Jobs	2,131	15,501	35,727	44,031	37,531	41,439

Source: Own elaboration based on GIZ, HINICIO Chile, 2021.

Table 50: Number of direct jobs in electricity transmission, Antofagasta

Phase	*Unit*	*2025*	*2030*	*2035*	*2040*	*2045*	*2050*
Construction	Jobs	762	4,953	10,668	7,620	2,667	3,048
Operation and maintenance	Jobs	45	338	968	1,418	1,050	1,170
Total Electricity Transmission	Jobs	807	5,291	11,636	9,038	3,717	4,218

Source: Own elaboration based on GIZ, HINICIO Chile, 2021.

18 The employment reduction factors were only used for wind, photovoltaic and hydrogen energy production. They were not used in the other segments of the value chain, since the information found by the GIZ study, HINICIO Chile, 2021, came from studies in other regions (Middle East and Asia), which could generate distortions in the results when applied to Chile.

19 In relation to energy and hydrogen production for the years 2025, 2035 and 2045, the employment factors for the years 2030, 2040 and 2050, respectively, were used.

20 Project Planning + Decommissioning

Table 51: Number of direct jobs in storage of H_2 (gas), Antofagasta

Phase	*Unit*	*2025*	*2030*	*2035*	*2040*	*2045*	*2050*
Construction	Jobs	2	12	26	19	6	7
Operation and maintenance	Jobs	8	65	184	269	298	330
Total Storage of H2 (Gas)	Jobs	10	78	210	288	305	337

Source: Own elaboration based on GIZ, HINICIO Chile, 2021.

Table 52: Number of direct jobs in NH_3 production, Antofagasta

Phase	*Unit*	*2025*	*2030*	*2035*	*2040*	*2045*	*2050*
Construction	Jobs	64	298	50	395	75	80
Operation and maintenance	Jobs	11	64	73	142	156	170
Total NH_3 Production	Jobs	75	362	123	537	230	250

Source: Own elaboration based on GIZ, HINICIO Chile, 2021.

Table 53: Number of direct jobs in LH_2 liquefaction, Antofagasta

Phase	*Unit*	*2025*	*2030*	*2035*	*2040*	*2045*	*2050*
Construction	Jobs	0	3	28	11	5	6
Operation and maintenance	Jobs	0	1	10	14	16	18
LH_2 liquefaction	Jobs	0	3	27	37	44	48

Source: Own elaboration based on GIZ, HINICIO Chile, 2021.

8.1.2 Indirect employment

Table 54: Number of indirect jobs in the Green Hydrogen value chain, Antofagasta

Antofagasta	*Unit*	*2025*	*2030*	*2035*	*2040*	*2045*	*2050*
Electrolysis	Jobs	673	4,968	11,714			
Photovoltaic Plant	Jobs	1.705	12.401	28.582	35.225	30.024	33.151
Electrical transmission	Jobs	630	4.725	13.545	19.845	22.050	24.570
H_2 Storage (Gas)	Jobs	25	193	545	798	885	979
Production NH_3	Jobs	8	43	48	95	104	113
LH_2 liquefaction	Jobs	0	7	83	112	126	141
Total	Jobs	3,041	22,336	54,517	71,320	66,924	74,129

Source: Own elaboration based on Report_V1-2_2022-02-10 and GIZ, HINICIO Chile, 2021.

In direct relation to the projected production values, indirect employment has a strong growth in the first five-year period considered (2025-2030), which decreases to about 10% between 2045-2050. On average, five-year employment growth is in the order of 100%.

8.1.3 Characteristics of direct employment

The following graph shows the distribution of each segment of the value chain in the generation of direct employment. The bulk of employment generation is attributable to electricity generation and transmission (around 84%), with the contribution of H_2 production varying around 14%.

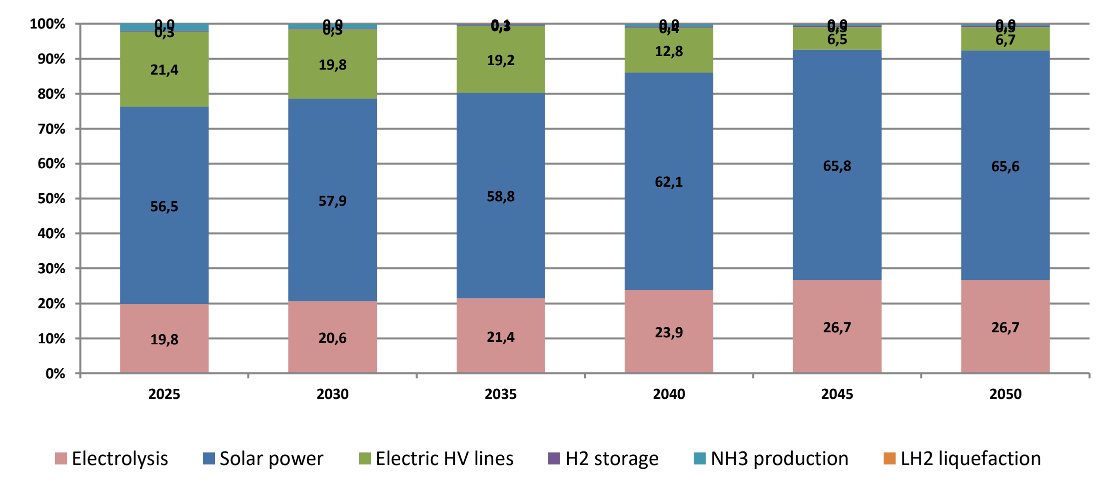


Figure 16: Percentage of direct employment generation by segment of the Green Hydrogen value chain, years 2025-2050, Antofagasta region. Source: Own elaboration based on Report_V1-2_2022-02-10 and GIZ, HINICIO Chile, 2021

At the end of the period, job creation in the three main industries reaches 62.500 direct jobs created.

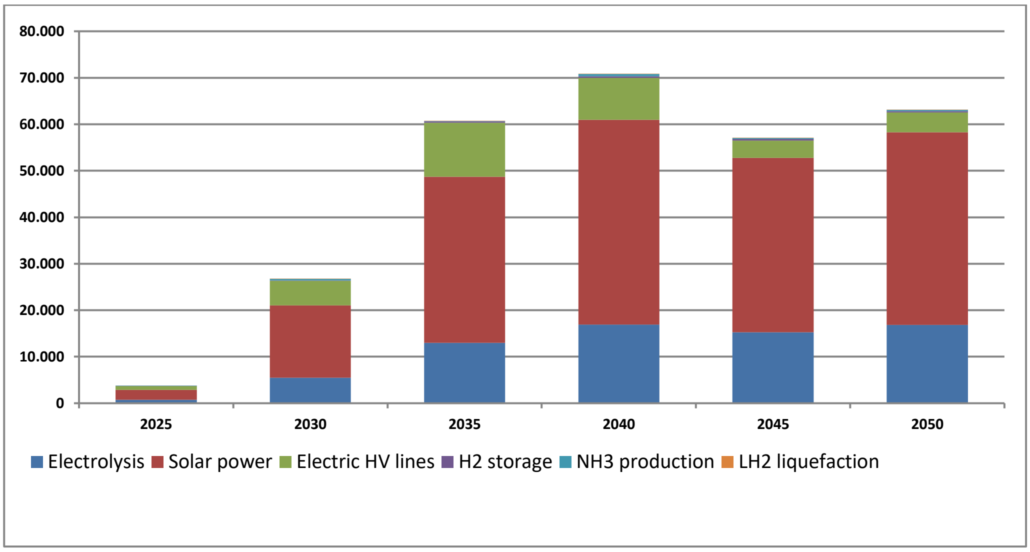


Figure 17: **Employment generation by segment of the Green Hydrogen value chain, years 2025-2050, Antofagasta region. Source: Own elaboration based on Report_V1-2_2022-02-10 and GIZ, HINICIO Chile, 2021**

8.1.4 Characteristics of indirect employment

In relation to indirect employment, the following graph shows the distribution of each segment of the value chain in the generation of indirect employment. Throughout the entire period, the most relevant industries are energy production and distribution.

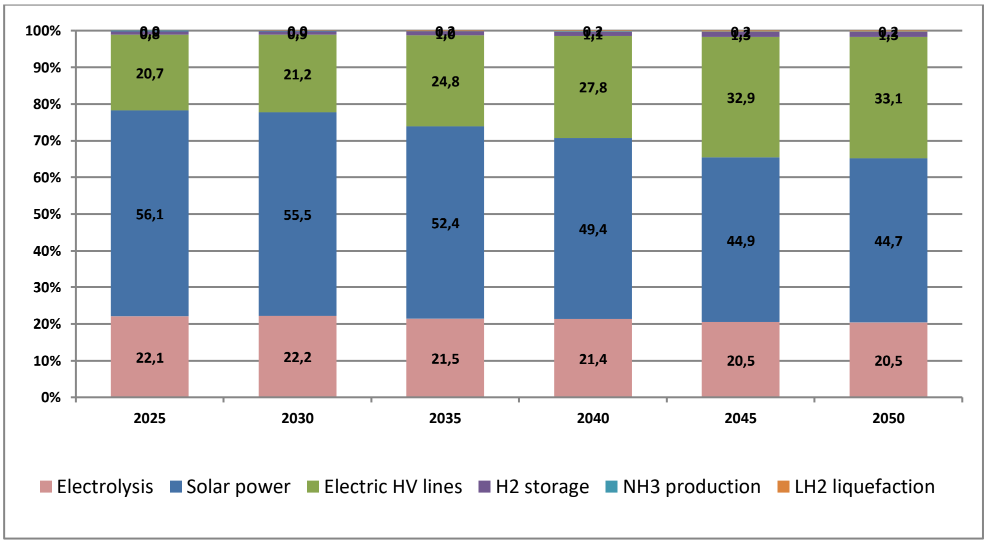


Figure 18: **Percentage of indirect employment generation by segment of the Green Hydrogen value chain, years 2025-2050, Antofagasta region. Source: Own elaboration based on Report_V1-2_2022-02-10 and GIZ, HINICIO Chile, 2021**

On the other hand, the production of NH_3, storage of LH_2, gaseous H_2 and electrolysis is of limited relevance in the generation of indirect employment.

8.1.5 Total jobs generated in Antofagasta

Table 55: Total number of jobs created in the GH_2 value chain by year, Antofagasta

Employment	*2025*	*2030*	*2035*	*2040*	*2045*	*2050*
Direct	3,771	26,754	60,750	70,858	57,065	63,128
Indirect	3,041	22,336	54,517	71,320	66,924	74,129
Total	6,812	49,090	115,267	142,178	123,989	137,258

Source: Own elaboration based on Report_V1-2_2022-02-10 and GIZ, HINICIO Chile, 2021.

Hydrogen production capacities increase significantly between 2025 and 2035 with more moderate growth thereafter. This has consequences on job creation at the regional level, as there is strong growth in employment between 2025 and 2035 turning to a stable situation thereafter. This is based on declining jobs in construction as the new construction of plants is decreasing while on the other hand operation and maintenance jobs continue to grow in parallel to increasing hydrogen production capacities (Figure 19).

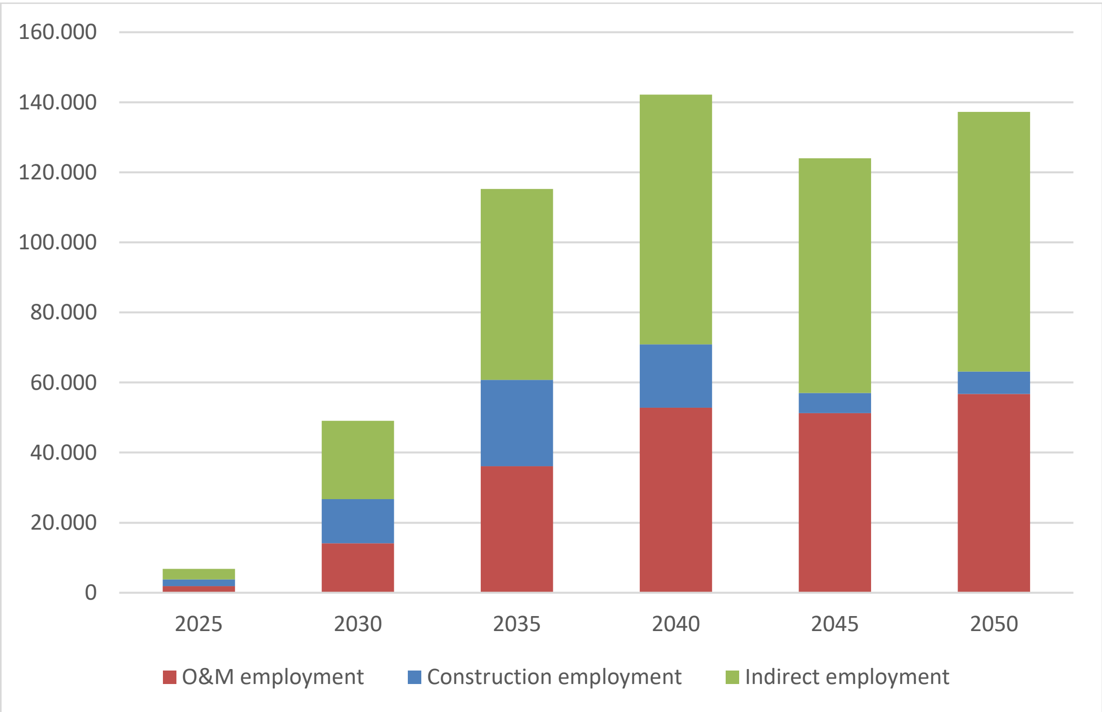


Figure 19: Generation of employment by phase of production cycle and indirect employment

As can be seen in the graph, throughout the period analyzed, indirect jobs have a similar significance as that observed in direct jobs, ranging between 44% and 50% of total jobs generated. On the other hand, the jobs generated during the construction process in the various industries reach approximately 40% to 50% of the total direct employment generated, until the year 2035. Subsequently, the operation and maintenance of the industries will become more important in the generation of employment.

8.2 Job creation in Magallanes

According to Report_V1-2_2022-02-10 the following production figures are considered in the various components of the Green Hydrogen value chain for the years 2025-2050:

Table 56: Production figures in the various components of the GH_2 value chain for the Magallanes region.

Magallanes	*Unit*	*2025*	*2030*	*2035*	*2040*	*2045*	*2050*
Electrolysis	MW	119	902	1,998	974	895	1,254
Photovoltaic Plant	MW	238	1,804	3,997	1,948	1,789	2,508
Electrical transmission	km	12	108	240	120	108	144
H_2 Storage (Gas)	1000 m³	5	38	84	41	37	53
Production NH_3	(kt/year)/year	61	462	528	36	199	100
LH_2 Storage	(kt/year)/year	0	9	109	74	75	110

These figures, according to the employment factors indicated above for each of the value chain segments, provide the following amounts of employment:

8.2.1 Direct employment[21]

Table 57: Number of direct jobs from green hydrogen production, Magallanes[22]

Phase	*Unit*	*2025*	*2030*	*2035*	*2040*	*2045*	*2050*
Construction	Jobs	134	1,017	2,022	985	802	1,125
Operation and maintenance	Jobs	312	2,680	7,110	9,403	10,190	12,805
Total Electrolysis	Jobs	447	3,697	9,132	10,389	10,993	13,930

Source: Own elaboration based on GIZ, HINICIO Chile, 2021.

Table 58: Number of direct jobs in wind power production, Magallanes

Phase	*Unit*	*2025*	*2030*	*2035*	*2040*	*2045*	*2050*
Construction	Jobs	811	6,150	13,429	6,545	5,940	8,328
Operation and maintenance	Jobs	238	2,041	6,038	7,986	9,775	12,283
Other[23]	Jobs	297	2,255	4,916	2,396	2,183	3,060
Wind Power Plant	Jobs	1,346	10,446	24,382	16,926	17,898	23,672

Source: Own elaboration based on GIZ, HINICIO Chile, 2021.

Table 59: Number of direct jobs in electricity transmission, Magallanes

Phase	*Unit*	*2025*	*2030*	*2035*	*2040*	*2045*	*2050*
Construction	Jobs	152	1,372	3,048	1,524	1,372	1,829
Operation and maintenance	Jobs	9	90	270	360	294	366
Electricity Transmission	Jobs	161	1,462	3,318	1,884	1,666	2,195

Source: Own elaboration based on GIZ, HINICIO Chile, 2021.

21 The employment reduction factors were only used for wind, photovoltaic and hydrogen energy production. They were not used in the other segments of the value chain, since the information found by the GIZ study, HINICIO Chile, 2021, came from studies in other regions (Middle East and Asia), which could generate distortions in the results when applied to Chile.

22 In relation to energy and hydrogen production for the years 2025, 2035 and 2045, the employment factors for the years 2030, 2040 and 2050, respectively, were used.

23 Project Planning + Decommissioning

Table 60: Number of direct jobs in H_2 storage (gas), Magallanes

Phase	*Unit*	*2025*	*2030*	*2035*	*2040*	*2045*	*2050*
Construction	Jobs	2	12	27	13	12	17
Operation and maintenance	Jobs	7	62	183	242	297	373
Storage of H2 (Gas)	Jobs	9	74	210	255	309	390

Source: Own elaboration based on GIZ, HINICIO Chile, 2021.

Table 61: Number of direct jobs in NH_3 production, Magallanes

Phase	*Unit*	*2025*	*2030*	*2035*	*2040*	*2045*	*2050*
Construction	Jobs	52	393	449	30	169	85
Operation and maintenance	Jobs	9	79	158	163	193	208
NH_3 Production	Jobs	61	472	606	193	362	292

Source: Own elaboration based on GIZ, HINICIO Chile, 2021.

Table 62: Number of direct jobs in LH_2 liquefaction, Magallanes

Phase	*Unit*	*2025*	*2030*	*2035*	*2040*	*2045*	*2050*
Construction	Jobs	0	3	33	22	22	33
Operation and maintenance	Jobs	0	1	12	19	27	38
LH_2 liquefaction	Jobs	0	4	45	41	49	71

Source: Own elaboration based on GIZ, HINICIO Chile, 2021.

8.2.2 Indirect employment

Table 63: Number of indirect jobs in the Green Hydrogen value chain, Magallanes

Antofagasta	*Unit*	*2025*	*2030*	*2035*	*2040*	*2045*	*2050*
Electrolysis	Jobs	402	3,327	8,219	9,350	9,893	12,537
Photovoltaic Plant	Jobs	1,077	8,357	19,506	13,541	14,318	18,937
Electrical transmission	Jobs	126	1,260	3,780	5,040	6,174	7,686
H_2 Storage (Gas)	Jobs	21	184	543	719	880	1,105
Production NH_3	Jobs	6	52	105	109	129	139
LH_2 Storage	Jobs	0	7	95	153	213	301
Total	Jobs	1,632	13,187	32,248	28,912	31,607	40,706

Source: Own elaboration based on Report_V1-2_2022-02-10 and GIZ, HINICIO Chile, 2021.

8.2.3 Characteristics of direct employment

The following graph shows the distribution of each segment of the value chain in the generation of employment. During the entire period analyzed, the bulk of the employment generated is due to the electricity generation industry, followed by the H_2 production industry.

Percentage of direct employment generation according to Green Hydrogen value chain segment, years 2025-2050, Magallanes Region.

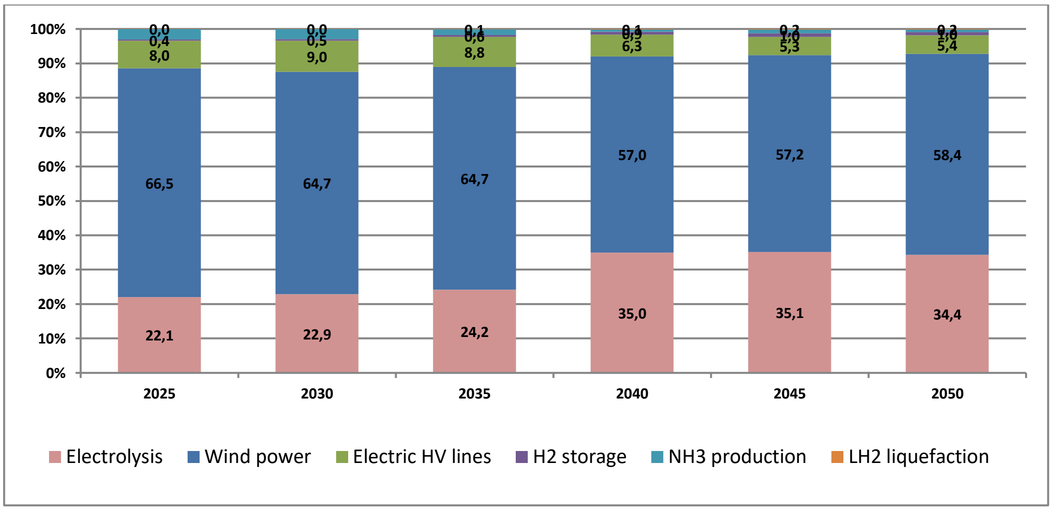


Figure 20: Percentage of direct employment generation by segment of the Green Hydrogen value chain, years 2025-2050, Magallanes region. Source: Own elaboration based on Report_V1-2_2022-02-10 and GIZ, HINICIO Chile, 2021

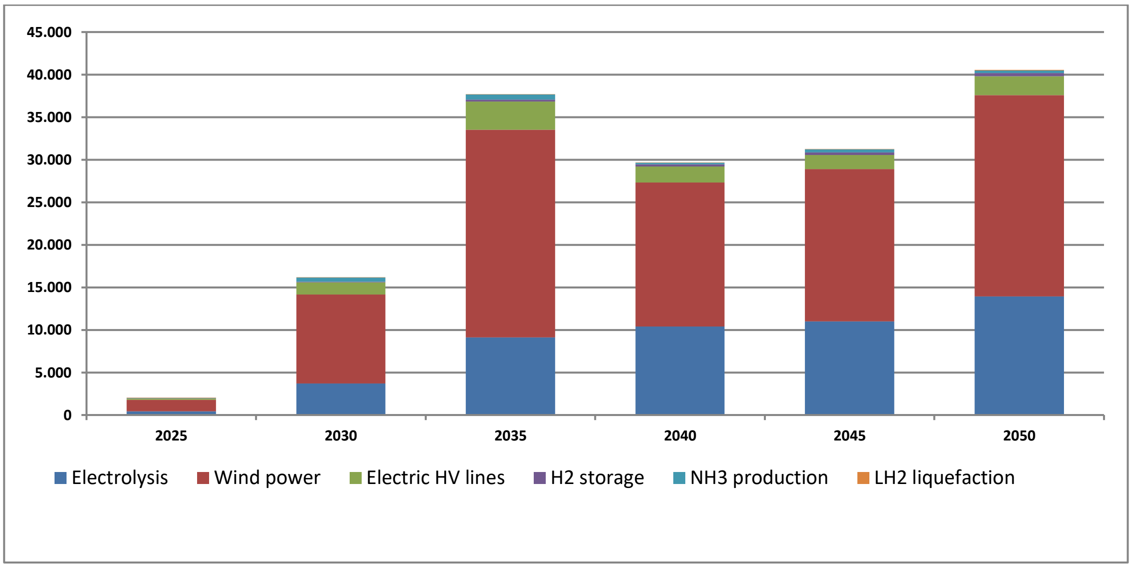


Figure 21: **Employment generation by segment of the Green Hydrogen value chain, years 2025-2050, Magallanes region. Source: Own elaboration based on Report_V1-2_2022-02-10 and GIZ, HINICIO Chile, 2021**

8.2.4 Characteristics of indirect employment

In relation to indirect employment, the following graph shows the distribution of each segment of the value chain in the generation of indirect employment. During the entire period considered, electricity generation is the main source of job creation, followed by production of H_2. The other industries have a secondary contribution.

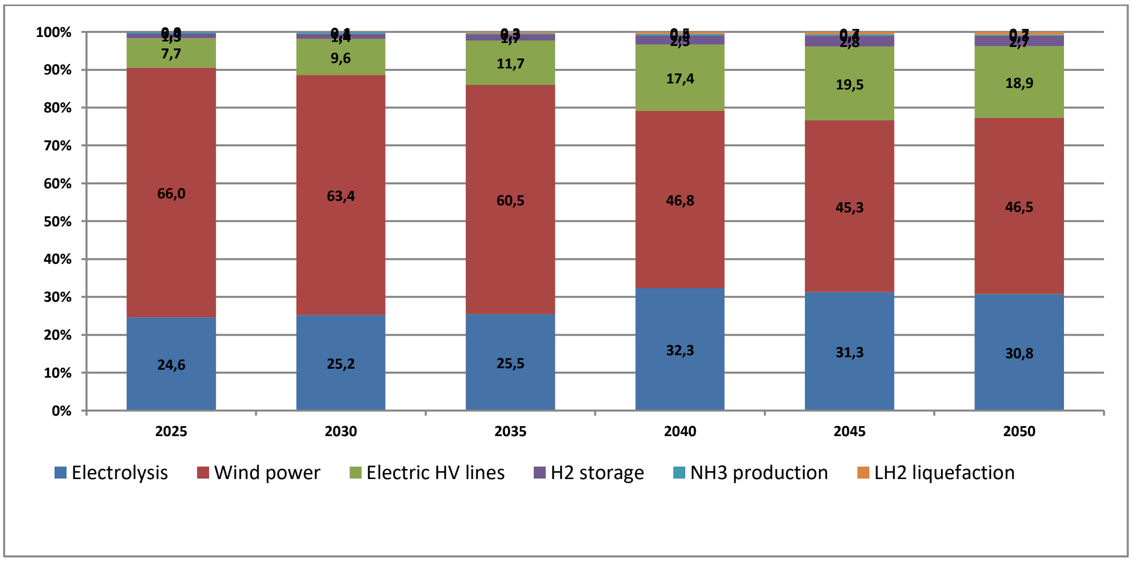


Figure 22: **Percentage of indirect employment generation by segment of the Green Hydrogen value chain, years 2025-2050, Magallanes region. Source: Own elaboration based on Report_V1-2_2022-02-10 and GIZ, HINICIO Chile, 2021**

8.2.5 Total jobs generated in Magallanes

Table 64: Total number of jobs created in the GH_2 value chain by year, Magallanes

Employment	*2025*	*2030*	*2035*	*2040*	*2045*	*2050*
Direct	2,024	16,154	37,693	29,689	31,276	40,549
Indirect	1,632	13,187	32,248	28,912	31,607	40,706
Total	3,656	29,341	69,941	58,600	62,883	81,255

Source: Own elaboration based on Report_V1-2_2022-02-10 and GIZ, HINICIO Chile, 2021.

Hydrogen production capacities increase significantly between 2025 and 2035 with more moderate growth thereafter. This has consequences on job creation at the regional level, as there is strong growth in employment between 2025 and 2035 turning to a stable situation thereafter. This is based on declining jobs in construction as the new construction of plants is decreasing while on the other hand operation and maintenance jobs continue to grow in parallel to increasing hydrogen production capacities (Figure 23).

Figure 23: Generation of employment by phase of production cycle and indirect employment. Source: Own elaboration based on Report_V1-2_2022-02-10 and GIZ, HINICIO Chile, 2021

As can be seen in the graph, throughout the period analyzed, indirect jobs have a similar significance to that observed in direct jobs, ranging between 44% and 50% of total jobs generated. On the other hand, the jobs generated during the construction process in the various industries reach approximately 70% of the total direct employment generated, until the year 2035. Subsequently, the operation and maintenance of the industries becomes more important in the generation of employment.

8.3 Conclusions

The greatest job creation impact occurs in the construction phase of installations, which represents two thirds of the total number of workers employed. This will be the case until 2035, when the operation and maintenance of the industries becomes more important in the generation of employment as new constructions decreases while the operational capacities continue to grow with related requirements for operation and maintenance.

The bulk of the employment generated relates to electricity generation and transmission, as well as to H_2 production. In both regions, in line with the growth of production values, employment grows strongly during the ten-year period 2025-2035. In both regions, the average employment growth during the period is above 80% per 5-year period.

Table 65: Comparison of employment between region

Employment	*2025*	*2030*	*2035*	*2040*	*2045*	*2050*
Antofagasta Direct	3,771	26,754	60,750	70,858	57,065	63,128
Magallanes Direct	2,024	16,154	37,693	29,689	31,276	40,549
Antofagasta Indirect	3,041	22,336	54,517	71,320	66,924	74,129
Magallanes Indirect	1,632	13,187	32,248	28,912	31,607	40,706
Antofagasta Total	6,812	49,090	115,267	142,178	123,989	137,258
Magallanes Total	3,656	29,341	69,941	58,600	62,883	81,255

9 Regulatory Restrictions and Challenges

To identify the main regulatory challenges facing the development of H_2 hubs, it is important to consider the territorial planning instruments that govern the areas of interest in this study, in the regions of Antofagasta and Magallanes.

However, the existence of these instruments was conditioned to the enactment and application of Law No. 20,074 of the Republic of Chile, which introduces amendments to Law No. 19,175, Constitutional Organic Law on Regional Government and Administration.

These amendments are aimed at strengthening the regionalization of the country. In particular, said law enacted in February 2018, included modifications to the law in force at that time. It is to be highlighted that the modification of Article 17, incorporates as exclusive attributions to the regional government the elaboration and approval of the regional land management plan, which governs the rest of the minor land management instruments.

It needs to be pointed out that during conversations with the regional governments, it became clear that the territorial instruments developed to date are no longer in force, and that new adjustments must be made in accordance with the new regional powers.

Considering the above, for the purpose of this study, the most recent territorial planning instruments (elaborated prior to the enactment of the new law) will be used to guide the discussions regarding the regulatory challenges in the implementation of H_2 hubs.

9.1 Definition of Terms

The different instruments used for territorial planning in Chile are shown in the figure below:

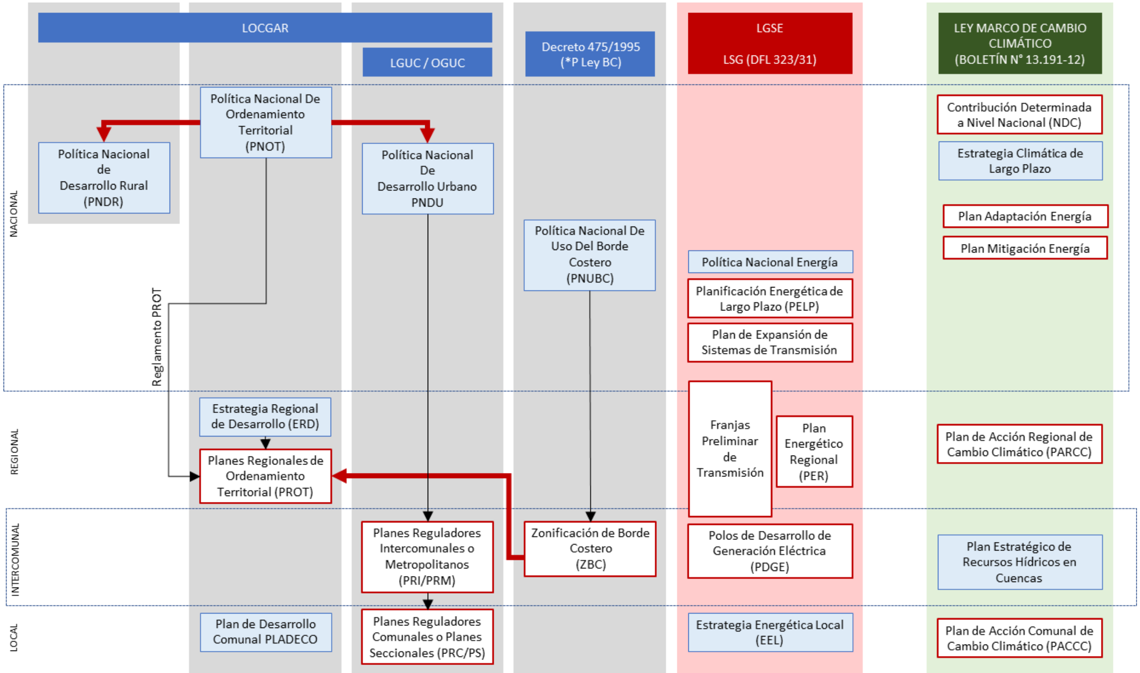


Figure 24: **Summary of the main instruments with territorial impact in Chile (Síntesis de los principales instrumentos con incidencia territorial en Chile), source: Ministerio de Energía. Esquema referencial elaborado en base a leyes referenciadas y Boletín n°13.191-1**

A brief definition of these documents is given below.

National land-use planning policy (PNOT)

The general objective of the Politica Nacional Ordenamiento Territorial (PNOT) is to provide a framework that strategically guides land use planning and management, based on its potential, singularities, and functional relationships, since it is the convergence of diverse interests and actions for the creation of opportunities, contributing to sustainable development, a low-emission economy, and the improvement of the quality of life of its inhabitants. This document is still being worked on and is not yet public.

National urban development policy (PNDU)

The Politica Nacional de Desarrollo Urbano PNDU) (Ministerio de Vivienda y Urbanismo, 2014). The PNDU focuses its attention on people and their quality of life, this being one of its fundamental axes.

The policy covers urban areas and human settlements in the country and proposes sustainable growth. It proposes profound reforms in the legislation and institutions that affect cities and therefore must be understood as a State Policy, which transcends governments.

Regional Land Use Plan (PROT)

Plan Regional de Ordenamiento Territorial (PROT) seeks to guide and harmonize the actions of the various bodies of the state administration in the region, as well as to inform private agents of the development model of the territory, which includes both its geographic dimension and its sustainability dimension, referring to the certainty that the result will remain valid in the medium and long term, given that the instrument arises from social agreements or socially constructed.

The planning instruments and tools to be applied in land-use planning will therefore be derived from the set of social values, national and regional public policies, and the economic and environmental conditions of the territories to be intervened.

These instruments must be duly reflected and integrated into the PROT, whose ultimate objective is to promote territorial development and equity.

General Law of Urbanism and Construction (LGUC)

Ley General de Urbanismo y Construccion (LGUC) this law is related to urban planning, urbanization and construction, and the ordinances on the matter issued by the President of the Republic, shall govern throughout the national territory.

This general legislation will have three levels of action:

a) The General Law, which contains the principles, attributions, powers, faculties, responsibilities, rights, sanctions, and other norms that govern agencies, officials, professionals and individuals in urban planning, urbanization and construction actions.

b) The General Ordinance, which contains the regulatory provisions of this law and regulates the administrative procedure, the process of urban planning, urbanization and construction, and the technical standards of design and construction required in the last two areas mentioned.

c) The Technical Standards, which contain and define the technical characteristics of the projects, materials, construction systems and urbanization, in accordance with the mandatory requirements established by the General Ordinance.

General Ordinance of Urbanism and Construction (OGUC)

Ordenanza General de urbanismo y construccion (OGUC) regulate the administrative procedure, the urban planning process, the urbanization process, the construction process, and the technical design and construction standards required.

For the two municipalities under study, the existing urban planning documents are shown below, these documents meet the requirements indicated in the Regional Land Use Plan (PROT), General Urban Planning and Construction Law (LGUC) and General Urban Planning and Construction Ordinance (OGUC).

Table 66: Regulation document sites and links

Document	*Site*	*Link*
National land-use planning policy (PNOT)	Not realeased	
National urban development policy (PNDU)	https://cndu.gob.cl/	PNOT
Regional Land Use Plan (PROT)	https://subdere.gov.cl/	PROT
General Law of Urbanism and Construction (LGUC)	https://www.bcn.cl/	LGUC
General Ordinance of Urbanism and Construction (OGUC)	https://minvu.cl/	OGUC

9.2 Mejillones

For the region of Antofagasta and the municipality of Mejillones, the following territorial planning instruments exist.

9.2.1 Regional urban development plan

The Plan Regional Desarrollo Urbano (Gobierno de Chile, Ministerio de Vivienda y Urbanismo, 2004) is an instrument to guide the concrete implementation in the respective territory of the criteria, objectives and basic agreements developed for the future of the region.

The regional plan map shown below indicates population centers, conservation protection areas, areas of the national system of state protected wildlife areas, and areas of historical interest.

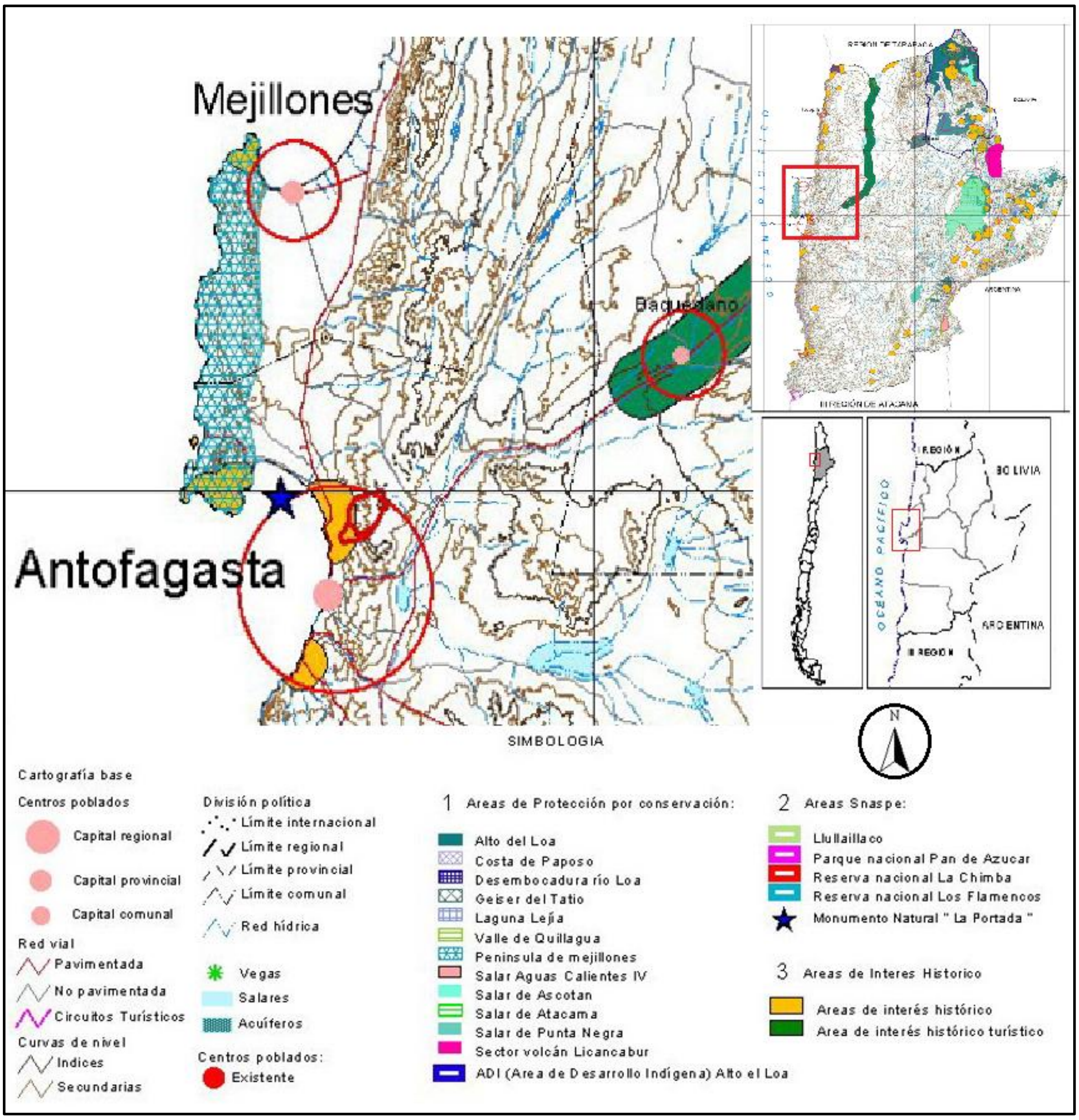


Figure 25: Part of the drawing of the regional urban development (Gobierno de Chile, Ministerio de Vivienda y Urbanismo, 2004)

Restrictions and Challenges

Regarding the challenges that this map shows, it is observed that to the west of Mejillones there are areas of historical interest and areas of conservation protection, covering an important part of the Mejillones peninsula, therefore no industrial construction can be carried out in that area.

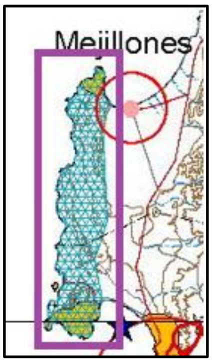


Figure 26: **Protected sector close to Mejillones, defined area of Figure 25**

In the whole region of Antofagasta, much of the east side is occupied by historic or protected sites, so projects in those areas have to be planned with accuracy and foresight.

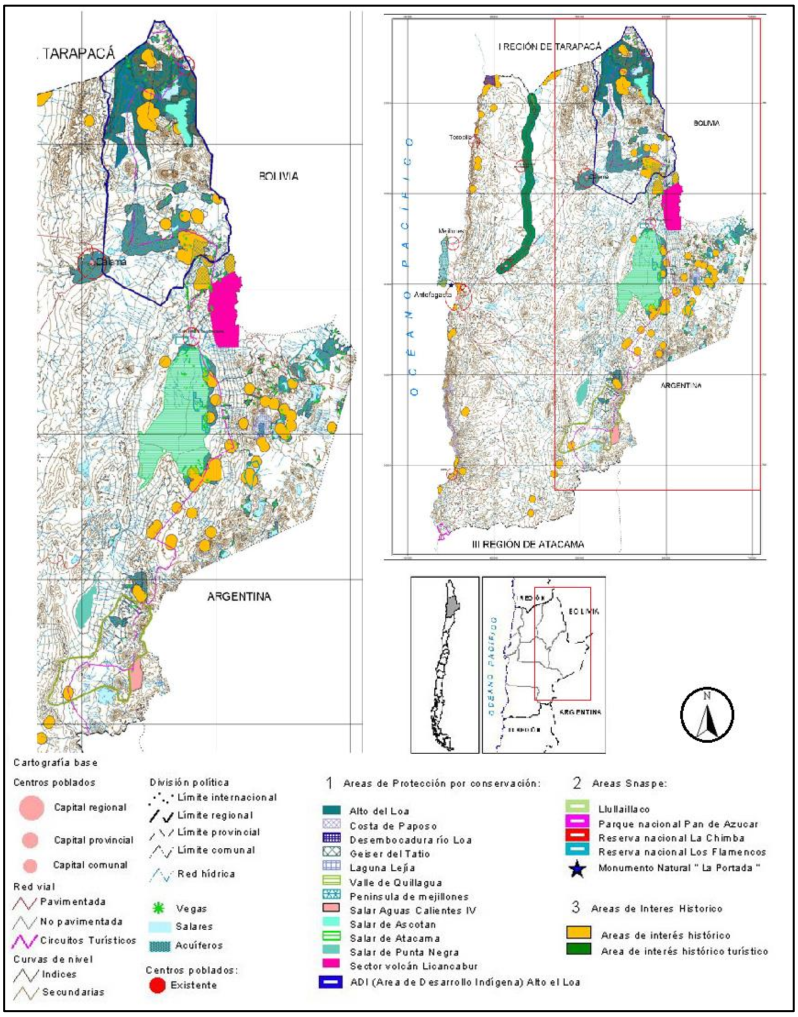


Figure 27: **Part of the drawing of the regional urban development (Gobierno de Chile, Ministerio de Vivienda y Urbanismo, 2004) , protected sector east of Antofagasta region**

9.2.2 Intercommunal Regulatory Plan of the Coastal Border of the II Region (PRIBCA)

The Plan Regulador Intercommunal del Borde Costero region de Antofagasta (PRIBCA) (Ministerio de Vivienda y Urbanismo, Gobierno de Chile, 2004) regulates and guides the physical development process of the coastal territory of the municipalities of Tocopilla, Mejillones, Antofagasta and Taltal, and consists of an ordinance and two coastal border plans.

The intercommunal regulatory plan ordinance defines the codification of plans and concepts. The plans of the regulatory plan indicate the intercommunal urban areas, including the zones that are delimited by the communal regulatory plans, protection areas, viability, and limitations.

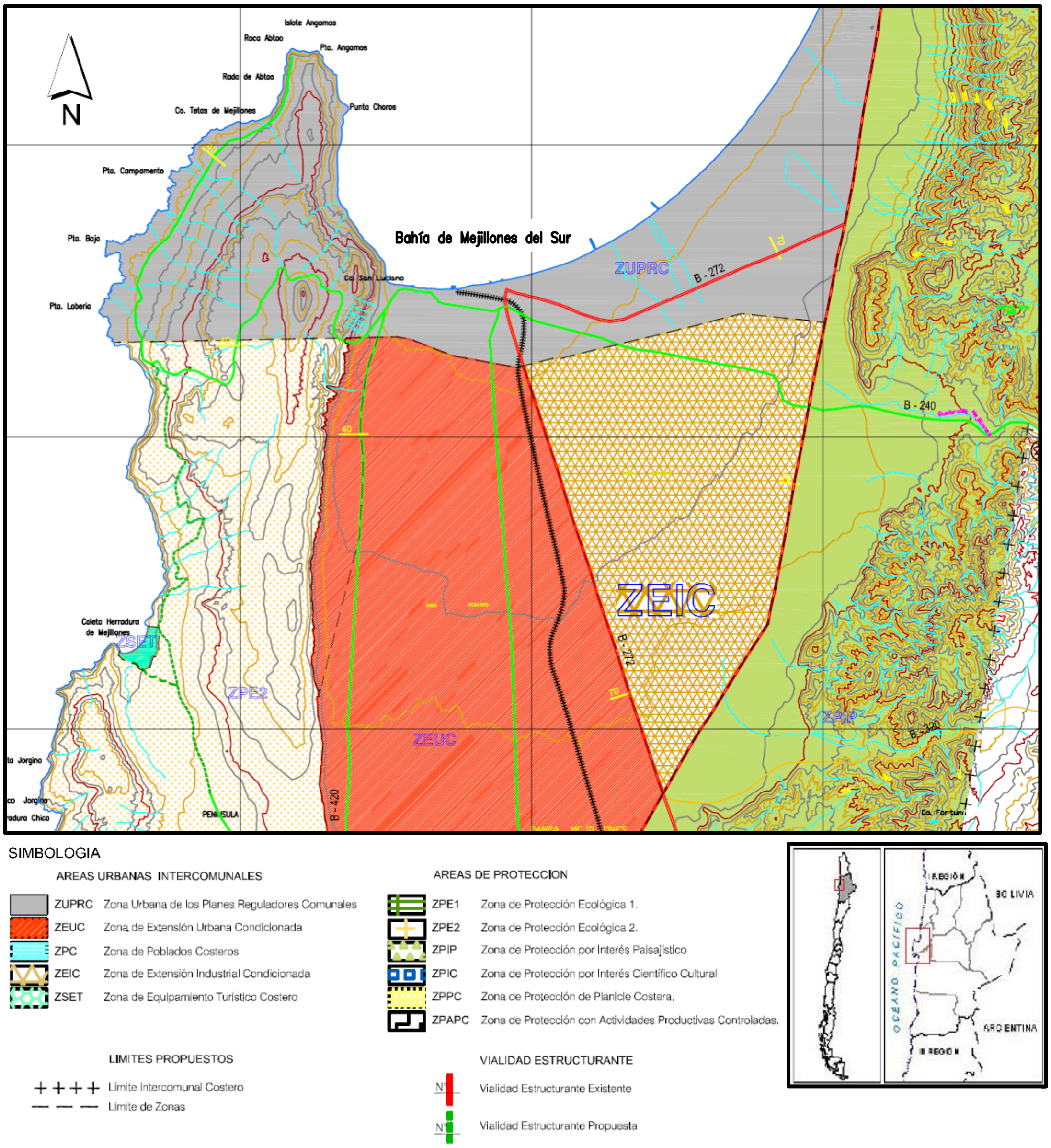


Figure 28: Part of the drawing of the Intercommunal regulatory plan of Antofagasta region. (Ministerio de Vivienda y Urbanismo, Gobierno de Chile, 2004)

Currently there is an update in process (Ministerio de Vivienda y Urbanismo, Gobierno de Chile, 2021), some of its objectives are a greater definition in smaller settlements and to reduce the effects of productive activities. Provisional drawing is in place, as changes may be made at different stages of the project and are expected to be approved between Nov. 2022 - Sep. 2023. The drawing available in February 2022, reduce the available zone for Industry close to the urban zone of Mejillones, and updates de regulation of this zone determined by the current Community Regulatory Plan regulate.

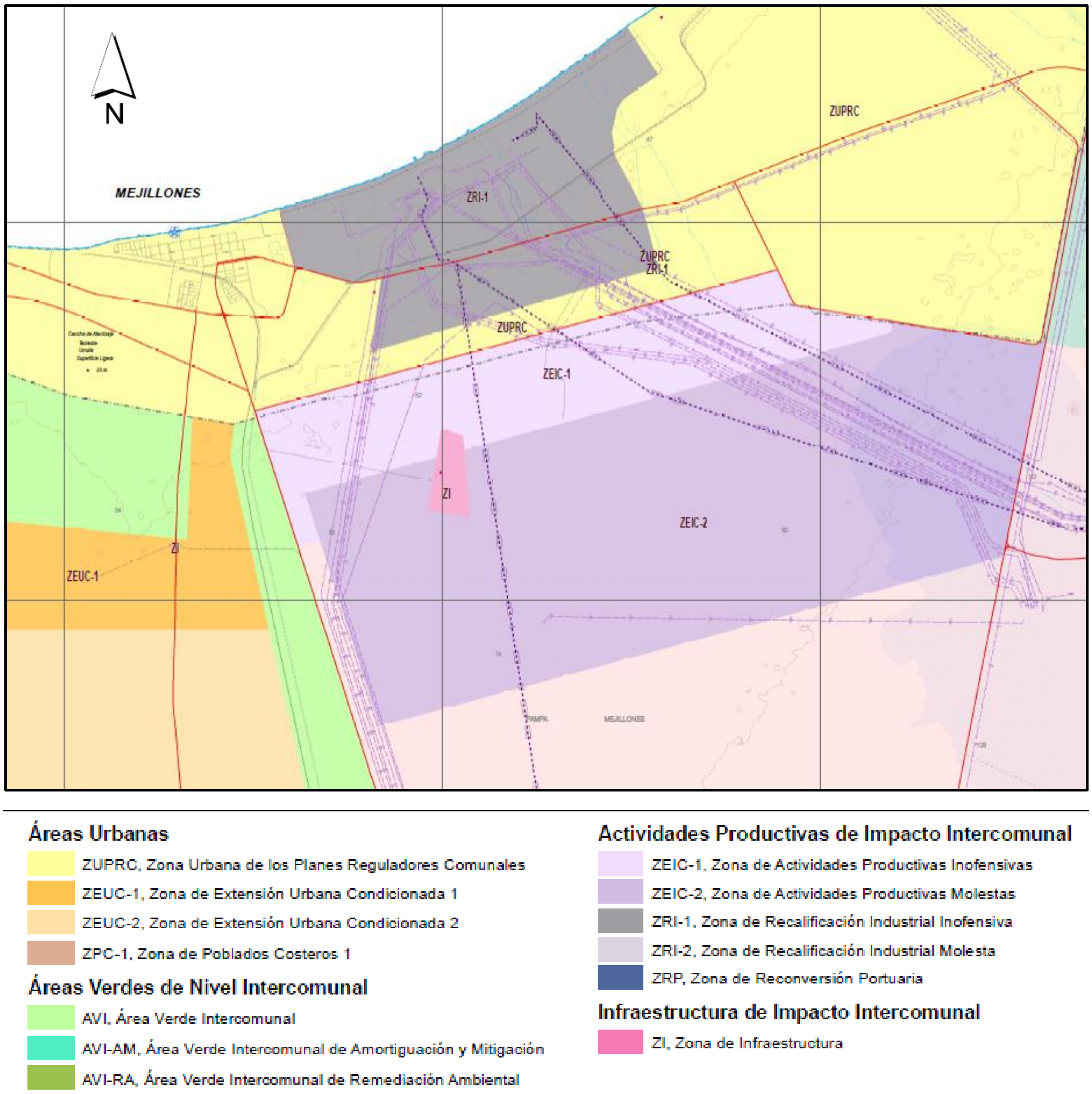


Figure 29: Part of intercommunal Plan in working. (NOT APPROVED)

Restrictions and Challenges

As in the regional plan, the Mejillones peninsula is shown as a protected area, and only the area with the acronym "ZEIC" (in light brown) in the following image is a conditional industrial zone (in compliance with Law No. 19,300, the General Environmental Bases Law).

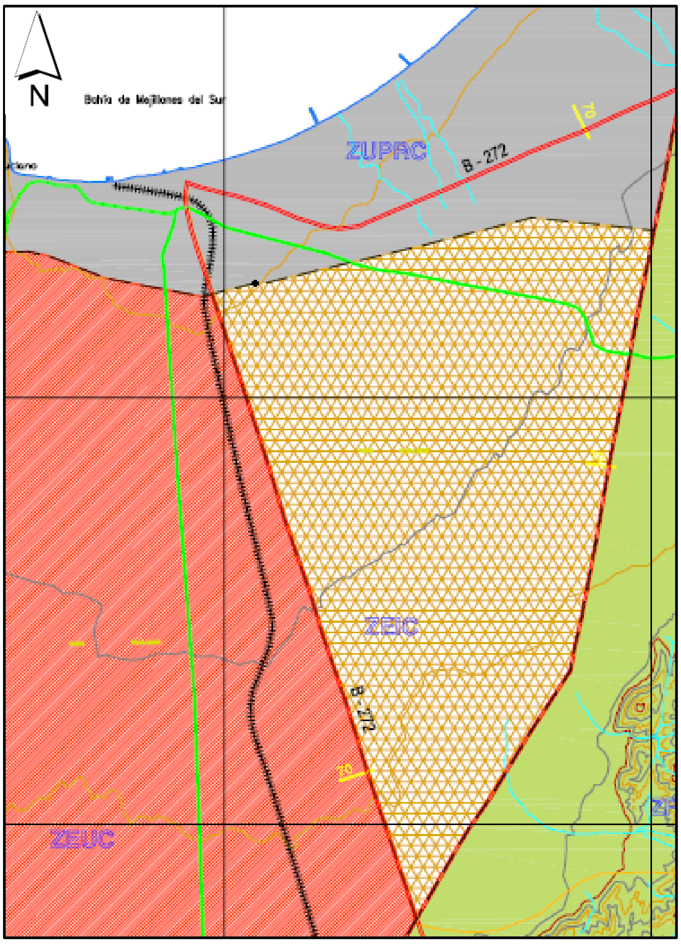


Figure 30: Intercommunal zone where industry can be installed. (Ministerio de Vivienda y Urbanismo, Gobierno de Chile, 2004)

9.2.3 Communal Regulatory Plan of the Port and Bay of Mejillones (PRC)

The communal regulatory plan for Mejillones South Bay (Plan Regulador Comunal de la Bahia de Mejillones del Sur) (SECRETARIA MINISTERIAL MINVU II REGION, 1999), has an ordinance and a plan. The ordinance specifies the codification of the plan and defines the types of structures allowed in the same.

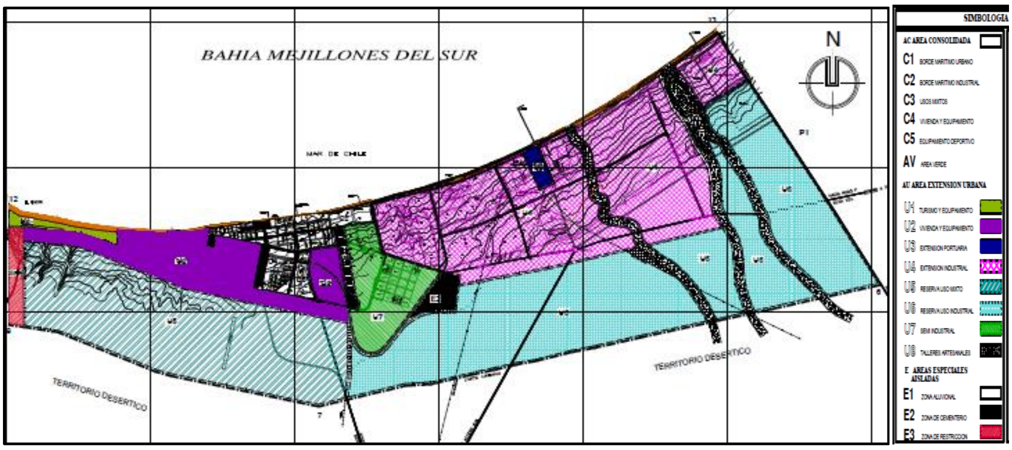


Figure 31: **Regulator plan of the dock and bay of Mejillones (SECRETARIA MINISTERIAL MINVU II REGION, 1999)**

Restrictions and Challenges

As can be seen in the map, the eastern part of the municipality is destined for industry, having as limitations the area of the cemetery indicated by the nomenclature E2 (in black color) and the extension of the port area indicated by the nomenclature U3 (in **blue** color).

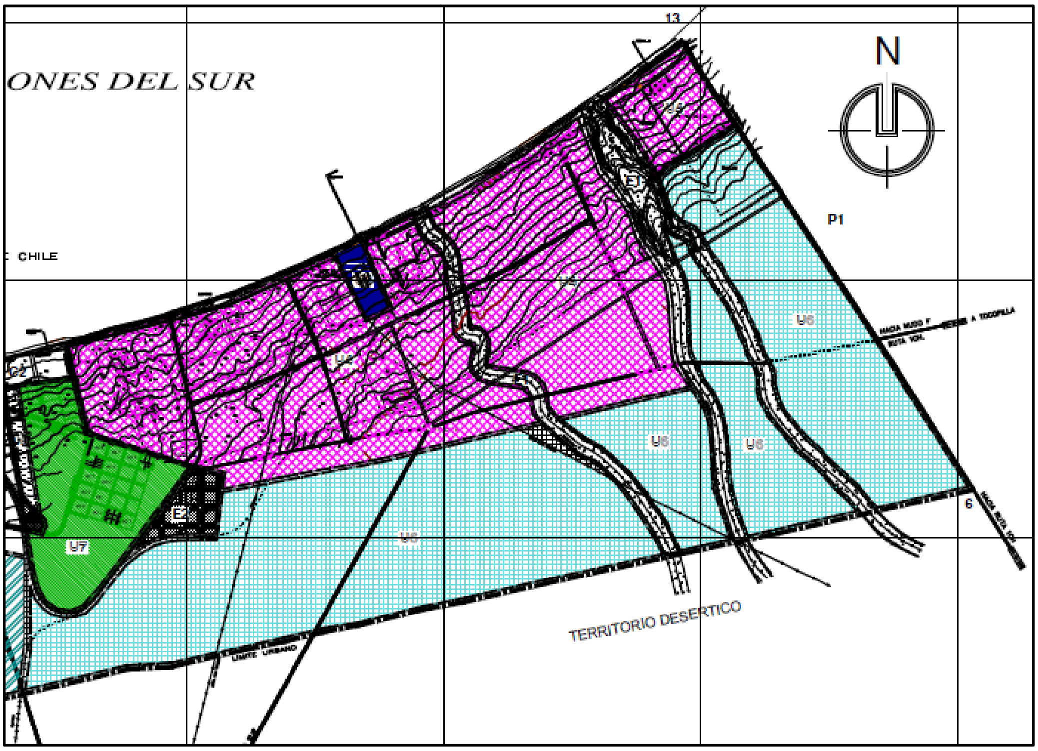


Figure 32: **Communal regulator plan where industry can be installed (SECRETARIA MINISTERIAL MINVU II REGION, 1999)**

9.2.4 Summary of outline restriction and challenges for Mejillones

As has been seen previously in the various land regulation plans at the regional, **intercommunal,** and communal levels, in the area of interest (Mejillones) there are well-defined zones for industrial use, urban use and protected areas. The following is a summary of the restrictions found for industrial activity and a visualization of a potential area free of these restrictions, this area includes approximately 13,800 Ha.

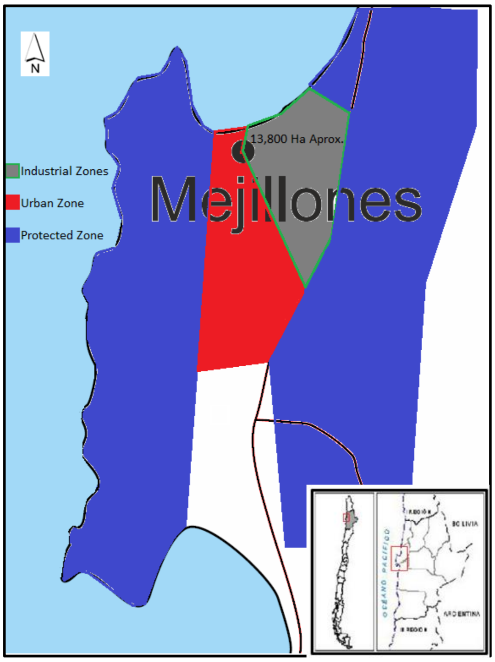


Figure 33: Union of the main restrictions of the territorial regulatory plans related to the municipality of Mejillones

There are thermoelectrical plants in the industrial zones that should be shut down in the next years, their infrastructure can potentially be reused, depending on agreements with the current owners.

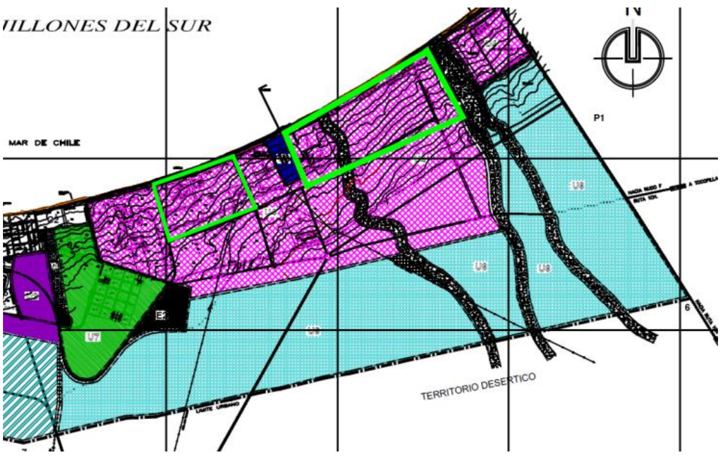


Figure 34: Thermoelectrical power plants in the industrial area of Mejillones

Table 67: Antofagasta Regulation document sites and links

Document	*Site*	*Link*
Regional urban development plan (PRDU)	http://observatoriourbano.minvu.cl/	PRDU
Intercommunal Regulatory Plan of the Coastal Border of the II Region (PRIBCA)	http://observatoriourbano.minvu.cl/	PRIBCA
Update Intercommunal Regulatory Plan of the Coastal Border of the II Region (PRIBCA)	https://www.minvu.gob.cl/	UPRIBCA
Communal Regulatory Plan of the Port and Bay of Mejillones (PRC)	http://observatoriourbano.minvu.cl/	PRC

9.3 Punta Arenas – Cabo Negro

For the Magallanes region, and in particular for the area of interest in the Cabo Negro zone, two territorial planning instruments were initially identified: the Regional Land Management Plan (PROT) (Gobierno Regional de Magallanes y Antártica Chilena, 2013) and the Punta Arenas Communal Regulatory Plan (PRC) (Secretaría Regional de Vivienda y Urbanismo, 2010).

It is important to note that, as mentioned at the beginning of this section, in the conversation with the regional authorities of Magallanes, it was established that all territorial planning instruments to date were repealed by the update of the new law. Therefore, all of these plans mentioned have passed to a modification stage and are not currently in force, however, the regional government authorities pointed out in the meetings that the available plans that passed to this modification stage can be used as a guide to establish regulatory challenges.

Table 68: Magallanes Regulation document sites and links

Document	*Site*	*Link*
Regional Land Management Plan (PROT)	https://www.goremagallanes.cl/	PROT
Community Regulatory Plan (PRC)	http://observatoriourbano.minvu.cl/	PRC

9.3.1 Regional Land Management Plan (PROT)

This plan is based on reports of urban, rural, coastal border, natural hazards and watershed dimensions, by the Department of Land Management and Planning of the Regional Development Unit of the Magallanes Regional Government.

It is worth mentioning that as an integration report, this plan covers four relevant aspects at the regional level, based on the previous studies: one, it provides a geographic synthesis of the territory, its structure and functionality, referring to the four components developed in the PROT process, and then based on this information and the survey of the Regional Development Strategy, develops an analysis of territorial scenarios with the final purpose of building a current territorial management model.

Within the areas covered by the plan, the rural areas are of special interest, since the Cabo Negro sector is in this classification because it is far from the nearest city, which is the city of Punta Arenas.

Researching the rural component of the plan, a topographic map related to the current land uses as of 2013 is presented below.

In this map it is convenient to analyze the areas designated as nature reserves, archaeological sites or other protected areas that prevent the development of the industrial activity sought for the implementation of the H_2 hubs.

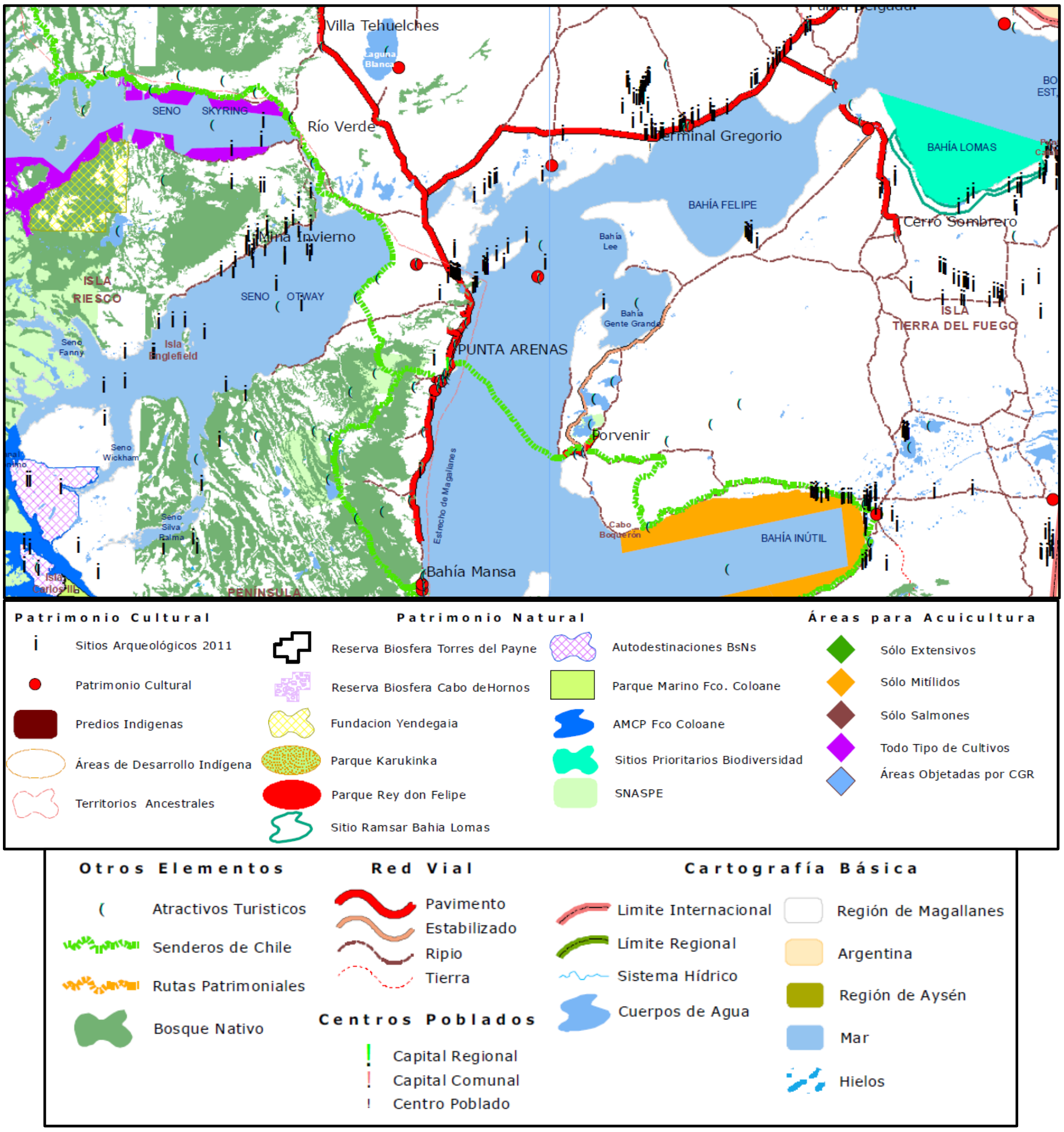


Figure 35: **Part of the topographic map related to the current land uses**

In the same direction, the presence of ecological reserves near the coastal sector and areas adjacent to Cabo Negro is not observed, on the other hand, the presence of native forest and archaeological sites as of 2011 is observed to a lesser extent, which should be verified case by case at present. It is also worth mentioning the presence of constructed roads that facilitate access to the area.

Finally, in relation to the PROT for the Magallanes region, it is important to mention the absence of regulations on the territory for industrial use in the rural component, which is of special interest for the development of the project discussed throughout this report.

However, projects have been developed and are being planned in these areas in relation to renewable energies and green hydrogen projects.

Two (2) big projects in the zone are the Total Eren "H2 Magallanes" project and the HIF "Haru Oni" project and exist the Methanex plant that produce methanol, so even if the zone is not regulated, it is apparently possible to build or at least plan industry.

Figure 36: Industry and projects close to Punta Arenas and Cabo Negro

9.3.2 Community Regulatory Plan (PRC)

The regulatory plan of Punta Arenas has an explanatory memorandum, a local ordinance, and a map. The local ordinance defines the codification and details the types of structures allowed in each zone.

The following map shows in detail the urban boundary, developable urban zones and areas restricted to urban development, associated with the town of Punta Arenas.

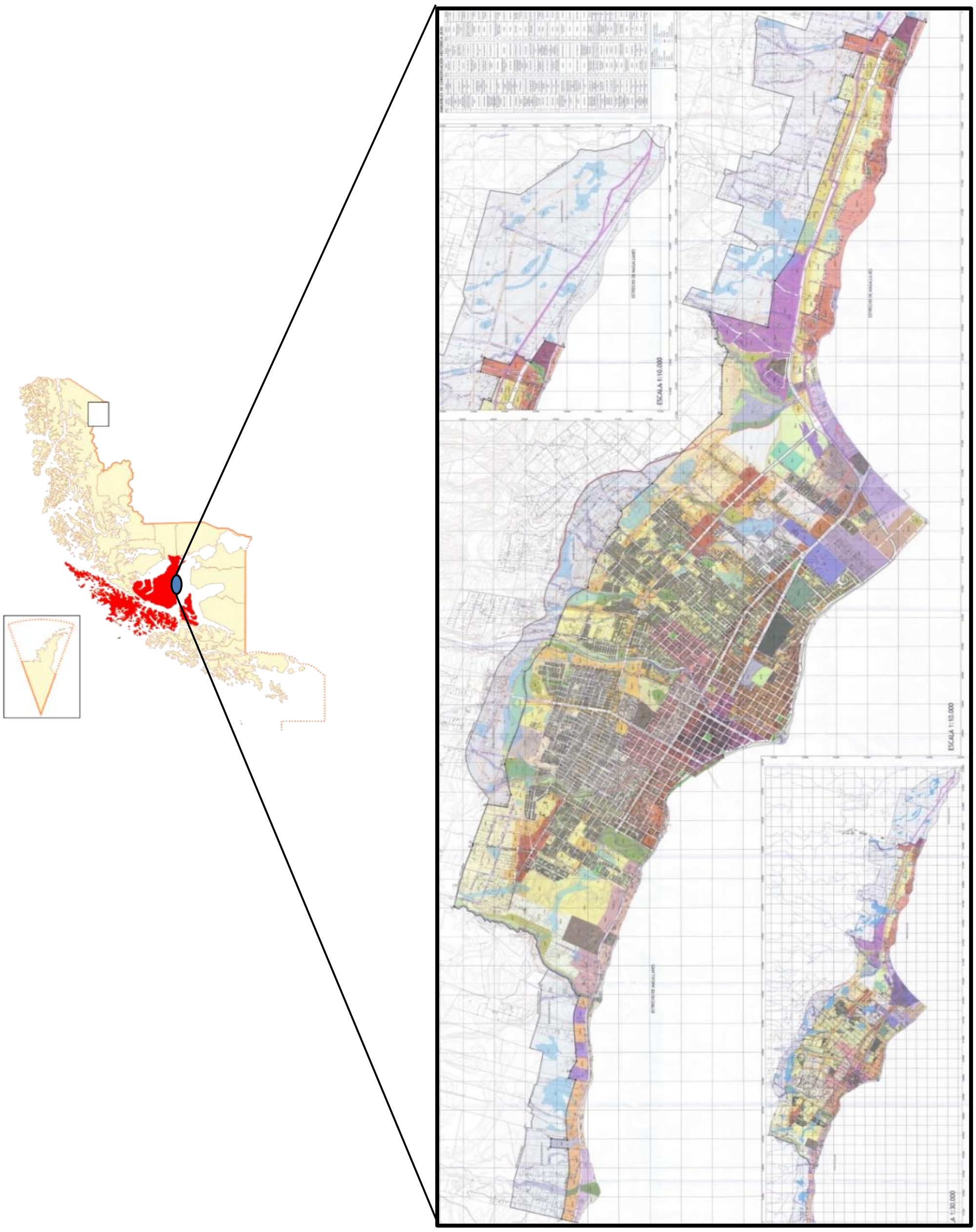


Figure 37: **Community regulatory plan of Punta Arenas. (Secretaría Regional de Vivienda y Urbanismo, 2010)**

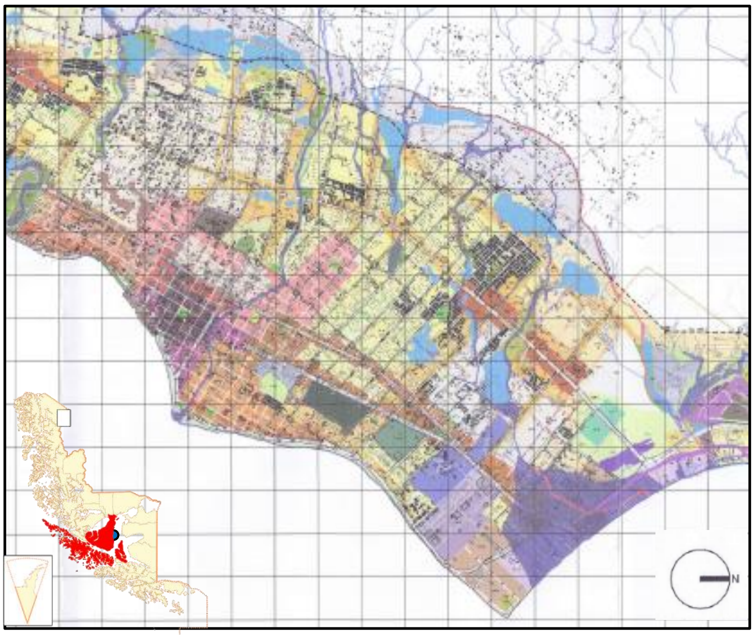


Figure 38: **Part of the regulator plan of community of Punta Arenas. (Secretaría Regional de Vivienda y Urbanismo, 2010)**

However, it is important to point out that this communal regulatory plan does not cover all the territory belonging to the municipality of Punta Arenas, but rather the areas surrounding the city.

As mentioned in previous reports, there is an area of interest to the north of the city of Punta Arenas, known as the Cabo Negro Industrial Park, where new projects associated with energy generation and industrial activity can be installed.

Restrictions and Challenges

The planning is very detailed and divided by several sectors, the sectors in which industry is allowed are zoned as Harmless Industry, Nuisance Industry and Polluting Industry.

Figure 39: **ZAP figures in the community regulatory plan of Punta Arenas. (Secretaría Regional de Vivienda y Urbanismo, 2010)**

The sectors coded with the acronym ZAP in the map below are sectors where industrial activities are allowed. ZAP-1 Productive Activities Zone 1 (Port Sector Zone) refers to zones where only harmless industry is allowed and where a large part of the sector is at risk of flooding (coded as ARN-ID).

Figure 40: **ZAP-1 Zone of productive activities, port sector. (Secretaría Regional de Vivienda y Urbanismo, 2010)**

ZAP-2 Productive Activities Zone 2 (Northern Industrial Zone) refers to permitted activities of the nuisance and inoffensive industry, located mainly at the border of the commune, with areas in between of military equipment sector and territory destined to communal parks.

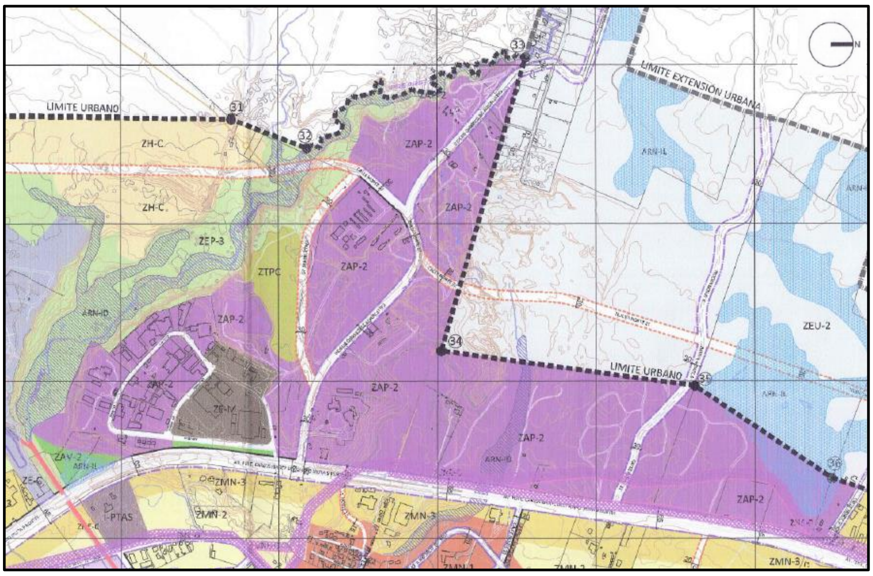


Figure 41: **ZAP-2 Zone of productive activities, north industry. (Secretaría Regional de Vivienda y Urbanismo, 2010)**

ZAP-3 Productive Activities Zone 3 (Rio Seco) refers to the zone at the eastern border of the municipality, allowing industrial activity of the inoffensive and nuisance type.

Figure 42: ZAP-3 Zone of productive activities, Rio Seco. (Secretaría Regional de Vivienda y Urbanismo, 2010)

10 ENVIRONMENTAL, ARCHAEOLOGICAL, HERITAGE AND CULTURAL PROFILE

This chapter includes the environmental profile of the municipalities of Mejillones, Antofagasta and Punta Arenas, Magallanes, considering the identified environmental aspects of flora & fauna and vegetation, archaeological or heritage sites, and relevant cultural activities or sites.

For all these areas, a general analysis was developed from secondary sources of information, which are specified in the respective chapters, and sought to conclude with the vision on the existence or not of possible risks that may eventually occur for the processing and development of the project in the defined locations.

The chapter is organized in three sections:

- The first describes the legal framework that regulates the protection of cultural heritage in Chile.
- The second provides the background information collected with respect to the commune of Mejillones, for the areas referred to (identification of flora & fauna and vegetation, archaeological or heritage sites and relevant cultural activities or sites), each of which ends with a section of conclusions on the presence or absence of potential risks.

- The third and final chapter details the information collected with respect to the commune of Punta Arenas, Cabo Negro sector, with the same breakdown as described above.

10.1 Legal framework for the protection of Cultural Heritage

In Chile there are two legal bodies that regulate the protection of cultural heritage: the Law of National Monuments (17.288)[24] of 1970, and the Law of General Bases of the Environment (19.300)[25] of 2010. Both laws have regulations that define how they operate.

The Law of National Monuments defines archaeological sites as national monuments by the sole authority of the law, being this property of the state of Chile, as explained in Article 21: "By the sole authority of the law, archaeological sites, ruins, deposits and anthropo-archaeological pieces that exist on or under the surface of the national territory are archaeological monuments owned by the state. For the effects of the present law, paleontological pieces and the places where they are found are also included".

Article 26 of this law also states that if any natural or juridical person finds archaeological remains resulting from excavations, he/she must notify the competent authority, which at the time of the promulgation of this law was the governor of the department: "Any natural or juridical person who, when making excavations at any point of the territory and for any purpose, finds ruins, deposits, pieces or objects of historical, anthropological, archaeological or paleontological character, is obliged to immediately report the discovery to the Governor of the Department, who will order to the police to be responsible for its surveillance until the council takes charge of it".

This situation was updated with the promulgation of the Regulations on Archaeological, Anthropological and Paleontological Excavations and/or Prospecting (Supreme Decree 484. Santiago, March 28, 1990), where it is specified that the Council of National Monuments will regulate the activities of prospecting, excavation and deposit of archaeological remains. In the case of archaeological visual inspections, the permit of the Council of National Monuments is not required, since it is a non-intrusive procedure in archaeological sites, without excavation or collection of materials on the surface.

Article 2 (letter ll) of the General Bases of the Environment Law (19,300) defines cultural heritage as an integral part of the environment, defining it as the "...global system constituted by natural and artificial elements of a physical, chemical or biological nature, sociocultural and their interactions, in permanent modification by human or natural action and which governs and conditions the existence and development of life in its multiple manifestations".

In the same article 2 (letter K), Environmental Impact is understood as: "the alteration of the environment, caused directly or indirectly by a project or activity in a determined area".

24 https://www.bcn.cl/leychile/navegar?idNorma=28892

25 https://www.bcn.cl/leychile/navegar?idNorma=30667

Article 11 (letter f) of Law 19,300 considers the alteration of monuments, sites with anthropological, archeological, historical value and, in general, those belonging to the cultural heritage. The presence or absence of these cultural resources must be evaluated based on the execution of a baseline that includes the archaeological component, which corresponds to the detailed description of the area of influence of a project or activity, prior to its execution (Article 2, letter i).

Article 11 of the Regulations of the Environmental Impact Assessment System specifies that: "The owner shall submit an Environmental Impact Study if its project or activity generates or presents alteration of monuments, sites with anthropological, archaeological, historical value and, in general, those belonging to the cultural heritage".

In order to assess whether the project or activity, including its associated works and/or actions, in any of its stages, generates or presents alteration of monuments, sites with anthropological, archaeological, historical value and, in general, those belonging to the cultural heritage, the following shall be considered:

a) the location in or around any National Monument of those defined by Law No. 17,288.

b) the removal, destruction, excavation, transfer, deterioration or modification of any National Monument of those defined by Law No. 17.288.

c) the modification, deterioration or location in constructions, places or sites that by their constructive characteristics, by their antiquity, by their scientific value, by their historical context or by their singularity, belong to the cultural patrimony.

d) the location in places or sites where manifestations of the culture or folklore of any people, community or human group are carried out."

10.2 Background information for the municipality of Mejillones

The background for the municipality of Mejillones will be analyzed for:

- Flora and vegetation
- Fauna
- Archeology
- Relevant cultural sites and activities
- Other cultural activities

10.2.1 Flora and Vegetation

The following is a bibliographic description of the flora and vegetation aspect of the industrial sector of the Mejillones Commune, Antofagasta Region; and in the following section (6.3.2), the fauna.

Given the variable to be collected, which is specific to the sector to be identified, preference has been given to the information contained in the projects presented and approved by the Environmental Impact Assessment System in the last 6 years, which can be found on the SEA

(Environmental Assessment Service) web page[26]. In addition, for this aspect, information from the Agriculture and Livestock Service (SAG) and CONAFhas been considered for more in-depth analysis.

The description of flora, fauna, and vegetation to be presented considers a general and introductory description of the aspect and a detailed description of the industrial sector of the commune, indicating the flora and fauna individuals that may be found and their vulnerability and risk for the development of the future project.

10.2.2 Characteristics of the study area

According to the vegetational background described for this sector, according to Gajardo's classification (1994), it is located in the desert region, sub-region of the Coastal Desert; in particular, in the vegetation formation of the "Coastal Desert of Tocopilla". The coastal desert sub-region extends along the oceanic coast from the I Region to the north of the IV Region, covering the western slopes of the Cordillera de la Costa, from sea level to approximately 1,500 m altitude. The plant life presents an exceptional development and a great floristic richness, due to the favorable action caused by the presence of frequent coastal fogs (called "Camanchacas") that provide the necessary precipitation. From a floristic point of view, it is of great interest due to the large number of endemic species that make up its flora.

Particularly, the "Tocopilla Coastal Desert" formation is the result of the most extreme conditions in the coastal desert, with vegetation existing only in very localized environments, although it should be noted that there are not many botanical studies (Gajardo, 1994).

Among the plant communities that can be recognized within this formation are:

- *Eulychnia iquiquensis - Frankenia chilensis*
- *Cassia brogniartii - Dinemandra ericoides*
- *Nolana sedifolia*
- *Tessaria absinthiodes - Distichlis spicata*

On the other hand, according to the classification of Luebert and Pliscoff (2018), this sector is inserted within the vegetational floor of "Copiapoa boliviana - Heliotropium pycnophyllum coastal Mediterranean desert scrub". This vegetation floor corresponds to an extremely xeromorphic open scrub, dominated by the shrubs Heliotropium pycnophyllum and Nolana peruviana, with the presence of the cactus Copiapoa boliviana. Vegetation cover is generally very low but increases slightly during the wettest years due to the emergence of herbaceous plants. It has large areas devoid of vascular plants. There is very limited specific background about this vegetation floor.

26 https://www.sea.gob.cl/

This vegetation floor is distributed in the low coastal zone of the Antofagasta region, between 0 and 450 m, upper inframediterranean and upper thermo-mediterranean upper ultra-hyperarid hyperoceanic bioclimatic floors.

Its floristic composition includes the species Cistanthe celosioides, Copiapoa boliviana, Cristaria integerrima, Dinemandra eriocoides, Heliotropium pycnophyllum, Nolana leptophylla, N. peruviana, Polyachyrus fuscus and Tetragonia maritima (Luebert & Pliscoff, 2018).

According to the authors Gajardo (1994) and Luebert and Pliscoff (2018), the flora species that could eventually be observed in the littoral platform and Coastal Range in the Mejillones area correspond to the list shown in Table 69. An important number of species is observed, however, it should be kept in mind that the distribution of vegetation is directly related to the altitude and phreatic water sources, and indirectly to the presence of coastal fogs, a pattern similar to that found in Paposo and Iquique (Johnston, 1929, 1936) and in the Pan de Azúcar National Park (Rundel & Mahu, 1976), but with a much more exiguous density and coverage.

Table 69: List of potential flora in the Study Area.

Species	Vegetation formation	Vegetational floor	EC	Source
	Coastal desert of Tocopilla	Coastal meditarranean desert scrub of Copiapoa boliviana and Heliotropium pycnophyllum.		
Adesmia tenella	x			
Alstroemeria violacea	x			
Alternanthera porrigens	x			
Argemone mexicana	x			
Argylia radiata	x			
Atriplex atacamensis	x			
Baccharis juncea	x			
Baccharis petiolata	x			
Bahia ambrosioides	x			
Chuquiraga ulicina	x			
Cistanthe celesioides		x		
Cistanthe grandiflora	x			
Cleome chilensis	x			
Copiapoa boliviana		x	**VU**	DS19/2012 MMA
Cristaria integerrima		x		
Dinemandra ericoides		x		
Distichlis spicata	x			
Drymaria cordata	x			
Eulychnia iquiquensis	x		**VU**	DS 50/2008 MINSEGPRE
Flaveria bidentis	x			
Frankenia chilensis	x			
Gilia ramosissima	x			
Heliotropium curassavicum	x			

Species	Vegetation formation	Vegetational floor	EC	Source
	Coastal desert of Tocopilla	**Coastal meditarranean desert scrub of Copiapoa boliviana and Heliotropium pycnophyllum.**		
Heliotropium pycnophyllum		x		
Hoffmanseggia prostrata	x			
Krameria cistoidea	x		**LC**	DS 42/2011 MMA
Lycium chanar	x			
Lycopersicon chilense	x			
Malesherbia humilis	x			
Menonvillea orbiculata	x			
Monttea chilensis	x		**EN**	DS 51/2008 MINSEGPRE
Nolana divaricata	x			
Nolana leptophylla	x	x		
Nolana peruviana		x		
Nolana sedifolia	x			
Ophryosporus triangularis	x			
Oxalis bulbocastanum	x			
Parietaria debilis	x			
Peperomia doellii	x			
Perytile emoryi	x			
Pluchea chingoyo	x			
Polychyrus fuscus		x		
Portulacca philippi	x			
Sicyos bryonaefolius	x			
Stachys pannosa	x			
Tessaria absinthioides	x			
Tetragonia maritima		x		
Tigridia philippiana	x		**VU**	DS 41/2011 MMA

Source: SEARCH, according to literature review. EC: Conservation Status; EN: Endangered; LC: Least Concern; VU: Vulnerable.

In addition, it is worth mentioning that in November 2018 Law No. 44 of the Ministry of the Environment was published in the Official Gazette entitled "APPROVES PLAN FOR RECOVERY, CONSERVATION AND MANAGEMENT OF NORTH COASTAL FLORA" that considers the species of the Conservation Plan of the Northern Flora, which includes the formation of the Tocopilla Coastal Desert and more than 90 species in different states of conservation, some not included in the previous table. This Plan considers the productive activities and civil works as threats to the flora. The Plan includes public-private actions that do not have financing and may be an opportunity for H2 projects to contribute to local environmental protection. The following table presents the list of prioritized species for monitoring compliance with the plan's goal.

Table 70: List of prioritized species for monitoring compliance with the plan's goal (Source: Tabla 1 de Ley 44 del MMA).

Species	Common name	State of conservation
Berberis litoralis	Michay de paposo	En Peligro
Dalea azurea	Dalea	En Peligro
Deuterocohnia chrysantha	Chaguar del jote	Vulnerable
Eulychnia iquiquensis	Copao de Iquique	En Peligro (I), Vulnerable (II-III)
Tillandsia tragophoba	Clavel del aire (genérico)	En Peligro
Alstroemeria lutea	Lirio del campo (genérico)	En Peligro
Eulychnia aricensis	Copao de Arica	En Peligro
Griselinia carlomunozi	Griselinia	En Peligro
Islaya iquiquensis	Iquiqueño	Vulnerable
Malesherbia tocopillana	Farolito	En Peligro
Tillandsia marconae	Clavel del aire (genérico)	En Peligro
Calceolaria paposana	Capachito (genérico)	Vulnerable
Copiapoa ahremephiana	Cactus	En Peligro
Copiapoa solaris	Cactus solar	En Peligro
Croton chilensis	Higuerilla de Paposo	En Peligro
Dicliptera paposana	Dicliptera	En Peligro
Gutierrezia taltalensis	Gutierrezia	Vulnerable
Tigridia philippiana	Tigridia	Vulnerable
Copiapoa krainziana	Cactus (genérico)	En Peligro Crítico
Eriosyce laui	Cactus (genérico)	En Peligro

10.2.3 Description of the vegetation and flora in the study area.

Identification of land use categories and vegetation description

There are two main categories of land use in the study area, corresponding to areas devoid of vegetation (areas naturally without vegetation) and urban and industrial areas, the latter of which show evidence of ancient earthworks. In general, according to specialists, the entire study area qualifies as a "non-vegetated area".

The terrain is characterized by moderate anthropogenic morphological modification, including vehicle tracks. Likewise, there is no evidence of vegetation. The vegetation characteristics of this sector are consistent with what has been reported in the literature, i.e. the presence of the most extreme conditions of the coastal desert, where vegetation can only develop in sectors with particular conditions, which is not present in the case of the study area.

Description of the vegetational formations in the Study Area

In general, there is no vegetation formations present in this sector. This condition is consistent with the vegetational context reported at the regional level for the coastal zone of the Atacama Desert, which describes formations and vegetational levels of absolute desert, with vegetation existing only in very localized environments and in the presence of particular conditions that are not present in the case of the Project's study area. Thus, almost the entire surface of the area in which the Study Area is located corresponds to areas devoid of vegetation.

Flora in the Study Area

In general, there are no vascular flora species present in the sector.

Identification of areas with environmental uniqueness

Consistent with the vegetation and flora, there are no environmentally singular cartographic units in the Study Area.

10.2.4 Conclusions

There are two categories of land use in the study area, corresponding to areas devoid of vegetation (areas naturally without vegetation) and urban and industrial areas, the latter with evidence of ancient earthworks.

The vegetational characteristics of this coastal sector, which includes areas devoid of vegetation throughout its length, are consistent with the vegetational context reported at the regional level for the coastal zone of the Atacama Desert, which describe formations and vegetational levels of absolute desert, with vegetation only in very localized environments.

Considering as an area of interest, the Mejillones area, mainly its industrial zone, with respect to floristic richness, no species of vascular flora are recorded. Finally, no environmentally singular cartographic units are identified for the vegetation and vascular flora component in the Study Area. Furthermore, no vegetation or vascular flora species are recorded in the study area.

Notwithstanding the foregoing, it is worth mentioning that the area of interest (Mejillones industrial zone) corresponds to a coastal area that provides enough water for the existence of the flora in danger of extinction identified in the previous points, so when doing the corresponding surveys of the areas to be intervened, it is convenient to emphasize this topic (http://caminantesdeldesierto.blogspot.com/2015/12/flora-de-la-comuna-de-Mejillones .html).

In relation to the above, it is worth mentioning the Morro Moreno National Park, which would correspond to the indirect area of interest close to the area of interest (industrial zone), whose objectives include the conservation of coastal flora.

10.2.5 Fauna

10.2.5.1 General characteristics of the fauna of the Region of Antofagasta

According to the biogeographical descriptions of Donoso-Barros (1966), the desert communities of Chile extend between Arica and the Copiapó River and from the coast to the Andean Mountain ranges.

From the climatic point of view, this region is characterized by its great dryness. The pampas receive the contribution of wetting fogs (camanchacas) and there are deep thermal variations between night and day, sometimes exceeding 40 °C, with daytime temperatures being naturally the highest. There is a notable edaphic concentration of nitrated and iodized salts.

The average temperature is approximately 18.7 °C being slightly lower towards the south. The average water level is considerably low. An important fact at this level is represented by the deviation of the Humboldt current, which determines a modification of the temperature of the coastal waters and the existence of forms that would not have access in sub-Antarctic waters.

The nature of the humidity corresponds in general to the so-called climatic post-climax, that is, to the condensation of coastal fogs whose hydrothermal action determines considerably lean plant communities.

According to the same author, the fauna of this region is relatively modest and only a few rodents of the genus Phyllotis and Akodon stand out. Towards the coast itself, the faunal contribution is integrated with communities of sea lions, chungungo and birds such as Catarhtidae that consume carrion and carcasses thrown by the sea. There are also seabirds, the most representative being Pelecanus and Phalacrocorax, although towards the south there are numerous gulls of the genus Larus and different varieties and species of plovers.

Osgood (1943), defines the project area as part of the "Northern or Atacama Desert", completely arid and without trees, and with many areas devoid of life. Regarding the presence of mammalian fauna, in some areas you can find fauna (which formerly ventured to the sea, at least sporadically), a few rodents and bats. In general, the few areas that are better prepared to support mammalian life have been used for human settlements, and in most cases, infested with rodents associated with urban areas, so the native populations that may have existed in such areas have disappeared.

The species potentially present for each class according to the bibliography consulted are listed below. Many of the species listed here are unlikely to be found in a location dominated by absolute desert, however, they are mentioned as a reference for the area.

Table 71: Potential species of the Amphibian Class

Scientific name	Common name	Origin	Conservation category
Orden Anura			
	Familia Bufonidae		
Rhinella arunco	Sapo de rulo	Native	VU
Rhinella atacamensis	Sapo de Atacama	Native	LC
	Familia Ceratophtydae		
Telmatobius dankoi	Sapo de Danko	Native	CR
Telmatobius peruvianus	Sapo peruano	Native	EN, Rara
Telmatobius vilamensis	Rana de Vilama	Native	CR
	Familia Leiuperidae		
Pleurodema thaul	Sapito de cuatro ojos	Native	NT

Source: Herpetology of Chile, Vidal and Labra 2008.

Table 72: Potential species of the Reptile Class (with altitudinal distribution below 1,000 meters above sea level)

Scientific Name	Common name	Origin	Conservation Status
Orden Squamata			
Family Colubridae			
Tachymenis peruviana	Culebra peruana	Native	Rara
Family Gekkonidae			
Homonota gaudichaudii	Salamanqueja del norte chico	Native	LC
Phyllodactylus gerrhopygus	Salamanqueja del Norte grande, Geko del Norte grande	Native	LC, VU
Family Liolaemidae			
Liolaemus hellmichi	Lagartija de Hellmich	Native	VU
Liolaemus reichei	Dragón de Reiche	Native	VU
Microlophus atacamensis	Corredor de Atacama	Native	VU
Microlophus tarapacensis	Corredor de Tarapacá	Native	DD
Family Teiidae			
Callopistes maculatus	Callopistes maculatus	Native	

Source: Reptiles in Chile, Demangel 2016 and Herpetology of Chile, Vidal and Labra 2008.

Table 73: Potential species of the Bird Class

Scientific Name	Common name	Origin	Conservation Status
ORDEN ACCIPITRIFORMES			
Family Accipitridae			
Geranoaetus polyosoma	Aguilucho común	Native	
Family Cathartidae			
Cathartes aura	Jote de cabeza colorada	Native	
Family Pandionidae			
Pandion haliaetus	Águila pescadora	Native	VU
ORDEN ANSERIFORMES			
Family Anatidae			
Anas discors	*Pato de alas azules*	Native	
ORDEN APODIFORMES			

Family Trochilidae			
Rhodopis vesper	Picaflor del norte	Native	
ORDEN CHARADRIIFORMES			
Family Charadriidae			
Charadrius nivosus	Chorlo nevado	Native	
Charadrius semipalmatus	Chorlo semipalmado	Native	
Oreopholus ruficollis	Chorlo de campo	Native	
Pluvialis dominica	Chorlo dorado	Native	
Pluvialis squatarola	Chorlo ártico	Native	
Family Haematopodidae			
Haematopus ater	Pilpilén negro	Native	
Haematopus palliatus	Pilpilén común	Native	
Family Laridae			
Chroicocephalus maculipennis	Gaviota cáhuil	Native	
Chroicocephalus serranus	Gaviota andina	Native	Rara, VU
Creagrus furcatus	Gaviota de las Galápagos	Native	
Larosterna inca	Gaviotín monja	Native	VU
Larus belcheri	Gaviota peruana	Native	
Larus dominicanus	Gaviota dominicana	Native	
Leucophaeus modestus	Gaviota garuma	Native	Rara, VU
Leucophaeus pipixcan	Gaviota de Franklin	Native	
Rynchops niger	Rayador	Native	
Sterna hirundinacea	Gaviotín sudamericano	Native	
Sterna hirundo	Gaviotín boreal	Native	
Sterna paradisaea	Gaviotín ártico	Native	
Sternula antillarum / albifrons	Gaviotín chico boreal / Charrancito	Native	
Sternula lorata	Gaviotín chico	Native	EN
Thalasseus elegans	Gaviotín elegante	Native	
Thalasseus sandvicensis	Gaviotín de Sandwich	Native	
Xema sabini	Gaviota de Sabine	Native	
Family Scolopacidae			
Actitis macularius	Playero manchado	Native	
Arenaria interpres	Playero vuelvepiedras	Native	
Bartramia longicauda	Batitú	Native	
Calidris alba	Playero blanco	Native	
Calidris bairdii	Playero de Baird	Native	
Calidris canutus	Playero ártico	Native	EN
Calidris mauri	Playero occidental	Native	
Calidris melanotos	Playero pectoral	Native	
Calidris minutilla	Playero enano	Native	
Calidris pusilla	Playero semipalmado	Native	
Calidris virgata	Playero de las rompientes	Native	
Limosa fedoa	Zarapito moteado	Native	
Limosa haemastica	Zarapito de pico recto	Native	
Numenius phaeopus	Zarapito común	Native	
Phalaropus fulicarius	Pollito de mar rojizo	Native	
Phalaropus tricolor	Pollito de mar tricolor	Native	
Tringa flavipes	Pitotoy chico	Native	
Tringa melanoleuca	Pitotoy grande	Native	
Tringa semipalmata	Playero grande	Native	
Family Stercorariidae			
Stercorarius chilensis	Salteador chileno	Native	
Stercorarius longicaudus	Salteador de cola larga	Native	
Stercorarius parasiticus	Salteador chico	Native	
Stercorarius pomarinus	Salteador pomarino	Native	

ORDEN COLUMBIFORMES			
Family Columbidae			
Columba livia	Paloma doméstica	Exotic	
Zenaida auriculata	Tórtola	Native	
Zenaida meloda	Paloma de alas blancas	Native	
ORDEN FALCONIFORMES			
Family Falconidae			
Caracara plancus	Traro	Native	
Falco femoralis	Halcón perdiguero	Native	DD
Falco peregrinus	Halcón peregrino	Native	LC, VU
Falco sparverius	Cernícalo	Native	
ORDEN PASSERIFORMES			
Family Emberizidae			
Zonotrichia capensis	Chincol	Native	
Family Furnariidae			
Asthenes modesta	Canastero chico	Native	
Cinclodes nigrofumosus	Churrete costero	Native	
Geositta cunicularia	Minero común	Native	
Geositta maritima	Minero chico	Native	
Leptasthenura aegithaloides	Tijeral común	Native	
Phleocryptes melanops	Trabajador	Native	
Upucerthia dumetaria	Bandurrilla común	Native	
Family Hirundinidae			
Hirundo rustica	Golondrina bermeja	Native	
Petrochelidon pyrrhonota	Golondrina grande	Native	
Pygochelidon cyanoleuca	Golondrina de dorso negro	Native	
Riparia	Golondrina barranquera	Native	
Family Icteridae			
Molothrus bonariensis	Mirlo común	Exotic	
Family Passeridae			
Passer domesticus	Gorrión	Exotic	
Family Troglodytidae			
Troglodytes aedon	Chercán común	Native	
Family Tyrannidae			
Agriornis montanus	Mero gaucho	Native	
Lessonia rufa	Colegial austral	Native	
Muscisaxicola maclovianus	Dormilona tontita	Native	
Muscisaxicola maculirostris	Dormilona chica	Native	
Muscisaxicola rufivertex	Dormilona de nuca rojiza	Native	
ORDEN PELECANIFORMES			
Family Ardeidae			
Ardea alba	*Garza grande*	Native	
Bubulcus ibis	*Garza bueyera*	Native	
Egretta caerulea	Garza azul	Native	
Egretta thula	Garza chica	Native	
Nycticorax	*Huairavo común*	Native	
Family Pelecanidae			
Pelecanus occidentalis	Pelícano pardo	Native	
Pelecanus thagus	Pelícano de Humboldt	Native	
ORDEN PHAETHONTIFORMES			
Family Phaethontidae			
Diomedea epomophora	Albatros real	Native	
Diomedea exulans	Albatros errante	Native	
Phoebastria irrorata	Albatros de las Galápagos	Native	
Thalassarche bulleri	Albatros de Buller	Native	

Thalassarche cauta	Albatros de frente blanca	Native		
Thalassarche melanophris	Albatros de ceja negra	Native	LC	
Family Hydrobatidae				
Oceanites gracilis	Golondrina de mar chica	Native	DD	(*)
Oceanites oceanicus	*Golondrina de mar de Wilson*	Native		
Oceanodroma hornbyi	Golondrina de mar de collar	Native	VU	
Oceanodroma markhami	Golondrina de mar negra	Native	EN	
Oceanodroma tethys	Golondrina de mar peruana	Native	VU	
Family Pelecanoididae				
Pelecanoides garnotii	Yunco de Humboldt	Native	VU	
Family Procellariidae				
Ardenna bulleri	Fardela de dorso gris	Native		
Ardenna creatopus	Fardela blanca	Native	V(*)	
Ardenna grisea	Fardela negra	Native		
Daption capense	Petrel damero	Native		
Fulmarus glacialoides	Petrel plateado	Native		
Macronectes giganteus	Petrel gigante antártico	Native		
Macronectes halli	Petrel gigante subantártico	Native		
Pachyptila belcheri	Petrel-paloma de pico delgado	Native		
Pachyptila desolata	Petrel-paloma antártico	Native		
Procellaria aequinoctialis	Petrel de barba blanca	Native		
Ardenna grisea	Fardela negra	Native		
Procellaria westlandica	Petrel de Westland	Native		
Pterodroma defilippiana	Petrel de Masatierra	Native	VU	
Pterodroma externa	Petrel de Juan Fernández	Native	EN	
ORDEN PSITTACIFORMES				
Family Psittacidae				
Myiopsitta monachus	Cotorra	Exotic		
ORDEN SPHENISCIFORMES				
Family Spheniscidae				
Spheniscus humboldti	Pingüino de Humboldt	Native	VU	
Spheniscus magellanicus	Pingüino de Magallanes	Native		
ORDEN SULIFORMES				
Family Phalacrocoracidae				
Phalacrocorax bougainvillii	Guanay	Native	VU	
Phalacrocorax brasilianus	Yeco	Native		
Phalacrocorax gaimardi	Lile	Native	DD	
ORDEN STRIGIFORMES				
Family Strigidae				
Athene cunicularia	Pequén	Native		
Bubo virginianus	Tucúquere	Native		
Family Tytonidae				
Tyto alba	Lechuza	Native		

Hunting Law (*)
Source: Aves de Chile, Jaramillo 2005, Aves de Chile sus Islas Oceánicas y Península Antártica, Couve, Vidal y Ruiz 2016. Taxonomy, Common Name and Origin, according to List of the Birds of Chile 2014, Barros, Jaramillo and Schmitt.

Table 74: Potential Species of the Mammal Class

Scientific Name	Common name	Origin	Conservation Status
ORDEN CHIROPTERA			
Family Molossidae			
Tadarida brasiliensis	Murciélago cola de ratón	Nativa	LC
Family Vespertilionidae			
Histiotus macrotus	Murciélago orejudo mayor	Nativa	
Histiotus montanus	Murciélago orejudo menor	Nativa	LC
Myotis atacamensis	Murciélago oreja de ratón del norte	Nativa	NT
Lasiurus borealis	Murciélago colorado o rojo	Nativa	LC
Orden Rodentia			
Family Cricetidae			
Abrothrix olivaceus	Ratón oliváceo	Nativa	
Oligoryzomys longicaudatus	Ratón de cola larga	Nativa	
Phyllotis magister	Ratón orejudo grande	Nativa	
Phyllotis darwini	Ratón orejudo de Darwin	Nativa	
Orden Carnivora			
Family Felidae			
Puma concolor	Puma	Nativa	NT
Family Canidae			
Lycalopex griseus	Zorro chilla	Nativa	LC
Family Mustelidae			
Lontra felina	Chungungo	Nativa	VU
Family Otariidae			
Arctocephalus australis	Lobo fino austral	Nativa	NT
Otaria flavescens	Lobo marino común	Nativa	LC

Source: Mammals of Chile, Iriarte 2008. Mammals of Chile, Muñoz-Pedreros, and Yañez. 2000. Mammals of Chile

Table 75: Codification and definition of conservation categories

CATEGORY	MEANING	ACRONYM
Extinct	A species shall be considered "Extinct" when there is no reasonable doubt that the last extant individual of that species has died. A species is presumed to be Extinct when exhaustive surveys of its known and/or expected habitats, at appropriate times (daily, seasonal, annual), and throughout its historical range, have failed to detect a single individual. Surveys should be conducted at time periods appropriate to the life cycle and life forms of the species.	EX
Extinct in the Wild	A species shall be considered "Extinct in the Wild" when it survives only in cultivation, in captivity or as a naturalized population (or populations) completely outside its original distribution. A species is presumed to be Extinct in the Wild when exhaustive surveys of its known and/or expected habitats, at appropriate times (daily, seasonal, annual), and throughout its historical range, have failed to detect a single individual. Surveys should be conducted at time periods appropriate to the life cycle and life forms of the species.	EW
Critically Endangered	A species will be considered "Critically Endangered" when the best available evidence indicates that it meets any of the criteria established by the IUCN for such a category and, therefore, it is considered to be facing an extremely high risk of extinction in the wild.	CR
In danger	A species will be considered "Endangered" when the best available evidence indicates that it meets any of the criteria established by the IUCN for such category and, therefore, it is considered to be facing a very high risk of extinction in the wild.	EN
Vulnerable	A species will be considered "Vulnerable" when the best available evidence indicates that it meets any of the criteria established by the IUCN for such a category and, therefore, it is considered to be facing a high risk of extinction in the wild.	VU
Near Threatened	A species will be considered "Near Threatened" when it has been assessed and does not currently meet the criteria for Critically Endangered, Endangered or Vulnerable, but is close to meeting the criteria for the latter or is likely to do so in the near future.	NT
Minor Concern	A species will be considered "Minor Concern" when, having been evaluated, it does not meet any of the criteria that define the categories of Critically Endangered, Endangered, Vulnerable or Near Threatened. This category includes species that are abundant and widely distributed, and therefore can be identified as of Least Concern.	LC
Insufficient Data	A species will be considered in the "Data Deficient" category when there is inadequate information to make an assessment, directly or indirectly, of its risk of extinction based on its distribution and/or population status. extinction based on distribution and/or population status.	DD

Source: DS 29/2012 MMA - IUCN Red List Categories and Criteria (Version 3.1, 2000).

10.2.5.3 Biotypes in the study area

Coastal desert

Characteristic biotope located on the western slopes of the coastal mountain range, composed mainly of coastal plains or dunes that provide habitat for various species, since they have better conditions due to the coastal fogs or camanchacas. In particular, this area is located in the vicinity of an industrial park and next to a railroad line. Among the species that usually inhabit these areas are the Culpeo and Chilla fox and a large number of coastal birds, especially the little tern (Sternula lorata).

Artificial accumulations of disturbed soil

It is perceived as an artificial biotope, originating from the alteration and accumulation of the soil, without the presence of vegetation cover. Adjacent to the desert plains described above, this biotope is identified by the presence of clumps of soil that have been subsequently treated, in which there are cracks and cavities that could eventually be occupied as refuges for species of low mobility.

10.2.5.4 Species in conservation categories in the study area.

In the Study Area, the presence of a terrestrial vertebrate species is detected in some state of conservation, considering the classification of species according to the sixteenth process of classification of species. This species corresponds to Sternula lorata (Little Tern),), a native species classified as "Endangered" according to the DS 151/2007 of MINSEGPRES.

10.2.5.5 Sites of ecological relevance

The Study Area is established as a sensitive area for the fauna component, due to the presence of the Little Tern (Sternula lorata), a species that uses the area as a nesting area and given its conservation category ("Endangered" according to D.S. No. 151/2007 of MINSEGPRES).

10.2.5.6 Conclusions

In general, the faunal component has a low richness and abundance, with the exception of the bird class being the only one represented.

According to the characteristics of the biotopes present, the Mejillones insdustrial area can be considered a hostile zone for the presence of fauna, whose surface corresponds to desert biotopes with scarce conditions and resources that structure habitats for some species. The main biotope of interest for fauna observation corresponds to sectors with disturbed soils, where the presence of cavities or cracked surfaces would eventually allow the observation of reptiles or micromammals.

On the other hand, according to bibliographic references in the study area, the presence of a terrestrial vertebrate species with conservation problems has been detected, which corresponds to Sternula lorata (Little Tern), a native species classified as "Endangered" according to DS 151/2007 MINSEGPRES. **This species uses the area located in the Mejillones sector as a nesting site, which is the main risk in relation to fauna in the study area** and should be studied in detail to ensure that there is no impact during the construction and operation of the project and because the sector is a potential nesting area for the Little Tern (Sternula lorata), we suggest following the recommendations of the **Fundación para la Sustentabilidad del Gaviotín Chico**, for the development of projects in the field.

It should be emphasized that according to the information gathered, nests and chicks have been identified in the study area, and it can be confirmed that the sector where the project will be located, which is part of the Mejillones coastal plain, corresponds to a potential nesting area for this species. What should be kept in mind is that the possibility of a pair deciding to choose a nesting site will be related to the level of human disturbance at the time that this species is looking for nesting sites.

It should be noted that to the north of Mejillones, the Itata-Gualaguala Nature Sanctuary is in the process of being approved, where the Little Tern, among other species, live.

10.2.6 Archeology

The following is a bibliographic description of the archaeological aspect of the commune of Mejillones, Antofagasta Region. Given the variable to be studied, which is specific to the sector to be identified, preference has been given to the information contained in the projects presented and approved by the Environmental Impact Assessment System in the last 6 years, which can be found on the SEA (Environmental Assessment Service[27]) website. In addition, for this aspect, information from the Council of National Monument National Monuments Council (Archeology and Heritage) has been considered for further study.

The archaeological description to be presented considers a general and introductory description of the aspect and a detailed description of the Mejillones Commune where the findings made during archaeological surveys presented to the SEIA (Environmental Impact Assessment System) for the development of future projects will be indicated.

27 https://www.sea.gob.cl/

10.2.6.1 Study Area

The study area corresponds to the industrial sector of the municipality of Mejillones, located on the outskirts of the city in the Antofagasta Region.

Figure 43: Antofagasta Region, Study Area

10.2.6.2 Archaeological background of the Antofagasta Region

At a general level, for the Mejillones commune, different types of sites can be identified depending on their functionality. The habitation sites are found in bays that have a good dock and protection from the winds, corresponding to monolithic shells with large deposits that in some periods have formal architecture and real estate infrastructure. Funerary places can correspond to burial mound cemeteries or isolated tombs, which are usually located on high ground away from the coast. Another type of site corresponds to slaughter sites (Ballester and Gallardo 2011), which are smaller in size and are the result of restricted labor activities, such as stone carving, animal slaughter, exploitation of marine resources, etc. The sites corresponding to road axes have the function of connecting the points of human activity. During the historical period, cart roads and multiple trails can be identified, created for the transfer of mining supplies and products, from the extraction points to the docks and coves; During the pre-Hispanic era, simple trails were identified that go into the interior of the hills, used mainly for the supply of lithic resources, lumber, minerals or for hunting guanaco. (Ballester 2018, ms).

10.2.6.3 SEIA Background

From the review of the archaeological background of projects submitted to the Environmental Evaluation System, it can be seen that near the study area (Mejillones Industrial sector), 12 archaeological sites were recorded in the framework of different projects submitted for evaluation.

Table 76: Background of Findings in the SEIA for the Mejillones Industrial Sector

Place	Project	UTM East	UTM North	Category	Chronology
Crucero 1	LAT S/E Chacaya S/E Crucero	365,523	7,440,637	Isolated finding	Historical
QAME 41	Sierra Gorda	362,583	7,441,995	Housing structure	Uncertain
QAME 42	Sierra Gorda	362,535	7,441,945	Parapet	Uncertain
QAME 43	Sierra Gorda	362,500	7,441,910	Parapet	Uncertain
45	Esperanza	362,501	7,441,910	Stone structure	Pre-Hispanic
46	Esperanza	362,543	7,441,943	Stone structure	Pre-Hispanic
47	Esperanza	362,594	7,441,989	Stone structure	Pre-Hispanic
48	Esperanza	362,504	7,441,863	Stone structure	Pre-Hispanic
OP-024	Reforzamiento Mejillones	365,327	7,439,574	Size event	Pre-Hispanic
OP-058	Reforzamiento Mejillones	360,609	7,428,983	Cart footprint	Historical
OP-037	Reforzamiento Mejillones	361,651	7,431,536	Ceramic dispersion	Historical
OP-114	Reforzamiento Mejillones	365,428	7,439,238	Size event	Pre-Hispanic
MP2	LTE 1x1110 KV Mejillones	362,117	7,442,441	Size event	Pre-Hispanic
M1	Terminal Mantención Mejillones	358,044	7,445,878	Isolated Finding	Pre-Hispanic
M2	Terminal Mantención Mejillones	357,903	7,445,889	Linear Trait	Historical
M3	Terminal Mantención Mejillones	358,293	7,446,285	Isolated Finding	Historical
M4	Terminal Mantención Mejillones	358,131	7,446,292	Linear Trait	Indeterminate

10.2.6.4 National Monuments near the project area

In the commune of Mejillones there are no National Monuments (MN). The closest ones are located in the commune of Antofagasta, more than 60 kilometers from the Study Area.

10.2.6.5 Conclusions

In the sector of interest, with the projects already developed, different findings have been found, ranging from isolated to historical findings. This makes it possible that during the development of the future project there will be findings, especially during the surface survey stage.

The archaeological and historical finds found in the study area are mainly superficial.

According to the known archaeological background for the area, **it is convenient to keep in mind as a suggestion the realization of permanent archaeological monitoring in archaeology in the work fronts**, this during the scarping works and all the activities that consider the removal of the surface during the construction of the respective access roads and construction of the plant.

It should be noted that in the event of an archaeological or paleontological finding (during excavations and even during the implementation of archaeological monitoring), the procedure must be in accordance with the provisions of Articles N° 26 and 27 of Law N° 17,288 on National Monuments and Articles N° 20 and 23 of the Regulations of Law N° 17,288, on excavations and/or prospecting archaeological, anthropological and paleontological, stopping the works in the affected sector, and immediately informing the National Monuments Council in writing, so that this body can determine the procedures to follow, whose implementation must be carried out by the owner of the Project.

10.2.7 Relevant cultural sites and activities

As in the case of the commune of Mejillones, in this area a process of review of various secondary sources of information was carried out to identify possible activities and/or sites of cultural significance that are currently in force for the local communities associated with the project development sector or its immediate communal or intercommunal surroundings, and that could eventually be affected by its implementation.

Special emphasis was given to the collection of information on the existing indigenous communities and associations and the possible current development of traditional and ancestral activities in the industrial sector of Mejillones and the surrounding area, as well as the possible existence of heritage sites and sites of cultural significance for the native peoples and also for the population in general.

The following sources were consulted for this purpose:

- Environmental processing files of previous projects developed in the sector and in the commune, available on the SEA website.[28]
- Indigenous Territorial Information System, SITI 2.0, of CONADI [29] (National Corporation for Indigenous Development), which integrates diverse georeferenced

[28] https://www.sea.gob.cl/

[29] https://siic.conadi.cl/

information related to the Indigenous Development Areas (ADI); existing indigenous communities with legal personality, constituted within the framework of the Indigenous Law No. 19,253; and of the titles of inheritance and succession communities, as well as of the census entities with a high percentage of indigenous population.

- Records of Indigenous Communities and Associations, from CONADI, updated as of January 13, 2022, available on the aforementioned page of SITI 2.0; as well as various other records, databases and documents available in said information system (historical file of land purchases, statistics on indigenous quality, regional statistics on indigenous peoples, etc.).
- Diverse information available on Tangible and Intangible Heritage, in the Council of National Monuments of Chile (CMN)[30], in IDE Patrimonio[31] and in the Information System for the Management of Intangible Cultural Heritage (SIGPA)[32].
- Diverse georeferenced information in the field of study of this chapter, available in IDE Chile, Geospatial Data Infrastructure[33].
- Information on Marine Coastal Spaces for Indigenous Peoples (ECMPO), available at SUBPESCA (Undersecretary of Fisheries and Aquaculture)[34].
- National Municipal Information System, SINIM, of SUBDERE (Undersecretary of Regional and Administrative Development), where the PLADECOs in force in the municipalities involved were consulted, as well as other information at the municipal level.
- Specialized bibliography in the area covered, to which specific reference is made in the chapter, when required.

10.2.7.1 General Background of Indigenous Peoples in the Region

Historically in the Antofagasta Region there has been a particular distribution of native peoples, with very different populations between those who lived in the coastal area and those who lived in the interior.

The coastal zone was dominated by the Changos, of a maritime-coastal tradition that covered the regions of Antofagasta, Atacama and Coquimbo. Their most distinctive symbol is the wolfskin raft, which was a unique design in the history of navigation. They were adapted to thrive in a coastal strip with almost no fresh water and no terrestrial plant or animal resources; therefore, they did not develop agriculture or livestock. The Changos today

30 https://www.monumentos.gob.cl/

31 https://ide.patrimoniocultural.gob.cl/herramientas/catalogo

32 http://www.sigpa.cl/

33 http://www.geoportal.cl/geoportal/catalog/main/home.page

34 https://www.subpesca.cl/portal/616/w3-channel.html y http://mapas.subpesca.cl/ideviewer/

recognize the sea and the cove as key references of their identity, in which the existence of their ancestors and their own has developed.

The Chango people were formally recognized as an indigenous Chilean ethnic group only recently, through a law enacted on October 17, 2020 (Law No. 21,273[35]), in a process that has the particularity of being described as "re-ethnicization" and "ethnogenesis", anthropological concepts that allude, the first, to "a process of cultural recomposition, through which individuals belonging to an ethnic group, associate values and meanings to new or pre-existing cultural practices". And where "The concept of ethnogenesis has traditionally been used to account for the historical process of the configuration of ethnic collectivities, as a result of migrations, invasions, conquests or fusions. On other occasions, the term has been used to indicate the emergence of new communities that designate themselves in ethnic terms, in order to differentiate themselves from other societies or cultures that they perceive as different from their social self-definition"[36].

On the other hand, in the valleys and foothills of the interior, are the Atacameño or Lican Antai people (the predominant in the region in terms of population), who occupy valleys, oases and ravines of the Salar de Atacama and the upper basin of the Loa River and its tributary, the Salado River, in the municipalities of Calama and San Pedro de Atacama. The art of the Atacameño or Lican Antai people includes ceramics, basketry, textiles, gold and silver work, dance and music, and its traditional economy based on agriculture and livestock.

However, the Aymara people are also present in the region, who are currently identified by their language, their Andean culture and the lands they inhabit in the regions of Arica and Parinacota, Tarapacá and Antofagasta. The Aymara communities occupy the altiplano, extending over an immense area around Lake Titicaca (Bolivia), the Norte Grande in Chile and northwestern Argentina. Among the Aymara artistic expressions, textile art stands out, mainly for clothing and ceremonial pieces. Music and dance are two very important cultural expressions of this people.

Finally, there is also the presence in the region of the Quechua people, who define themselves as an ethnic group based on their language, Quechua. Their communities are located in the Ollagüe area and on the San Pedro River, a tributary of the Loa River. This region has historical relations with the Salar de Uyuni (Bolivia), and economic links with the Loa River basin and the Pacific coast. Its economy is based on livestock and agriculture, and today they preserve pottery and textile art as handicrafts.

The historical background and cultural dynamics of the indigenous communities of the Atacameño or Lican Antai people[37], the majority in the region, speak of a continuous

35 https://www.bcn.cl/historiadelaley/nc/historia-de-la-ley/7800/

36 https://senado.cl/comisiones/derechos-humanos/buscan-el-reconocimiento-del-pueblo-chango-como-etnia-indigena-de-chile

37 Informe Comisión Verdad Histórica y Nuevo Trato con los Pueblos Indígenas, 2009, volume I, chapter two. Bicentennial Library.

ancestral settlement with a very high level of ecological adaptation to the conditions of the Andean desert environment.

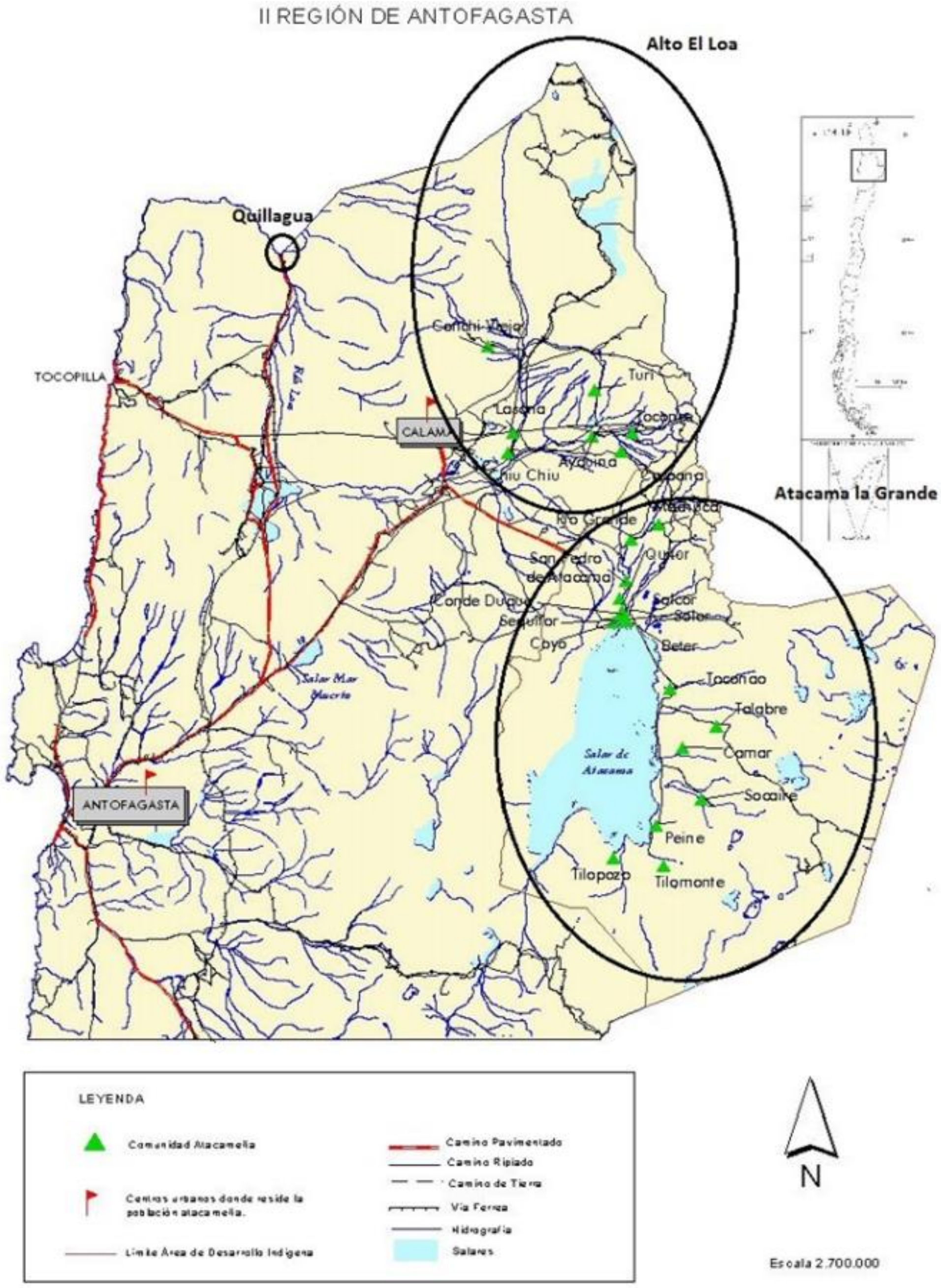
The current Indigenous Development Areas (ADIs[38]), Alto El Loa and Atacama La Grande, gather in their interior the two large sectors of settlement that have lasted over time, with a high percentage of Atacameño indigenous population. Historically, there has been a permanence of Atacameño communities and their location patterns since the first chronicles of the colony.

Currently, of the 607,534 inhabitants registered in the region in 2017, 14% recognize themselves as belonging to a native people. Of that total, the majority is the Atacameño or Lican Antai People, with 30.6% and then followed by the Mapuche, with 21.3%, the Aymara with 15.7%, Quechua with 12.7% and Diaguitas with 10.3%.[39]

The following map shows the areas where indigenous communities and ADIs are located in the region:

[38] The ADIs are created as territorial spaces defined by the State in order to focus public investment for the benefit of indigenous peoples and, at the same time, to guide private investment. They are configured on the basis of various criteria: territorial spaces in which indigenous ethnic groups have lived ancestrally; high density of indigenous population; existence of lands of indigenous communities or individuals; ecological homogeneity; and, dependence on natural resources for the balance of these territories, such as management of watersheds, rivers, riverbanks, flora and fauna.

[39] http://resultados.censo2017.cl/Region?R=R02



Fuente: MIDEPLAN - CONADI

Figure 44: Distribution of communities and ADIs in the Antofagasta Region

10.2.7.2 Indigenous Communities and Associations

As of January 2022, there are 43 legally constituted indigenous communities in the region (mostly belonging to the Atacameño or Lican Antai people and the remaining Aymara and Quechua), with a total of 2,207 families and 4,384 members, located in the province of El Loa (except for one). There are no indigenous communities in the commune of Mejillones or, in general, in any coastal sector of the region.

Table 77: Indigenous communities in the Antofagasta Region.

PROVINCE	COMMUNE	COMMUNITY NAME	N° OF FAMILIES	N° OF MEMBERS	DATE OF CONSTITUTION
EL LOA	Calama	Comunidad atacameña de caspana	65	128	26-08-1994
EL LOA	Calama	Comunidad atacameña de conchi-viejo	75	126	19-11-1994
EL LOA	Calama	Comunidad atacameña de lasana	71	133	01-12-1995
EL LOA	Calama	Comunidad atacameña de ayquina-turi	70	98	29-04-1995
EL LOA	Calama	Comunidad atacameña de cupo	14	79	20-05-1995
EL LOA	Calama	Comunidad atacameña de toconce	90	222	05-04-1995
EL LOA	Calama	Comunidad atacameña san francisco de chiu-chiu	248	471	10-06-1995
EL LOA	Calama	Comunidad indigena del pueblo de san pedro	39	128	06-08-2000
EL LOA	Calama	Comunidad indigena sumac-llajta	23	30	07-09-2003
EL LOA	Calama	Comunidad indígena atacameña taira	17	53	27-11-2003
EL LOA	Calama	Comunidad indígena de la banda	10	17	06-05-2008
EL LOA	Calama	Comunidad atacameña agricola y cultural, "kamac mayu hijos de yalquincha"	15	30	01-12-2010
EL LOA	Calama	Comunidad indígena chunchuri	15	45	02-05-2013
EL LOA	Calama	Comunidad de indios atacameños en el sector de chunchuri	13	13	09-07-2013
EL LOA	Calama	Comunidad indigena "pankara loa"	3	10	14-01-2015
EL LOA	Calama	Yalquincha lickan ichai paatcha.	10	18	12-06-2015
EL LOA	Calama	Comunidad indígena quechua ayllu ojos de san pedro	0	14	24-10-2017
EL LOA	Calama	Atacameña likan tatay	34	22	23-03-2018
EL LOA	Ollagüe	Comunidad quechua de ollague	80	139	04-12-1995
EL LOA	Ollagüe	Comunidad indígena cebollar - ascotán	12	30	24-09-2015

EL LOA	Ollagüe	Kosca	0	5	26-08-2019
EL LOA	San Pedro De Atacama	Comunidad atacameña de machuca	34	77	16-09-1994
EL LOA	San Pedro De Atacama	Comunidad atacameña de rio grande	51	129	22-09-1994
EL LOA	San Pedro De Atacama	Comunidad atacameña de quitor	35	85	15-10-1994
EL LOA	San Pedro De Atacama	Comunidad atacameña de coyo	80	166	15-10-1994
EL LOA	San Pedro De Atacama	Comunidad atacameña de san pedro de atacama	140	380	30-10-1994
EL LOA	San Pedro De Atacama	Comunidad atacameña de solor	30	53	04-08-1995
EL LOA	San Pedro De Atacama	Comunidad atacameña de socaire	146	173	25-05-1995
EL LOA	San Pedro De Atacama	Comunidad atacameña de camar	20	71	23-05-1995
EL LOA	San Pedro De Atacama	Comunidad atacameña de talabre	25	74	06-02-1995
EL LOA	San Pedro De Atacama	Comunidad atacameña de peine	160	192	08-06-1995
EL LOA	San Pedro De Atacama	Comunidad atacameña de toconao	427	692	08-12-1995
EL LOA	San Pedro De Atacama	Comunidad atacameña de sequitor y checar	24	26	06-04-1999
EL LOA	San Pedro De Atacama	Comunidad atacameña de larache	25	54	06-12-1999
EL LOA	San Pedro De Atacama	Comunidad indígena atacameña de catarpe	30	58	27-09-2003
EL LOA	San Pedro De Atacama	Comunidad indígena del ayllu de cucuter	8	45	03-10-2004
EL LOA	San Pedro De Atacama	Comunidad atacameña de solcor	15	42	02-10-2004
EL LOA	San Pedro De Atacama	Comunidad atacameña de yaye	12	25	15-08-2009
EL LOA	San Pedro De Atacama	Comunidad indígena atacameña de guatín	16	61	23-03-2014
EL LOA	San Pedro De Atacama	Comunidad indigena atacameña de la puna de tocol, alis, celeste y puques	0	31	10-01-2016
EL LOA	San Pedro De Atacama	Comunidad indígena atacameña de agricultores y regantes del rio vilama	12	12	04-10-2016
EL LOA	San Pedro De Atacama	Atacameña de tulor y beter	0	25	14-09-2018
TOCOPILLA	María Elena	Comunidad aymara de quillagua	13	102	16-10-2003

Source: Registry of Indigenous Communities, CONADI, updated as of 1/13/2022.

The number of legally constituted Indigenous Associations is 126, made up mostly of Atacameño people and comprising 6,543 members. It is repeated that in the commune of Mejillones there is no constituted indigenous association and only five of the associations belong to the coastal zone, located in the commune of Antofagasta.

Beyond the above mentioned about indigenous communities and associations constituted under the Indigenous Law and the inexistence in the current records of organizations corresponding to the Chango People, it is relevant to mention that in January 2020 the "National Council of the Chango People" was constituted, constituted by at least three organizations of the commune of Mejillones, all of them artisanal fishermen:[40]

- CODEPCU Caleta Punta Cuartel (Cooperativa de Trabajo Caleta Punta Cuartel).
- Sindicato de Pescadores de Caleta Hornitos (Fishermen's Union of Caleta Hornitos).
- Agrupación de Pescadores Artesanales y Asociados de Hornitos, Mejillones.

After the approval of the law recognizing the Changos as an official indigenous "ethnic group" (according to the terms used in the law), processes have begun to recognize the indigenous status of people of the Chango people and it is expected that in the near future, as progress is made in the respective procedures in CONADI, the constitution of indigenous communities and associations of this native people will take place and they will be able to access the various public policy instruments currently in place for their development.

10.2.7.3 Coastal Marine Spaces for Indigenous Peoples

Within the framework of territorial claims that indigenous communities have made in Chile, the creation of the ECMPO, or “Espacios Costeros Marinos de Pueblos Originarios” (Original Peoples' Marine Coastal Spaces), stands out. These were created in 2008 through Law No. 20,249, known as the Lafkenche Law: "The legislation arose from the political mobilization of the Mapuche Lafkenche indigenous communities settled in southern Chile. This movement sought legal recognition of the historical, socio-cultural and ecological relationship of the native peoples with the sea and its natural resources, through the protection of their customary uses. The Law filled a gap in national legislation that defined and authorized various concessions of marine and coastal spaces, without considering the specificity of the ways of life of the native peoples settled in the coastal zone".

The objective of the ECMPO is to "safeguard the customary use of these spaces, in order to maintain the traditions and use of natural resources by the communities linked to the coastal zone" (Article 3 of the law). The law defines customary use as the practices or behaviors carried out by the generality of the members of the association of communities, in a habitual manner and that are part of their culture. For example: fishing, religious, recreational and medicinal uses.

The approval of an ECMPO application by an association of two or more indigenous communities (or an indigenous community, in the case that it is found that only it has made a traditional and permanent use of that space and there are no other communities linked to it), implies that the Undersecretariat of Fisheries hands over the administration of the marine coastal space to the association of communities or the applicant community, who manages

[40] https://www.aqua.cl/2021/07/21/consejo-nacional-del-pueblo-chango-dijo-rechazar-la-representacion-de-fernando-tirado-como-constituyente/

it through an administration plan, which specifies the uses and activities that will be developed in it.

It is emphasized that "the legal recognition of customary uses through the ECMPO allows the protection of natural banks of fishery resources; subsistence practices such as seaweed and shellfish harvesting; sacred sites and sites of cultural significance; local ecosystems such as kelp forests, beaches, fjords, coastal wetlands and intertidal zones. In other words, by safeguarding customary uses, the ECMPOs are contributing to the sustainability of the coastal marine zone through the management of productive activities and the conservation of biodiversity in areas subject to environmental and extractive pressures."

In the Antofagasta Region there is no application for a Marine Coastal Space for Indigenous Peoples (Espacios Costeros Marinos Pueblos Originarios ECMPO), which corresponds to the previously reviewed background of non-existence of indigenous communities with roots in the coastal zone of the region.

As mentioned in the previous section, it is to be expected that as the conformation and recognition of eventual indigenous communities of the Chango people progresses, they will be able to access the various existing public support instruments. And given the important correlation of many of the organizations that claim their status as Changos with the artisanal fishing activity (organizations of fishermen's coves, as in the case of the three from Mejillones mentioned), it would also be expected that one of the processes they could initiate would be the presentation of ECMPO applications.

10.2.7.4 Relevant cultural sites and activities in the study area.

The review did not identify any specific sites of high cultural significance or of current use in traditional practices or rituals, both for the native peoples and for the general population in the industrial area of Mejillones, beyond what was previously mentioned in the archeology section.

However, it is relevant to mention the existence of artisanal fishermen's coves in the area (Caleta Punta Cuartel, Caleta Hornitos), whose families have traditionally developed this trade and depend on fishing and gathering for their economic livelihood. On the coast of Mejillones there are people and families that carry out different tasks and trades associated with the sea, such as artisanal fishing, shellfish divers, shore harvesting, product marketing, and also the transformation of resources into final products such as food or handicrafts.

The location of the fishing coves is shown in the following map:

Figure 45: Fishing coves in Mejillones.

In this regard, there is evidence of a certain level of tension between artisanal fishing and shellfish extraction activities, with the increase in the productive activity of the Mejillones industrial park. In a recent socio-territorial diagnosis for the elaboration of a territorial intervention plan of Servicio País 2021-2022 in the commune, the following is described, referring to the productive vocation of the commune: "The commune of Mejillones has four productive activities: commerce, fishing, energy/chemical industry and tourism. During the last stage of the last century, these activities were able to converge smoothly, but during the beginning of the new century, the negative externalities in the bay due to the increase in the productive activity of the industrial park generated environmental and social conflicts. As a result, fishing activity has been reduced, but not eliminated. Nevertheless, those who work as fishermen or shellfish extractors must travel long distances offshore or even leave the regional territory in order to extract marine resources. On the other hand, the industrial park of the commune provides jobs for the community and has developed a wide range of services for its workers, being mainly the gastronomy in its format of food on the way and the rental of houses for the floating population, one of the main consequences of the increase in the productive activity of the industries".[41]

10.2.7.5 Other cultural activities

In the commune of Mejillones some important festivities take place annually for its inhabitants:

- The anniversary of Mejillones or Mejillonina Week: It is celebrated during the month of October. The festivity is organized by the municipality, where neighborhood

[41] Fundación Superación de la Pobreza-Servicio País: Plan de Intervención Territorial Servicio País 2021-2022 Mejillones, March 2021, p. 16. Available at: http://www.superacionpobreza.cl/transparencia/mejillones/#:~:text=En%20la%20comuna%20Mejillones%202C%20el,Punta%20Cuartel%20y%20Caleta%20Hornitos.

organizations and the community in general develop various recreational, artistic, cultural and sports activities. It includes the election of a queen, the ornamentation of streets, the installation of inns and kitchens that consider the preparation of typical dishes and the organization of games, among others.

- The San Pedro Festival: Associated with the work of the artisanal fishermen of the area. It is celebrated in the month of June. It corresponds to an offering to San Pedro, patron saint of fishermen in the area, consisting of pilgrimages, dances and songs around the sea.
- La Fiesta de la Candelaria: Religious festivity that is celebrated in February, where dances, processions, prayers, and songs are performed.[42]

10.2.7.6 Conclusions

From the background information presented, it is noted that there is no significant presence of current cultural activities or spaces associated with the immediate development area of the project that could pose a risk or any level of impact on the project's activities.

In this regard, it is important to take into consideration the conclusions of the archeology area regarding the potential for archeological findings in the area and the recommendations to be followed during the construction phase of the project.

Finally, it is concluded that cultural issues would not be an impediment or a relevant risk at present for the development of the Hydrogen Center project in the commune of Mejillones.

It would be advisable, in the future, to evaluate in greater detail the possible existence of environmental and social conflicts due to the supposed increase of productive activity in the industrial park and the incidence that the Hydrogen Center project could have on it.

10.3 Background of the Punta Arenas community, Cabo Negro sector

The background of the commune of Punta Arenas will be presented in the following order:

- Flora and vegetation
- Fauna
- Archeology
- Relevant cultural sites and activities
- Other cultural activities

10.3.1 Flora and vegetation

The following is a bibliographic description of the flora and vegetation aspect of the Cabo Negro sector, Punta Arenas commune, Magallanes and Chilean Antarctica Region.

[42] Municipality of Mejillones, Community Development Plan 2008-2018.

Given the variable to be studied, which is specific to the sector to be identified, preference has been given to the information contained in the projects presented and approved by the Environmental Impact Assessment System in recent years, which can be found on the SEA (Environmental Assessment Service) web page[43]. In addition, for this aspect, information from the Agriculture and Livestock Service (SAG) and CONAF has been considered for more in-depth analysis.

The description of flora & fauna and vegetation to be presented considers a general and introductory description of the aspect and a detailed description of the Cabo Negro sector, where the possible flora & fauna individuals to be found, their vulnerability and the risk it means for the development of future projects will be indicated.

10.3.1.1 Characteristics of the Cabo Negro area

The study area is in the continental area of the province of Magallanes, in the commune of Punta Arenas, in an ecotonal zone where the Patagonian Steppe and the Deciduous Forest converge (Pisano, 1977). The project is located within a transition area between two climatic types. The first, Cold Steppe (BSk'), according to Köppen's classification (Di Castri & Hajek, 1976), corresponds to a dry zone climate (B), steppe type (S) and very cold, with average annual temperatures, including the warmest month, below 18ºC (k'). In this climate, rainfall varies approximately between 300 and 400 mm/year, decreasing from west to east. The second climatic type corresponds to the transition with Steppe Degeneration (Dfk'c). As its name indicates, this climatic type is found in the eastern trans-Andean region and represents a transitional form between extremely rainy and dry zones. The uniformity in the seasonal distribution of precipitation in the study area makes the development of a deciduous forest of classification (Df) possible, where k' means that it belongs to very cold zones. Geomorphologically, the Cabo Negro sector is characterized by low relief and landscapes of extensive terraced surfaces that do not exceed 30 m above sea level, making it one of the westernmost sectors of the region where important thicknesses of Quaternary deposits are exposed (Caldenius, 1932; Maragunic, 1974; Clapperton, 1988). The predominant soils are classified as Prairie soils, characterized by rainfall ranging from 300-400 mm per year (Pisano, 1977; Sáez, 1995).

10.3.1.2 Vegetation

In the Cabo Negro area, three types of vegetation and one constructed zone have been described, which corresponds mainly to areas that have been filled with stabilized material in order to facilitate the transit of machinery. Of the three vegetation types, two are natural and one, the Anthropic Prairie, is a secondary pasture.

In general, the richness of the flora is composed of 28 families, 45 genera and 47 species. From a taxonomic point of view, 5 are lichens of the Ascomycotina class, 2 are pteridophytes (ferns) and 40 angiosperms: 33 dicotyledons and 8 monocotyledons. The greatest richness was found in the dicotyledons. The richest families are *Asteraceae* and *Apiaceae* with 5 and

43 https://www.sea.gob.cl/

4 species. Monocots are represented by only 3 families Juncaceae, Orchidaceae and Poaceae, Poaceae being the most important with 5 species.

Of the 47 species, only Maytenus magellanica (woody hedge; maiten de magallanes) presents conservation problems and is classified as "vulnerable" for the Magallanes Region (Benoit, 1989).

On the occasion of surveys done for other projects, specifically in the area of interest in the Cabo Negro sector, the list of possible species to be found is 23 and is shown in the following table:

Table 78: List of species likely to be found in the Cabo Negro area

Family	*Species*	*Origen*	*Condition*
Rosaceae	Acaena magellanica (Lam.) Vahl	N	Ss
Rosaceae	Acaena pinnatifida Ruiz et Pav	N	Hp
Poaceae	Agrostis capillaris L.	I	Hp
Asteraceae	Baccharis magellanica (Lam.) Pers.	N	Sh
Asteraceae	Baccharis patagonica Hook. et Arn.	N	Sh
Berberidaceae	Berberis microphylla G. Forster	N	Sh
Asteraceae	Chiliotrichum diffusum (G. Forst.) Kuntze	N	Sh
Asteraceae	Chiliotrichum diffusum (G. Forst.) Kuntze	N	Sh
Asteraceae	Cirsium vulgare (Savi) Ten.	I	Ha
Poaceae	Deschampsia flexuosa (L.) Trin.	N	Hp
Empetraceae	Empetrum rubrum Vahl ex Willd.	N	Ss
Poaceae	Festuca gracillima Hook. f.	N	Hp
Asteraceae	Hieracium pilosela L.	I	Hp
Poaceae	Holcus lanatus L.	I	Ha
Poaceae	Hordeum chilense Roem. et Schult.	N	Hp
Asteraceae	Leucanthemum vulgare Lam.	I	Hp
Nothofagaceae	Nothofagus antarctica (G. Forst.) Oerst.	N	T
Asteraceae	Perezia lactucoides (Vahl) Less.	N	Hp
Hydrophyllaceae	Phacelia secunda J.F. Gmel.	N	Hp
Plantaginaceae	Plantago lanceolata L.	I	Hp
Polygonaceae	Rumex acetosella L.	I	Hp
Polygonaceae	Rumex crispus L.	I	Hp
Poaceae	Trisetum spicatum (L.) K.Richt.	N	Hp

N=Native, I=Introduced. Biological condition: T=Tree, Sh=Shrub, Hp=Herbaceous perennial, Ha=Herbaceous annual, Sa=Subshrub.

10.3.1.3 Description of plant community

Nothofagus antarctica Forest

The Nothofagus antarctica (Ñirre) forest community generally has an upper canopy composed of trees up to 5 meters in height and 20 cm in diameter at breast height, with an average canopy cover of 30% (Figure 37). The shrub layer is composed of specimens of N. antarctica as well as Chiliotrichum diffusum and Berberis microphylla. The herbaceous stratum is dominated by Holcus lanatus, Leptinella scariosa and Osmorhiza chilensis. In the tree canopy the parasitic shrubs Misodendron punctatum are established.

Figure 46: Physiognomy of the Nothofagus *antarctica* forest vegetation community in the area

Chiliotrichum diffusum shrubland

This community is distributed in sites where the soil is deep and rich in organic matter. It is preferentially established in sites protected from the wind. In the area of study, the Chiliotrichum diffusum scrub is distributed in certain protected areas that have been maintained despite strong anthropic pressure (Figure 35). This community is dominated by the shrub Chiliotrichum diffusum, which presents a density of approximately 55% in plant cover, accompanied by other herbaceous species such as Agrostis capillaris and Holcus lanatus.

Figure 47: General View of the Chiliotrichum diffusum Scrub in the Area

Anthropic prairie

The physiognomy of the community is herbaceous, dominated by the introduced grasses Agrostis capillaris and the creeping shrub Baccharis magellanica (Figure 36). The established vegetation is therefore considered secondary, due to the exclusive dominance of an allochthonous, non-native plant. Among the herbs that accompany the dominants are Holcus lanatus and Acaena magellanica.

Figure 48: General View of the Anthropic Prairie in the area of study

Built

This category corresponds to those areas that are filled with stabilized material, often leveled to facilitate the transit of vehicles and machinery. These areas have a very low vegetation cover (> 10%), which is normally composed only of introduced plants.

10.3.1.4 Conclusion

Although according to general studies of the Magallanes region it is possible to find 47 species, according to surveys done specifically in the Cabo Negro area, 23 types of vascular plants were found, where native perennial grasses dominate, and among these no species endemic to Chile were found, of which only one in conservation category.

It is worth mentioning that, of the 47 species mentioned in general, only Maytenus *magellanica* (leñadura) presents conservation problems and is classified as "vulnerable" for the Magallanes Region (Benoit 1989). There are no endangered species and there are also sectors where the intervened area has an anthropic meadow.

10.3.2 Fauna

According to the existing information on the fauna present in the area, in the studies and surveys carried out in Cabo Negro for other projects submitted to SEA, the following species can be found:

Table 79: List of fauna species likely to be found in the Cabo Negro area

Specie	*Scientific name*	*Common name*
Birds	*Circus cinereus*	Vari
	Caracara plancus	Carancho
	Milvago chimango	Tiuque
	Vanellus chilensis	Queltehue
	Larus dominicanus	Gaviota dominicana
	Geranoaetus melanoleucus	Águila Mora
	Aphrastura spinicauda	Rayadito
	Xolmis pyrope	Diucón
	Lessonia rufa	Colegial
	Phrygilus patgonicus	Cometocino patagónico
	Turdus falcklandii	Zorzal
	Zonotrichia capensis	Chincol
	Sturnella loyca	Loica
Mammals	*Abrothrix xanthorhinus*	Laucha de nariz amarilla
	Oryctolagus cuniculus	Conejo
	Lepus capensis	Liebre
	Lycalopex griseus	Zorro chilla
	Conepatus humboldti	Chingue
	Puma concolor	Puma

Of the species of wild vertebrates identified, Tachyeres patachonicus (Quetru Volador) is classified as "Insufficiently Known" according to the Hunting LawLey de Caza (SAG, 2012), while Conepatus humboldti (chingue) and Pseudalopex griseus (chilla fox , introduced species) are classified as of "Minor Concern" nationally, according to Supreme Decrees No. 13/2013 and No. 33/2012 of the Ministry of Environment, are classified as of "Least Concern" at the national level, according to Supreme Decrees No. 13/2013 and No. 33/2012 of the Ministry of the Environment, most of which are residents of the area and generally very frequent to observe.

Notwithstanding the above, the following is a systematic list (not exhaustive) of the tetrapod vertebrates potentially present in the study area. For birds, the order and nomenclature follows Araya *et al*. (1995) and for mammals, Yañez & Muñoz-Pedreros (2000).

Table 80: List of Birds species likely to be found in the Cabo Negro area

Order Podicipediformes	
Family Podicipedidae	
Common name	*Scientific name*
Pimpollo	*Rollandia rolland* (Quoy & Gaima)
Huala	*Podiceps major* (Boddaert 1783)
Order Procellariiformes	
Family Procellariidae	
Common name	*Scientific name*
Petrel gigante antártico	*Macronectes giganteus* (Gmelin 1789)
Order Pelecaniformes	
Family Phalacrocoraciidae	
Common name	*Scientific name*
Yeco	*Phalacrocorax brasilianus* (Gmelin 1789)
Cormorán de las rocas	*Phalacrocorax magellanicus* (Gmelin 1789)
Order Ciconiiformes	
Family Ardeidae	
Common name	*Scientific name*
Garza boyera	Bubulcus ibis (Linnaeus 1758)
Huairavo	Nycticorax (Linnaeus 1758)
Order Ciconiiformes	
Family Threskiornithidae	
Common name	*Scientific name*
Bandurria	Theristicus melanopis (Gmelin 1789)
Order Phoenicopteriformes	
Family Phoenicopteridae	

Common name	*Scientific name*
Flamenco chileno	Phoenicopterus chilensis (Molina 1782)
Order Anseriformes	
Family Anatidae	
Common name	*Scientific name*
Cisne de cuello negro	Cygnus melanocorypha (Molina 1782)
Canquén	Chloephaga poliocephala (Sclater 1857) [44]
Caiquén	Chloephaga picta (Gmelin 1789)
Pato juarjual	Lophonetta specularioides (King 1828)
Quetru volador	Tachyeres patachonicus (King 1831)
Pato jergón chico	Anas flavirostris (Vieillot 1816)
Pato jergón grande	Anas georgica (Gmelin 1789)
Pato real	Anas sibilatrix (Poeppig 1829)
Order Falconiformes	
Family Accipitridae	
Common name	*Scientific name*
Vari Circus cinereus	*Circus cinereus (Vieillot 1816)*
Aguila Mora	Geranoetus melanoleucus (Vieillot 1819)
Aguilucho	Buteo polyosoma (Quoy & Gaimard 1824)
Order Falconiformes	
Family Falconidae	
Common name	*Scientific name*
Carancho	Caracara plancus (Miller 1777)
Tiuque	Milvago chimango (Vieillot 1816
Cernícalo	Falco sparverius (Linnaeus 1758)
Halcón peregrino	Falco peregrinus (Tunstall 1771)
Order Gruiformes	
Family Rallidae	
Common name	*Scientific name*
Pidén	Pardirallus sanguinolentus (Swainson 1838)
Tagua	Fulica armillata (Vieillot 1817)
Order Charadriiformes	
Family Charadriidae	
Common name	*Scientific name*
Queltehue	Vanellus chilensis (Molina 1782)

[44] Canquén Colorado plan https://mma.gob.cl/gran-paso-en-la-proteccion-de-una-especie-en-peligro-se-oficializa-plan-recoge-canquen-colorado-en-magallanes/#:~:text=Plan%20RECOGE%20del%20Canqu%C3%A9n%20Colorado,-El%20Plan%20RECOGE&text=Este%20Plan%20posee%20un%20alcance,plazo%20estimado%20de%2015%20a%C3%B1os.

Chorlo de doble collar	Charadrius falklandicus (Latham 1790)
	Order Charadriiformes *Family Haematopodidae*
Common name	*Scientific name*
Pilpilén austral	Haematopus leucopodus (Garnot 1826)
	Order Charadriiformes *Family Scolopacidae*
Common name	*Scientific name*
Playero de lomo blanco	Calidris fuscicollis (Vieillot 1819)
Becasina	Gallinago paraguaiae (Vieillot 1816)
	Order Charadriiformes *Family Thinocoridae*
Common name	*Scientific name*
Perdicita	Thinocorus rumicivorus (Eschscholtz 1829)
	Order Charadriiformes *Family Laridae*
Common name	*Scientific name*
Gaviota dominicana	Larus dominicanus (Lichtenstein 1823)
Gaviotín sudamericano	Sterna hirundinacea (Lesson 1831)
	Order Strigiformes *Family Strigidae*
Common name	*Scientific name*
Nuco	Asio flammeus (Pontoppidan 1763)
	Order Piciformes *Family Picidae*
Common name	*Scientific name*
Carpintero negro	Campephilus magellanicus (King 1828)
	Order Passeriformes *Family Furnariidae*
Common name	*Scientific name*
Churrete acanelado	Cinclodes fuscus (Vieillot 1818)
Churrete	Cinclodes patagonicus (Gmelin 1789)
Rayadito	Aphrastura spinicauda (Gmelin 1789)
	Order Passeriformes *Family Tyrannidae*
Common name	*Scientific name*
Diucón	Xolmis pyrope (Kittlitz 1830)

Dormilona tontita	Muscisaxicola macloviana (Garnot 1829)
Colegial	Lessonia rufa (Gmelin 1789)
Fío-fío	Elaenia albiceps (Lafresnaye & D’Orbigny 1837)
Order Passeriformes *Family Hirundinidae*	
Common name	*Scientific name*
Golondrina chilena	Tachycineta meyeni (Cabanis 1850)
Golondrina dorso negro	Pygochelidon cyanoleuca (Vieillot 1817)
Order Passeriformes *Family Troglodytidae*	
Common name	*Scientific name*
Chercán	Troglodytes aedon Vieillot 1809
Order Passeriformes *Family Muscicapidae*	
Common name	*Scientific name*
Zorzal	Turdus falcklandii (Quoy & Gaimard 1824)
Order Passeriformes *Family Emberizidae*	
Common name	*Scientific name*
Chirihue austral	Sicalis lebruni (Oustalet 1891)
Chincol	Zonotrichia capensis (Müller 1776)
Loica	Sturnella loyca (Molina 1782)
Tordo	Curaeus (Molina 1782)
Order Passeriformes *Family Fringillidae*	
Common name	*Scientific name*
Cometocino patagónico	Phrygilus patagonicus (Lowe 1923)
Jilguero	Carduelis barbata (Molina 1782)

It is worth making a special mention of the Canquén Colorado (Chloephaga rubidiceps) because through the publication in the Official Gazette with it Supreme Decree No. 22/2020 of the Ministry of the Environment, the “Plan de Recuperación, Conservación y Gestión del Canquén Colorado en Magallanes” was made official. Plan that serves as an administrative instrument and has actions, measures and procedures that must be executed to recover, conserve and manage species that are classified within the framework of the Regulation for the Classification of Wild Species according to Conservation Status.

The Canquén colorado (Chloephaga rubidiceps) is an endemic species of Eastern Patagonia and the Malvinas Islands that lives in humid environments of the steppe, the decrease in its population has been reported since the end of the 70s by researchers and ornithologists, who alert the community about the decline in its population in southern Chile and Argentina, which is mainly related to habitat modification and predation by the chilla fox and the mink, both species introduced to Tierra del Fuego Island in the years fifty.

Table 81: List of Mammalia species likely to be found in the Cabo Negro area

Order Chiroptera Family Vespertilionidae	
Common name	*Scientific name*
Murciélago oreja de ratón	Myotis chiloensis (Waterhouse 1838)
Murciélago orejudo	Histiotus montanus (Philippi & Landbeck 1861)
Order Rodentia Family Muridae	
Common name	*Scientific name*
Ratón de los espinos	Oligoryzomys magellanicus (Allen 1905)
Laucha de nariz amarilla	Abrothrix xanthorhinus (Waterhouse 1837)
Order Rodentia Family Myocastoridae	
Common name	*Scientific name*
Coipo	Myocastor coypus (Molina 1782)
Order Lagomorpha Family Leporidae	
Common name	*Scientific name*
Conejo	Oryctolagus cuniculus (Linnaeus 1758)
Liebre	Lepus capensis (Linnaeus 1758)
Order Carnivora Family Canidae	
Common name	*Scientific name*
Zorro Culpeo	Lycalopex culpaeus (Molina 1782)
Zorro Chilla	Lycalopex griseus (Gray 1837)
Puma	Puma concolor (Linnaeus 1771)
Order Carnivora Family Mustelidae	
Common name	*Scientific name*
Quique	Grison cuja (Molina 1782)
Chingue	Conepatus humboldtii (Gray 1837)

Canquén colorado is classified in the category of “Endangered”. Periodic censuses carried out from 1999 to 2021 in the breeding area have shown a consistent decline over time. For this reason, in Chile and Argentina the Canquén colorado is a species that is protected by law.

Conclusion

As special attention should be considered this area as the habitat of the Canquén Colorado (Chloephaga rubidiceps) as it is classified in the category of "Endangered", for this reason, in Chile and Argentina the Canquén Colorado is a species that is protected by law.

All species identified in this study correspond to highly mobile organisms with wide home ranges, so the surface intervention associated with the construction of any project should not be significant. The above considering that the area where the project would be located does not present exceptional habitat conditions or breeding sites for endangered species or areas of relevant fauna concentration, and that the current record of species, for the most part, has not suffered great change with the implementation of projects, so it would not generate adverse environmental impacts on the fauna of vertebrate tetrapods present in the study area.

It should be borne in mind that Bahía Lomas is located near Cabo Negro, which is a Ramsar Site and a Nature Sanctuary (it is a legally protected area). One of its main goals is to protect migratory birds, which arrive by the thousands each summer, from North America.

10.3.3 Archaeology

The following is a bibliographic description of the archaeological aspect of the Cabo Negro sector, commune of Punta Arenas, Magallanes and Chilean Antarctica Region. Given the variable to be studied, which is specific to the sector to be identified, preference has been given to the information contained in the projects presented and approved by the Environmental Impact Assessment System in recent years, which can be found on the SEA (Environmental Assessment Service) website. In addition, for this aspect, the information from the National Monuments Council (Archeology and Heritage) has been considered for further study.

The archaeological description to be presented considers a general and introductory description of the aspect and a detailed description of the Cabo Negro sector, where the findings made when archaeological surveys submitted to the SEIA (Environmental Impact Assessment System) for the development of future projects will be indicated.

10.3.3.1 General Background

Continental Southern Patagonia was the landscape crossed from the end of the Pleistocene (i.e. 12,000 years approx.), until historical times, by different groups of hunter-gatherers who inhabited the area. This territory covers sixty thousand (60,000) km^2, with orographic characteristics of plateau plains, fluvial and coastal plains and mountain ranges, where the orography has conditioned fluvial systems that drain into the Atlantic Ocean, water courses that are important when evaluating the presence of prehistoric or ethnographic populations in the area. The existence of lagoons and seasonal water courses is also important.

The exploration or colonization of this area would have taken place at the end of the last glaciation, in an environment of pro-glacial lakes (Clapperton, 1992). The evidence of these early hunter-gatherers has been conceptualized as the Fell, Magallanes or Bird I Period, taking as a reference the chronology established by Junius Bird for the continent, which in the 1980s was revised by Massone, proposing three major units: early hunter-gatherers (Bird I and II), middle (Bird III) and late (Bird IV-V) (Massone, 1981a; Bird, 1993).

It is also necessary to mention that the archaeology of continental hunters in southern Patagonia on both sides of the border has been conceptualized differently. Thus, in Argentine Patagonia, studies focus on cultural industries (Menghin, 1952), while in Chilean Patagonia, the use of cultural periods is predominant (Bird, 1993).

10.3.3.2 Ethnohistoric and Ethnographic background

Ethnohistoric information comes from navigators such as Hernando de Magallanes (1520), Juan Ladrillero (1558), Sarmiento de Gamboa (1580-1584), Lord Byron (1764-1765), Boungainville (1766-1767), Córdoba (1785-1786) and Fitz-Roy (1826-1836).

The contact between indigenous peoples and european travelers since the 16th century led to a series of adoptions, such as the incorporation of metal and glass as raw materials. In the case of metal, it was used mainly in the manufacture of personal adornments and horse implements and to a lesser extent in the manufacture of instruments (Martinic, 1995), while glass was used exclusively in the manufacture of artifacts such as scrapers (Jackson, 1991a and b).

These ethnohistoric accounts indicate that the Aonikenk lived as nomads, moving between sites for hunting and gathering, with a predilection for guanaco and ostrich consumption, as well as the incorporation of coastal resources. One of the most frequented stopovers was located in San Gregorio, where they used to winter. Thus, numerous Aonikenk stopovers have been found along the northern coast of the Strait, such as Punta Delgada, Posesión and Punta Dungeness (Massone, 1984).

A relevant fact, which marks a turning point in the late hunter-gatherer groups of continental Patagonia, is related to the adoption of the horse, which implied radical changes in the hunting activities of these groups (Massone, 1981a). The use of arrowheads was abandoned, adopting the exclusive use of bolas in hunting activities; on the other hand, inter-ethnic contact with other groups of Northern Patagonia, influenced the adoption of ceramics and textile elements (Massone, 1984, Martinic, 1995).

Regarding the cultural phases defined for historical times, we can mention the Equestrian Complex (adoption of the horse) and the Alcoholic Complex, since alcohol would be the cause of the cultural decadence and extinction of the southern Tehuelches (Martinic & Prieto, 1985-1986). This definition of Alcoholic Complex is undoubtedly questionable, since the determining factors in the destructuring of the hunter-gatherer way of life were the contagion of diseases such as smallpox and the cattle occupation of the continental steppe, which caused the displacement of the Aonikenk from their ancestral territories.

10.3.3.3 Background of the study area: Cabo Negro

In the Cabo Negro sector, the findings made during the archaeological inspection for the EIS "Construction of Polyduct 6 from Río Pescado to Cabo Negro" stand out, from which there are records of 12 sites within the area (Tureuna, 2010). All of these correspond to isolated lithic sites and/or findings and different concentrations of heritage material.

For its part, within the project "Construction of Pier No. 2 Cabo Negro Terminal", 3 points of archaeological interest were found within the protection or buffer zones (area of indirect influence) and two archaeological sites outside the project area (Ocampo & Rivas, 2000).

The archaeological findings in the study area are detailed below:

Table 82: Geographical Coordinates of Findings (Datum WGS 84).

Name	*TYPE OF FINDING*	*East*	*North*	*Reference*
Ha1	Isolated Finding	378,137	4,133,624	Ocampo & Rivas, 2000
Bahía Laredo 4	Archaeological site	378,026	4,131,563	Prieto, 1988
Bahía Laredo 5	Archaeological site	378,465	4,131,945	Prieto, 1988, 1993-94; Martinic, 1992
Sitio 1	Archaeological site	378,843	4,133,396	Ocampo & Rivas, 2000
Bahía Laredo 3	Archaeological site	378,305	4,131,632	Prieto, 1988
Sitio 1	Archaeological site	378,888	4,133,271	Ocampo & Rivas, 2000
Sitio 1	Archaeological site	378,930	4,133,273	Ocampo & Rivas, 2000
Bahía Laredo 1C	Archaeological site	378,669	4,131,981	Prieto, 1988
Bahía Laredo 1A	Archaeological site	378,635	4,131,857	Prieto, 1988
Sitio N° 5	Archaeological site	378,543	4,131,697	Ocampo & Rivas, 2000
Construcción Muelle N2 Terminal Cabo Negro	Archaeological site	379,173	4,133,041	Catastro 2010
Bahía Laredo 2	Archaeological site	378,895	4,131,925	Prieto, 1988
Sitio N° 4	Archaeological site	378,967	4,131,849	Ocampo & Rivas, 2000
Sitio 2	Archaeological site	379,328	4,133,215	Ocampo & Rivas, 2000
Poliducto 6" C Negro - Rio Pescado	Isolated Finding	374,700	4,134,403	Catastro 2010
Proyecto Poliducto 6" Cabo Negro - Rio Pescado	Isolated Finding	374,694	4,134,395	Catastro 2010
Poliducto 6" C Negro - Rio Pescado	Isolated Finding	374,698	4,134,402	Catastro 2010
Proyecto Poliducto 6" Cabo Negro - Rio Pescado	Isolated Finding	374,692	4,134,398	Catastro 2010
Proyecto Poliducto 6" Cabo Negro - Rio Pescado	Isolated Finding	374,687	4,134,396	Catastro 2010

Poliducto 6" C Negro - Rio Pescado	Isolated Finding	374,677	4,134,400	Catastro 2010
Proyecto Poliducto 6" Cabo Negro - Rio Pescado	Isolated Finding	374,675	4,134,400	Catastro 2010
Proyecto Poliducto 6" Cabo Negro - Rio Pescado	Isolated Finding	374,675	4,134,401	Catastro 2010
Normalización Pol Posesión – Cabo Negro	Archaeological Concentration	374,621	4,134,324	Catastro 2010
Gasoducto Kimiri Aike - Cabo Negro	Archaeological site	374,609	4,134,321	Catastro 2010
BASHOA 6	Archaeological site	374,612	4,134,351	Constantinescu et al. 1999
Proyecto Poliducto 6" Cabo Negro - Rio Pescado	Archaeological site	374,580	4,134,405	Tureuna, 2010
Proyecto Poliducto 6" Cabo Negro - Rio Pescado	Archaeological Concentration	374,541	4,134,422	Tureuna, 2010
Proyecto Poliducto 6" Cabo Negro - Rio Pescado	Isolated Finding	374,533	4,134,426	Tureuna, 2010
Normalización Pol Posesión – Cabo Negro	Archaeological Concentration	374,505	4,134,381	Catastro 2010
Proyecto Poliducto 6" Cabo Negro - Rio Pescado	Isolated Finding	374,537	4,134,456	Catastro 2010
Normalización Pol Posesión – Cabo Negro	Archaeological Concentration	374,470	4,134,400	Catastro 2010
Normalización Pol Posesión – Cabo Negro	Archaeological Concentration	374,448	4,134,397	Catastro 2010
Gasoducto Kimiri Aike - Cabo Negro	Isolated Finding	374,412	4,134,495	Catastro 2010
Poliducto 6" Cabo Negro - Rio Pescado	Isolated Finding	374,412	4,134,508	Catastro 2010
Proyecto Poliducto 6" Cabo Negro - Rio Pescado	Isolated Finding	374,412	4,134,508	Catastro 2010
Gasoducto Kimiri Aike - Cabo Negro	Isolated Finding	374,339	4,134,472	Catastro 2010
Proyecto Poliducto 6" Cabo Negro - Rio Pescado	Archaeological Concentration	374,293	4,134,559	Catastro 2010
Proyecto Poliducto 6" Cabo Negro - Rio Pescado	Archaeological Concentration	374,281	4,134,558	Catastro 2010
Normalización Poliducto Posesión – Cabo Negro	Archaeological site	374,230	4,134,470	Catastro 2010
Gasoducto Kimiri Aike - Cabo Negro	Isolated Finding	374,220	4,134,473	Catastro 2010
Gasoducto Kimiri Aike - Cabo Negro	Isolated Finding	374,237	4,134,633	Catastro 2010
Gasoducto Kimiri Aike - Cabo Negro	Archaeological Concentration	374,216	4,134,675	Catastro 2010
BASHOA 5	Archaeological Concentration	374,211	4,134,680	Constantinescu et al. 1999

Poliducto 6" Cabo Negro - Rio Pescado	Isolated Finding	373,941	4,134,653	Tureuna, 2010
Proyecto Poliducto 6" Cabo Negro - Rio Pescado	Isolated Finding	373,941	4,134,653	Catastro 2010
Gasoducto Kimiri Aike - Cabo Negro	Isolated Finding	374,051	4,134,879	Catastro 2010
3 Covacevich	Archaeological site	374,113	4,134,990	Catastro 2010
Proyecto Poliducto 6" Cabo Negro - Rio Pescado	Isolated Finding	373,881	4,134,667	Catastro 2010
Gasoducto Kimiri Aike - Cabo Negro	Isolated Finding	373,895	4,134,827	Catastro 2010
Proyecto Poliducto 6" Cabo Negro - Rio Pescado	Isolated Finding	373,798	4,134,693	Catastro 2010
Gasoducto Kimiri Aike - Cabo Negro	Archaeological site	373,654	4,134,667	Catastro 2010
Normalización Poliducto Posesión – Cabo Negro	Archaeological Concentration	373,625	4,134,619	Catastro 2010
BASHOA 4	Archaeological site	373,650	4,134,697	Constantinescu et al. 1999
Gasoducto Kimiri Aike - Cabo Negro	Archaeological Concentration	373,605	4,134,632	Catastro 2010
BASHOA 2	Archaeological Concentration	373,613	4,134,665	Constantinescu
Gasoducto Kimiri Aike - Cabo Negro	Archaeological site	373,629	4,134,705	Catastro 2010
BASHOA 3	Archaeological site	373,630	4,134,727	Constantinescu et al. 1999
Poliducto 6" C Negro - Rio Pescado	Archaeological Concentration	373,578	4,134,747	Tureuna, 2010
Proyecto Poliducto 6" Cabo Negro - Rio Pescado	Archaeological Concentration	373,578	4,134,747	Catastro 2010
Proyecto Poliducto 6" Cabo Negro - Rio Pescado	Archaeological Concentration	373,578	4,134,751	Catastro 2010
Poliducto 6" Cabo Negro - Rio Pescado	Archaeological Concentration	373,575	4,134,751	Catastro 2010
Proyecto Poliducto 6" Cabo Negro - Rio Pescado	Archaeological Concentration	373,575	4,134,751	Catastro 2010
Proyecto Poliducto 6" Cabo Negro - Rio Pescado	Archaeological Concentration	373,559	4,134,735	Tureuna, 2010
Gasoducto Kimiri Aike - Cabo Negro	Archaeological site	373,427	4,134,507	Catastro 2010
BASHOA 1	Archaeological site	373,430	4,134,536	Constantinescu et al. 1999
Proyecto Poliducto 6" Cabo Negro - Rio Pescado	Archaeological Concentration	373,468	4,134,755	Tureuna, 2010
Poliducto 6" Cabo Negro - Rio Pescado	Archaeological Concentration	373,473	4,134,779	Tureuna, 2010
Normalización Poliducto Posesión – Cabo Negro	Archaeological site	373,428	4,134,695	Catastro 2010

Poliducto 6" Cabo Negro - Rio Pescado	Isolated Finding	373,470	4,134,787	Catastro 2010
Poliducto 6" C Negro - Rio Pescado	Isolated Finding	373,411	4,134,789	Tureuna, 2010
Normalización Poliducto Posesión – Cabo Negro	Archaeological Concentration	373,158	4,134,784	Catastro 2010

10.3.3.4 Conclusions

In the sector of interest (Cabo Negro), with respect to projects already developed, different archaeological findings have been found, ranging from isolated finds to archaeological sites. This makes it possible that during the development of the future project there will be findings, either during the surface survey stage or during the construction stage (excavations).

In general, for those areas where there is no intervention of any kind, archaeological visibility is medium to low, which makes it impossible to correctly record the sedimentological matrix and eventually archaeological or other findings of heritage interest protected by Law 17,288 of National Monuments, which could be found under the topsoil. This is relevant for the project, considering the high potential that exists in the area, known through the archaeological background previously exposed.

In accordance with the above and the known archaeological background for the area, it is convenient to keep in mind as a suggestion the realization of a permanent archaeological monitoring in archaeology in the work fronts included within the areas currently not intervened, this during the scarping works and all the activities that consider the removal of the surface during the construction of the respective access roads and construction of the plant.

It should be noted that in the event of an archaeological or paleontological find (during excavations and even during the implementation of archaeological monitoring), the procedure must be in accordance with the provisions of Articles N° 26 and 27 of Law N° 17,288 on National Monuments and Articles N° 20 and 23 of the Regulations of Law N° 17,288, on excavations and/or prospecting of the site. 288, on archaeological, anthropological and paleontological excavations and/or prospecting, stopping the work in the affected sector and immediately informing the National Monuments Council in writing, so that this body can determine the procedures to be followed and whose implementation must be carried out by the owner of the Project.

It is also important to note that there are no indigenous communities in the area that have claimed archaeological sites as ancestral heritage, which results in a low level of risk for the project that this could lead to extensive or more complex environmental processing processes and involve developing an indigenous consultation process for this purpose.

10.3.4 Relevant cultural sites and activities

For the Magallanes region, various secondary sources of information were reviewed to identify possible activities and/or sites of cultural significance that are currently in force for the local communities associated with the project development sector or its immediate communal or intercommunal surroundings, and that could eventually be affected by its implementation.

Special emphasis was placed on gathering information on the existing indigenous communities and associations and the possible current development of traditional and ancestral activities in the Cabo Negro sector and the surrounding area, as well as the possible existence of heritage sites and sites of cultural significance for the native peoples and also for the population in general.

The following sources were consulted:

- Environmental processing files of previous projects developed in the sector and in the commune, available on the SEA website.
- Indigenous Territorial Information System, SITI 2.0, of CONADI (National Corporation for Indigenous Development), which integrates diverse georeferenced information related to the Indigenous Development Areas (ADI); existing indigenous communities with legal status, constituted within the framework of the Indigenous Law No. 19,253; and titles of merced and inheritance communities, as well as census entities with a high percentage of indigenous population.
- Records of Indigenous Communities and Associations, from CONADI, updated as of January 13, 2022, available on the aforementioned page of SITI 2.0; as well as various other records, databases and documents available in that information system (historical file of land purchases, statistics on indigenous quality, regional statistics on indigenous peoples, etc.).
- Diverse information available on Tangible and Intangible Heritage, in the Council of National Monuments of Chile (CMN), in IDE Patrimonio and in the Information System for the Management of Intangible Cultural Heritage (SIGPA).
- Diverse georeferenced information in the area of study of this chapter, available in IDE Chile, Geospatial Data Infrastructure.
- Information on Marine Coastal Spaces for Indigenous Peoples (ECMPO), available at SUBPESCA (Undersecretary of Fisheries and Aquaculture).
- National Municipal Information System, SINIM, of SUBDERE (Undersecretary of Regional and Administrative Development), where the PLADECOs in force in the municipalities involved and other background at the municipal level were consulted.
- Specialized bibliography in the area covered, to which specific reference is made in the chapter, when required.

10.3.4.1 General background of Indigenous Peoples in the region

Of the four main peoples known to have lived ancestrally in the Magallanes Region at the time of the arrival of the colonizers, only two have survived to the present day: the Kawésqar and the Yagán people, although in very small numbers. The rest are extinct: Aónikenk and Selk'nam, as a result of the devastating process of extermination that took place in a large part of the southern zone, derived from the expansion of the cattle business and the hunting of sea lions.

The Kawésqar people were originally a canoeist, nomadic, hunter-gatherer group. At present they are located in Puerto Eden, Puerto Natales and the city of Punta Arenas.

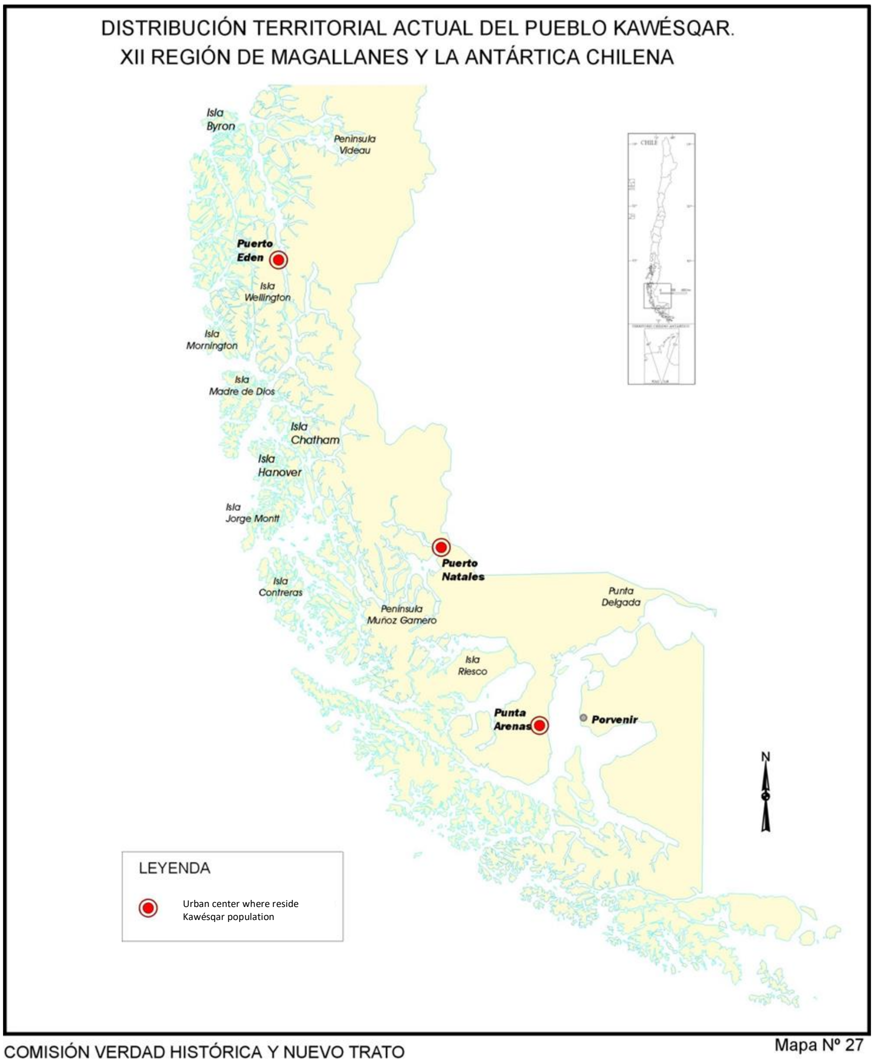


Figure 49: Current territorial distribution of the Kawésqar People

The Yagán people, on the other hand, are the southernmost canoe people in the world. They occupied the islands south of Tierra del Fuego, between the Beagle Channel and Cape Horn, whose last families are settled today in Villa Ukika and Bahía Mejillones, near Puerto Williams. They are characterized by being nomadic peoples who carry out hunting, fishing and gathering activities. The canoe was central to their way of life, and was built from the whole bark of a tree, trimmed and shaped like a gondola.

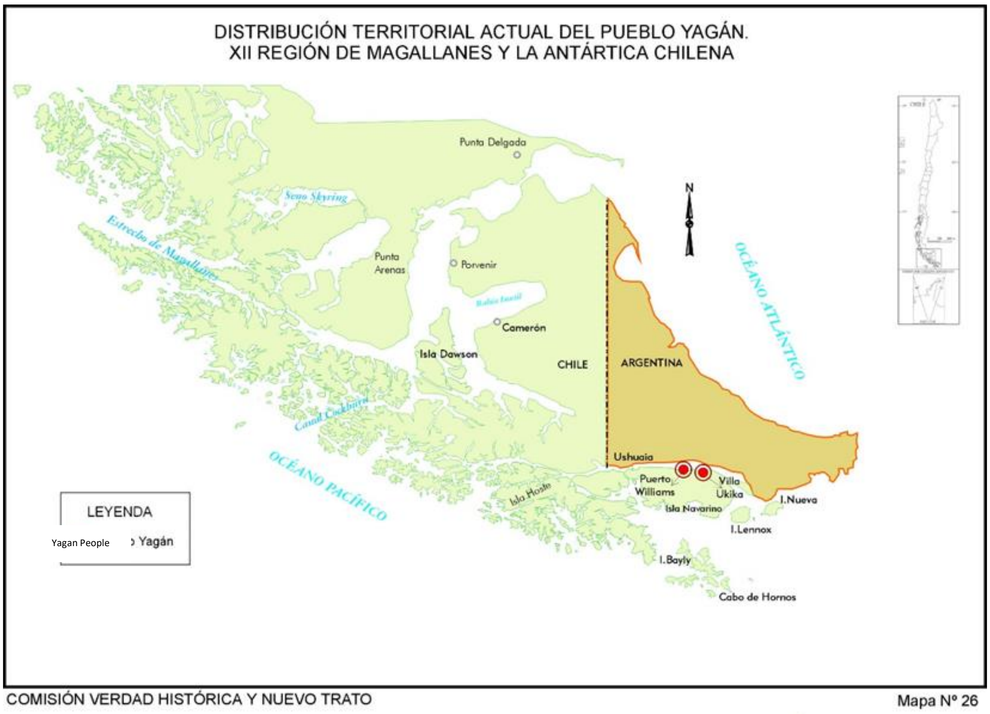


Figure 50: Current territorial distribution of the Yagán People

Currently, of the 166,533 inhabitants registered in the region in 2017, 23% recognize themselves as belonging to a native people, although 93% of this total corresponds to migrant Mapuche (particularly from the Huilliche area - Chiloé Island) and only 2.5% to the Kawésqar people and 0.9% to the Yagán people.

10.3.4.2 Indigenous Communities and Associations

At January 2022, there are 17 legally constituted indigenous communities in the region (belonging to the Kawésqar and Yagán peoples), 9 of which are located in the commune of Punta Arenas and bring together a total of 53 families and 123 members, all residing in the city of Punta Arenas.

Table 83: Indigenous Communities Magallanes Region

PROVINCE	COMMUNE	COMMUNITY NAME	N° OF FAMILIES	N° OF MEMBERS	DATE OF CONSTITUTION
ANTÁRTICA CHILENA	CABO DE HORNOS	COMUNIDAD INDÍGENA YAGHAN DE BAHÍA MEJILLONES	20	75	21-11-1994
MAGALLANES	PUNTA ARENAS	COMUNIDAD INDÍGENA KAWASHKAR RESIDENTE EN PUNTA ARENAS	15	24	05-10-1994
MAGALLANES	PUNTA ARENAS	COMUNIDAD INDÍGENA KAWASHKAR "CANOEROS AUSTRALES"	3	8	31-03-1999
MAGALLANES	PUNTA ARENAS	COMUNIDAD INDÍGENA KAWESQAR CAZADORES PATAGÓNICOS	6	16	11-07-2005
MAGALLANES	PUNTA ARENAS	COMUNIDAD INDÍGENA KAWÉSQAR DE ANCÓN SIN SALIDA	4	9	28-06-2012
MAGALLANES	PUNTA ARENAS	COMUNIDAD INDIGENA ATAP	4	9	02-07-2013
MAGALLANES	PUNTA ARENAS	COMUNIDAD INDIGENA YAGAN LOM SAPAKÚTA	2	10	14-02-2015
MAGALLANES	PUNTA ARENAS	COMUNIDAD INDÍGENA KAWÉSQAR GRUPOS FAMILIARES NOMADES DEL MAR	10	18	08-08-2017
MAGALLANES	PUNTA ARENAS	COMUNIDAD INDÍGENA KAWÉSQAR ISLA DAWSON	5	18	28-09-2017
MAGALLANES	PUNTA ARENAS	COMUNIDAD INDÍGENA KAWASQAR "JETARKTE"	4	11	04-01-2021
MAGALLANES	RÍO VERDE	COMUNIDAD INDÍGENA KAWÉSQAR "EKCEWE LEJÉS WOES"	9	11	27-10-2014
ÚLTIMA ESPERANZA	NATALES	COMUNIDAD INDÍGENA KAWÉSQAR RESIDENTE EN PUERTO EDÉN	5	19	20-10-1994
ÚLTIMA ESPERANZA	NATALES	COMUNIDAD INDÍGENA KAWASHKAR RESIDENTE EN PUERTO NATALES	10	19	17-01-1995
ÚLTIMA ESPERANZA	NATALES	COMUNIDAD INDÍGENA KAWÉSQAR KSKIAL DE PUERTO NATALES	4	26	13-01-2004
ÚLTIMA ESPERANZA	NATALES	COMUNIDAD INDÍGENA ASWAL LAJEP	1	14	07-01-2014
ÚLTIMA ESPERANZA	NATALES	C AP JUANA PEREZ	5	12	03-03-2016
ÚLTIMA ESPERANZA	NATALES	COMUNIDAD INDÍGENA KAWESQAR RESIDENTE RÍO PRIMERO	12	12	08-08-2017

The number of legally constituted Indigenous Associations is 25, made up mostly of Mapuche-Huilliche migrant population (either recent or several generations). Of this total, 15 are located in the urban area of Punta Arenas.

Table 84: Geographical Coordinates of Findings (Datum WGS 84)

PROVINCE	COMMUNE	COMMUNITY NAME	N° OF MEMBERS	DATE OF CONSTITUTION
ANTÁRTICA CHILENA	CABO DE HORNOS	ASOCIACIÓN INDÍGENA MAPUCHE HUILLICHE DE PUERTO WILLIAMS	64	08-05-1998
MAGALLANES	PUNTA ARENAS	ASOCIACIÓN INDÍGENA MAPUCHE HUILLICHE RAÑINTULEUFU	38	01-07-2000
MAGALLANES	PUNTA ARENAS	ASOCIACIÓN INDÍGENA MAPUCHE HUILLICHE HUILLI RUPE	31	22-07-2000
MAGALLANES	PUNTA ARENAS	ASOCIACIÓN INDÍGENA MAPUCHE HUILLICHE DE TRABAJADORES INDEPENDIENTES HUILLI RELMU	65	26-05-2001
MAGALLANES	PUNTA ARENAS	ASOCIACIÓN INDÍGENA MAPUCHE HUILLICHE PUKEM	26	10-08-2001
MAGALLANES	PUNTA ARENAS	ASOCIACIÓN INDÍGENA ARTESANOS DEL PUEBLO KAWASHKAR	23	23-08-2001
MAGALLANES	PUNTA ARENAS	ASOCIACIÓN INDÍGENA MAPUCHE HUILLICHE PEWU ANTU	61	07-08-2002
MAGALLANES	PUNTA ARENAS	ASOCIACIÓN INDÍGENA FUTA COYAN DE PUNTA ARENAS	34	21-01-2003
MAGALLANES	PUNTA ARENAS	ANTILCO	26	14-08-2003
MAGALLANES	PUNTA ARENAS	ASOCIACIÓN INDÍGENA DE PRODUCTORES AGRÍCOLAS "WAYWEN" DE PUNTA ARENAS	185	08-06-2006
MAGALLANES	PUNTA ARENAS	ASOCIACION INDÍGENA URBANA ÑUKE RUKA	40	20-06-2008
MAGALLANES	PUNTA ARENAS	ASOCIACION INDIGENA REUQUEN WILLI LAFKEN DE PUNTA ARENAS	35	12-05-2008
MAGALLANES	PUNTA ARENAS	ASOCIACION INDÍGENA KETRAWE MAPU	59	19-07-2012
MAGALLANES	PUNTA ARENAS	ASOCIACIÓN INDÍGENA "WECHE PEPIUKELEN"	189	12-06-2014
MAGALLANES	PUNTA ARENAS	ASOCIACIÓN INDÍGENA AUCAPAN	53	05-11-2015
MAGALLANES	PUNTA ARENAS	ASOCIACION INDIGENA MOCHULLA FOLIL	30	28-08-2021
TIERRA DEL FUEGO	PORVENIR	ASOCIACIÓN INDÍGENA URBANA JOWSKEN	32	04-06-1998
ÚLTIMA ESPERANZA	NATALES	ASOCIACIÓN INDÍGENA MAPUCHE HUILLICHE NATALES SHAKIN AYILÉN	94	16-11-1996
ÚLTIMA ESPERANZA	NATALES	ASOCIACIÓN INDÍGENA MAPUCHE HUILLICHE LAFKEN MAWIDA	55	07-09-1999
ÚLTIMA ESPERANZA	NATALES	ASOCIACIÓN INDÍGENA MAPUCHE HUILLICHE MAWIDA CHE DE VILLA DOROTEA	25	29-04-2000
ÚLTIMA ESPERANZA	NATALES	ASOCIACIÓN INDÍGENA MAPUCHE HUILLICHE WILLI ANTU DE PUERTO NATALES	85	24-06-2001

PROVINCE	COMMUNE	COMMUNITY NAME	N° OF MEMBERS	DATE OF CONSTITUTION
ÚLTIMA ESPERANZA	NATALES	ASOCIACIÓN INDÍGENA DE HUERTEROS FOYECO	40	01-12-2001
ÚLTIMA ESPERANZA	NATALES	ASOCIACIÓN INDÍGENA ETNIAS UNIDAS	47	22-06-2005
ÚLTIMA ESPERANZA	NATALES	ASOCIACION INDIGENA NEWEN LAFKEN	35	13-03-2008
ÚLTIMA ESPERANZA	NATALES	ASOCIACION INDIGENA INTERCULTURAL PAYANDI MARA	25	22-01-2021

10.3.4.3 Coastal Marine Spaces for Indigenous Peoples

To date, there are two ECMPO applications in the Magallanes Region, submitted by Kawésqar indigenous community associations: Península Muñoz Gamero and Kawésqar-Última Esperanza. The first is currently being processed by CONADI and the second is under judicial appeal.

The following figure shows the area covered by both ECMPO requests:

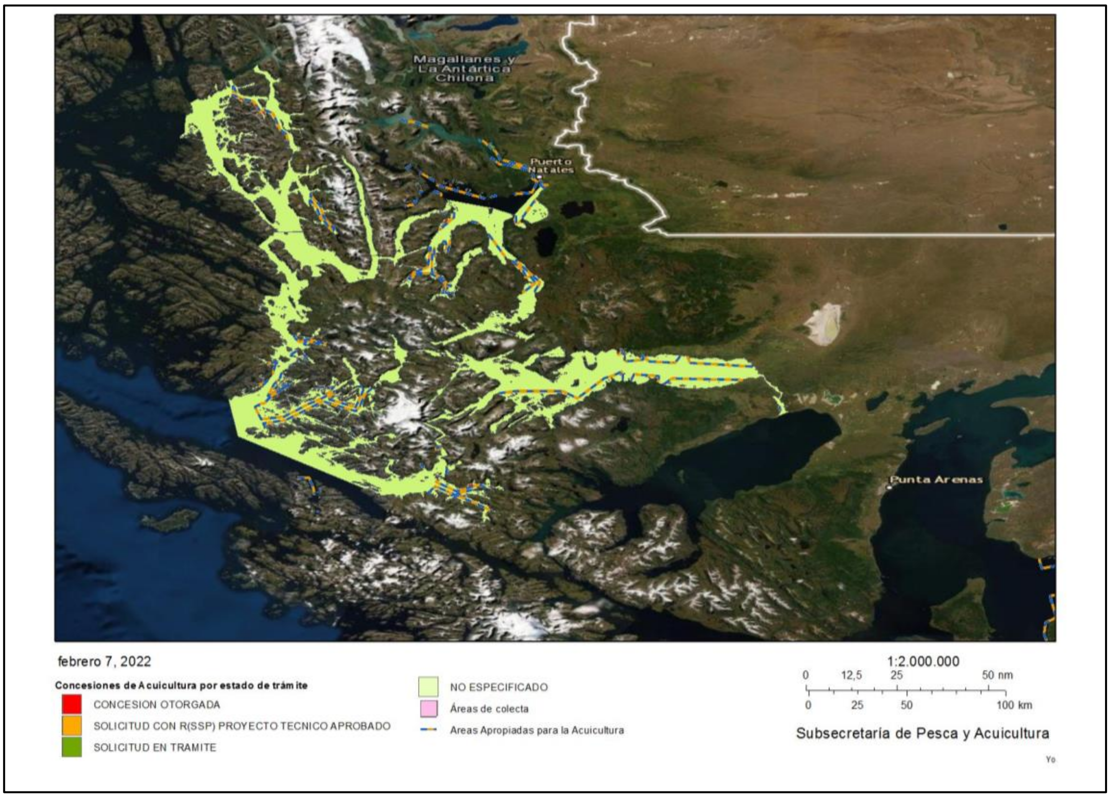


Figure 51: Area covered by ECMPO Muñoz Gamero Peninsula and Kawésqar-Última Esperanza. **(Source Subpesca, http://mapas.subpesca.cl/ideviewer/)**

As can be seen, these ECMPOs are far from the Cabo Negro project area, involving maritime areas independent of it. For more detail, the following illustration shows an enlarged map of the Kawésqar-Última Esperanza ECMPO sector closest to the project area, located in the Fitz Roy Channel, at the mouth of Otway Sound, approximately 50 linear kilometers from Cabo Negro:

Figure 52: **Close-up of a section of the Kawésqar-Última Esperanza ECMPO. (Source Subpesca, http://mapas.subpesca.cl/ideviewer/)**

10.3.4.4 Relevant cultural sites and activities in the study area.

The review did not identify specific sites of high cultural significance or that were of current use in traditional practices or rituals, both for the native peoples and for the general population in the Cabo Negro area, beyond what was previously reported in the section on archeology and what will be detailed in the following section in relation to National Monuments.

It is significant in this regard that, in the environmental assessment processes of projects previously developed in the area, no spaces or activities with the aforementioned high cultural significance in the sector have been identified.

10.3.4.5 Heritage

In the general area of tangible and intangible heritage, there are several historical monuments in the commune of Punta Arena, as well as a traditional activity that has been identified as Intangible Cultural Heritage of the country.

Historical Monuments

There are two historical monuments in the area closest to the project, although both are more than 10 kilometers from the project:

- Faro Magdalena: located on the island of the same name (which has Protected Wildlife Area status due to the large number of penguins that come to nest there during the summer season), in the Strait of Magellan, 35 kms. from the city of Punta Arenas. Its construction was directed by the Scottish architect George Slight, as part of a policy promoted by the government of President Jorge Montt, aimed at ensuring navigation along this route that linked the Atlantic Ocean to the Pacific long before the Panama Canal was opened. The lighthouse, built in iron, bricks and concrete, was inaugurated in 1902. In addition to the 13.5 meter cylindrical tower, the construction had rooms arranged to serve as offices, oil storage and kitchen, spaces for employees and masonry ponds. In 1955 the lighthouse operation system was automated by means of a wind power generator, which eliminated the need for a permanent staff. Because of this, the house was left in a state of abandonment for approximately 30 years, during which time it was the object of numerous robberies. The Magdalena Island Lighthouse was declared a Historic Monument in 1976.
- Kon-Aikén Cemetery: The Kon-Aikén Cemetery is located north of the city of Punta Arenas. It dates from the beginning of the 20th century and contains tombs of the first foreigners who settled in the area, mainly English cattle ranchers associated with the old Peckett Harbour ranch. It was declared Historical Monument in 1976.

Apart from those mentioned above, there are several Historical Monuments in the city of Punta Arenas, corresponding to various buildings of historical and patrimonial importance and the highly valued municipal cemetery.

The following map shows the location of these monuments.

National Inventory of Intangible Cultural Heritage

The traditional activity of coastal carpentry in the Magallanes Region is recognized within this national inventory, which seeks to recognize representative and/or at-risk elements of the intangible cultural heritage of the communities that inhabit the Chilean territory and prioritizes the targeting of resources for the eventual implementation of safeguarding plans.

"The Carpintería de Ribera that is developed in the Magallanes region is a specialized trade that consists of the handcrafted construction of wooden boats for fishing, transportation and tourism activities, learned orally and from observation, through practice. Among the traditional knowledge that characterizes them is a set of ecosystemic knowledge about the local flora, which is very relevant for the selection of native woods in places near Punta Arenas, Puerto Natales, Puerto Eden and Puerto Williams. It also highlights the knowledge about tides, climate and navigation, articulating long-standing indigenous territorial memories... It constitutes a legacy that incorporates the presence of knowledge of navigation and knowledge of the environment in Kawéskar (Puerto Edén) and Yagán (Puerto Williams) territory, which indicates the integration of these construction techniques by indigenous navigating populations".

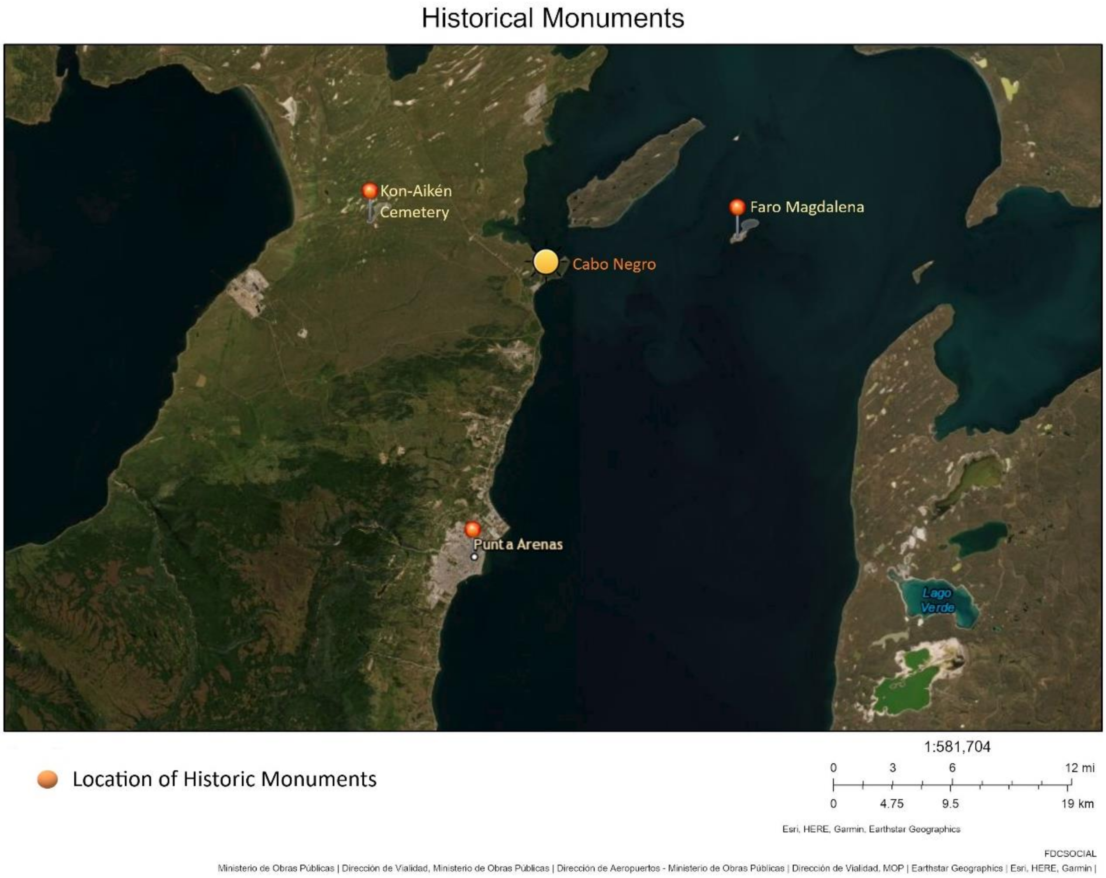


Figure 53: Location of Historic Monuments in the commune of Punta Arenas.(Source Nómina de Monumentos Nacionales June 2021)

10.3.4.6 Other cultural activities

In the commune of Punta Arenas and, in general, in much of Patagonia, there are various festivities associated with traditional work on sheep ranches, such as the shearing festival, horseback riding, traditional festivals, as well as music festivals, religious festivities, winter carnival, etc. They take place both in the city of Punta Arenas and in various rural localities of the surrounding communes and in Tierra del Fuego. However, no particular event of these characteristics has been identified that is especially associated with the Cabo Negro area.

In addition, in the vicinity of the project area there are traditional areas for motor sports activities, such as the Cabo Negro racetrack (50 years old) and family recreation, such as Chabunco Park, a common recreational area for the inhabitants of Punta Arenas.

10.3.4.7 Conclusions

From the background presented, it is noted that there is no significant presence of current cultural activities or spaces associated with the project development area that could pose a risk or any level of impact on the project's activities.

In this regard, it is important to take into consideration what was stated in the conclusions of the archeology area, regarding the high potential for archeological findings in the area and the recommendations to be followed during the construction phase of the project. However, as noted above, it is not visualized that this has an impact on a high level of risk for the processing of the project from the perspective of the existing indigenous communities, since there is no previous background in this regard.

The Marine Coastal Areas of Indigenous Peoples currently being processed, if finally approved, will not influence the development of the project, since they are associated with remote sectors and do not interfere with or disable the port activities contemplated in the Cabo Negro area.

Finally, it is concluded that cultural issues would not be an impediment or a relevant risk for the development of the Hydrogen Center project in the commune of Punta Arenas.

11 Opportunities of growth for the regions

The different parts of the value chain of the green hydrogen generation can produce job opportunities and growth in the region. The green hydrogen value chain considered for the analysis of this study is as follows:

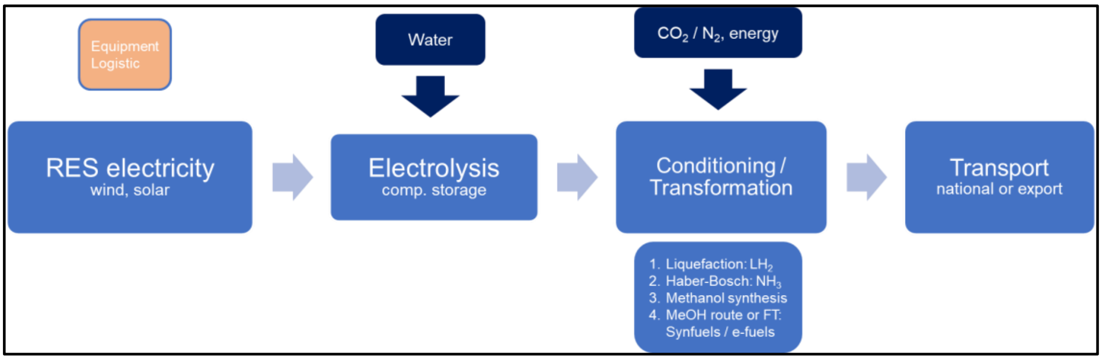


Figure 54: Value chain of the green hydrogen

For this analysis, meetings were held with the regional authorities of Antofagasta and Magallanes, with the participation of their respective Regional Governments (Gore) and Ministerial Energy Secretariats (Seremi). The delivery of their knowledge and points of view were taken into account in determining the opportunities for the development of local value and growth of the region in the implementation of the H_2 hubs.

The different parts of the hydrogen chain will be evaluated to identify opportunities to utilize local industry resources or project the production needed to meet the requirements of the development pathways studied.

Equipment Logistics

It should be emphasized that an important part that is indirect to the green hydrogen value chain is the capacity to transport equipment and components of the facilities required by any part of the value chain, ports and roads must be able to support the large weights and sizes of these. Therefore, adequate facilities must be planned in advance before projects are started.

11.1 Mejillones, Antofagasta Region

11.1.1 Power Generation

Chile plans to promote the generation of renewable energies, in its Long-term Energy Planning (updated with background 2020)[45]. In this planning, five scenarios are proposed for renewable energy in the energy matrix for the year 2050.

Table 85: Long-term energy planning from Minister of Energy.

Scenario	*National renewable energy capacity*	*Origen*
Today	26 GW	51%
Scenary A Year 2050	54 GW	83%
Scenary B Year 2050	74 GW	88%
Scenary C Year 2050	67 GW	85%
Scenary D Year 2050	50 GW	82%

In all scenarios more than 80% of the generation of the Antofagasta region is by renewable energy, so considering the scenario with the highest energy capacity (scenery B), approximately 24 GW of renewable energy generation is projected for the year 2050 for the Antofagasta region, which is lower than those required for the development paths of the GH_2 hub analyzed in previous points where 77.6 GW are required, so dedicated energy generation is required for the GH_2 Hub.

In Antofagasta there are several solar generation plants such as

- Uribe Solar 57.62 MW
- FV Bolero 146.64 MW
- Maria Elena FV 68 MW
- Parque solar Finis Terrae 138 MW

45 Available at: https://energia.gob.cl/planificacion-energetica-de-largo-plazo-proceso

No plant of significant capacity operates in the vicinity of Mejillones.

The AR Changos Solar project with a capacity of 470 MW is already environmentally approved and will be located in the community of Mejillones.

There are high levels of solar radiation in the area (5.6 installed capacity of energy generated per day, source Solargis) makes solar power generation possible, so projects to self-supply the hub requirements are possible.

From this perspective, the construction of new solar power plants is required to supply the energy demand exposed in the low export scenario proposed in Report 1. From the analysis made previously in the characterization of companies linked to the items of the value chain in the region of Antofagasta, it is estimated that the following items can actively participate in the construction of new solar power plants:

- Construction: 936 companies registered as of 2020.
- Trade and Commerce: 1276 companies registered by 2020. They can actively participate in the import of equipment and technologies from abroad or from domestic trade.
- Transportation: 2205 companies, participating in the movement of materials and equipment from trade centers to construction sites.
- Professional Activities: 1330 companies, those dedicated to engineering can contribute to the planning and execution of projects.

In the analysis of the previous sections of this report on the characterization of employment, the potential impact that exists in the aforementioned areas in terms of job creation is detailed, concentrating in the area of construction the greatest growth in terms of the imperative need for the construction of new energy plants in the region.

From conversations with members of the regional government, they mentioned that Mejillones as a community has a great capacity for energy generation, it has several thermoelectric plants very close to the community that has brought pollution and dislike towards the industry, so informing and educating the population is recommended to be well seen by the community, it was also mentioned that it would be advisable that if there are large generation projects in the area, they should deliver some benefit to the community as a reduction in electricity rates.

The electrical network in the region is as follows (Source: sic.coordinador.cl):

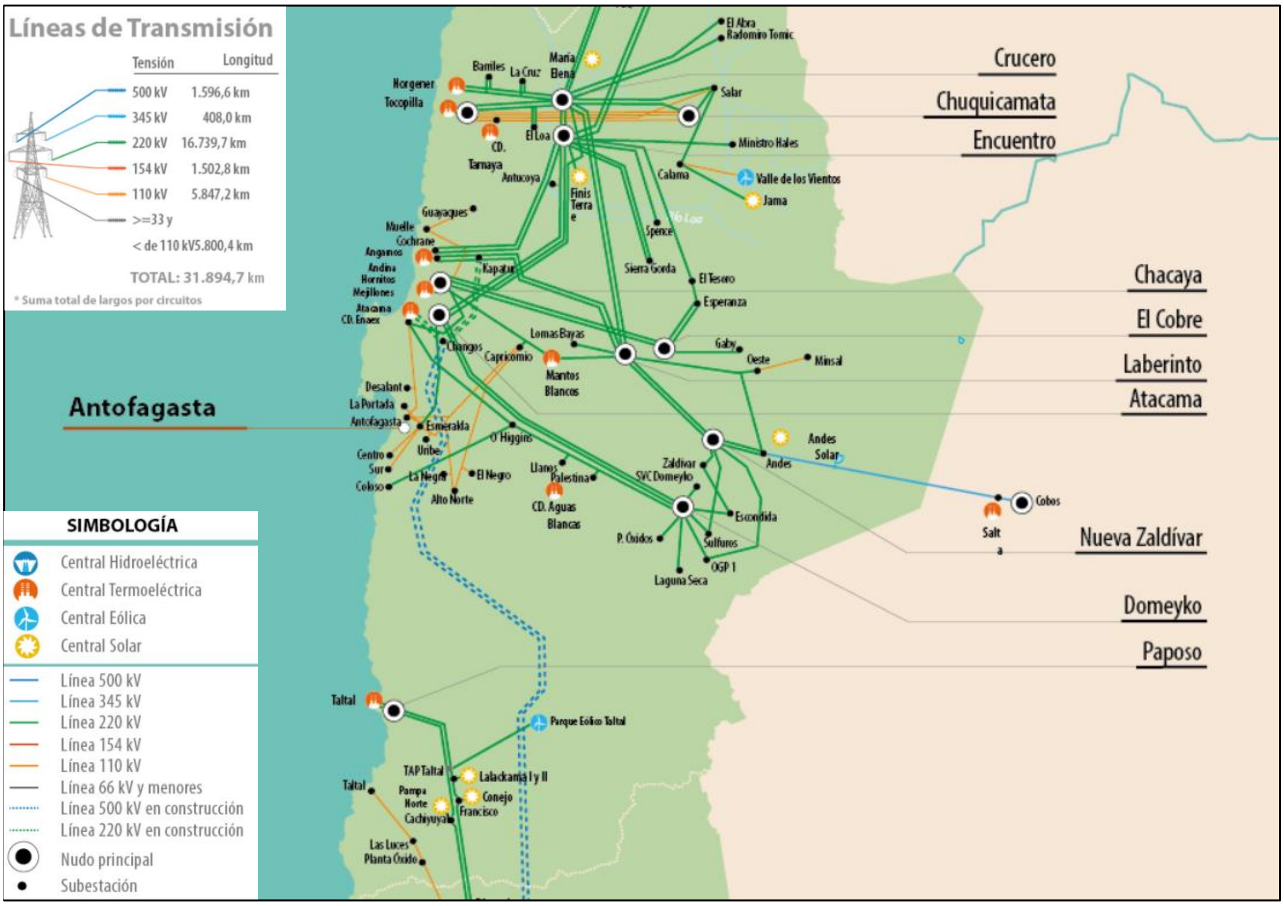


Figure 55: Electrical network of Antofagasta.

11.1.2 Water Supply

The following desalination plants are located in the area near Mejillones:

- Moly-Cop (4,3 L/s)
- Angamos (210 L/s)
- Minera Spence (2.000 L/s)

They may be able to supply, either by having spare capacity available or by increasing their production. It is possible to supply the requirements of the GH_2 Hub until the 2035 module of the development path for the low export hub Table 14 Report 1, The amount required for that module is very high and would require a desalination plant dedicated to the GH_2 Hub. Since Mejillones is a coastal commune, new desalination projects are possible without having to install large pipelines to transport seawater, and the mining industry could be a possible buyer if more than the required amount is produced.

Information provided by an expert in the area, the localities have the following capacity of reused water from water companies that can be processed to obtain pure water.

Table 86: Supply of reuse water in Antofagasta region

Locality	*Ability to supply reuse water*
Antofagasta	900 L/s
Calama	250 L/s
Tocopilla	90 L/s
Mejillones	60 L/s

With this background, the need for the construction of new seawater desalination plants in the sector is recognized, so the sectors previously mentioned for the photovoltaic plants will also have a relevant participation from the local value of the region. In particular, the possible participation of the mining sector is recognized with respect to its existing desalination plants mentioned above, contributing with existing infrastructure and increased capacities, or on the other hand, technical knowledge resulting from the experience in its current operations.

Regarding such cooperation alternatives with the mining sector, the technical and professional knowledge that can be obtained is more valued, particularly considering that the existing infrastructure of desalination plants already occupies a large part of its capacity in the mining processes, so the path points to the construction of new plants.

11.1.3 Electrolysis

Regarding electrolysis, in both regions the characteristics are the same, as there is no development of this technology in the country, the electrolyzers will have to be imported, the major producers are in the United States, Europe and China.

Some of the major producers of electrolyzers are:

- ITM
- NEL
- Siemens
- Cummins
- PlugPower
- Sunfire
- HyTRON (Neumann & Esser)

There are many companies that manufacture electrolyzers, the production may not be sufficient for the market that is being projected since these technologies are required worldwide, especially in large scale or capacity.

The electrolyzer market is growing and the capacity of the electrolyzers is increasing, the aim is to reach GW electrolyzer factories and to reduce the cost of the equipment by standardization and improvement of the facilities.

The opportunities for local strength, as well as for the other plants mentioned, involve the active participation of the engineering and construction sectors, as well as trade and commerce in the case of importing technologies and components that are not currently manufactured in Chile, as is the case of electrolyzers.

However, due to the high installed capacity goals of this technology with respect to the low export scenario proposed for the Antofagasta region, of 996 MW by 2025, rising to almost 39,000 MW by 2050, it is possible to think about the development of a manufacturing industry of these technologies according to the regional authorities. This would boost the industry, innovation, and technological development at the local level, in addition to a strong input from the academic and research world developed in the country's universities. Another impact could be the decompression of the incident load in the port capacity of importing these technologies.

11.1.4 Conditioning/ Transformation and CO_2/ N_2 supply

Following the same line of the previous analyses, just as there is currently no developed technology for electrolyzer plants in the region, there is also no developed technology for transformer plants and conditioning of the green hydrogen produced.

However, there is no developed technology at present, but it is under development, with several projects planned to start operating in the following years.

The main characteristics of each of these projects, projected in the Antofagasta Region, are presented below:

Table 87: Main characteristics of GH_2 projects planned in the Antofagasta region

Name	Location type	Location	Products	Domestic/ export	COD	RES type	RES capacity	Electrolysis capacity	H2 production	Derivative production	Developer(s)
							MW	MWe		t/a	
AES Andes	Coast tbc.		NH_3, H_2	For export and as maritime fuel	2025	Solar & wind	800		50.000	250.000	AES Andes
HyEx	Coast	Tocopilla	NH_3	For domestic consumption (replacing imports) and for export	1st phase: 2025 Industrial plant: 2030	Solar & grid		2000 Pilot: 26MW		700.000	Enaex, Engie
Atacama Hydrogen Hub	Off-coast tbc.		H_2, NH_3	H_2 for domestic consumption (freight train, mining operations), H_2 transport by pipeline to Mejillones port, NH_3 and LH_2 for export	Pilot: 2022 Industrial phase: 2030	Solar & grid		10	110.000		GH_2, Complejo Portuario Mejillones
ACH-MRP	Coast tbc.		NH_3	For export	2027	Solar & wind	3.000			1.000.000	AKER Clean Hydrogen, Mainstream Renewable Power
San Pedro de Atacama	Off-coast	San Pedro de Atacama	H_2	For local electricity supply	2022-2023	Solar	4,2	2,2	143		Cummins Chile; potentially: CESPA

HOASIS	Coast tbc.		H_2, NH_3	For domestic fertilizer production	2024	Solar & grid			102.000	250.000	TCI Geocomp
H2 SOLAR	Off coast tbc.	Lalcktur tbc.	H_2	For domestic mining commuter buses	2022	Solar	1,2		48		Air Liquide, ATAMOSTEC, CEA, Universidad de Antofagasta, CDEA
HYDRA	Off coast tbc.		H_2	For domestic mining trucks	2022	Solar & grid					Engie, Mining3, Mitsui, Ballard, Reborn, CSIRO Chile, Thiess, Hexagon Purus, Liebherr
Pauna Greener Future Project	Off coast		H_2, NH_3	To supply the Chilean domestic market and for export. alternatively, will be used to produce green ammonia for export.	2025	Solar	671	S1:100 S2:400	S1:8500 S2: 170000 Tonnes of NH_3 per year	170.000	Statkrafti
H2Genesis Project	Coast		H_2	Produce, store and distribute green hydrogen and oxygen both for energy generation and industrial heat (local) and probably for export	2025	Grid	Pilot **4 MW** will scale up to **100 MW** within 5 years	100	6.200		Antuko
H2CSP+ PV	Off coast		H_2	Local supply	2024	Solar (PV and CSP)	210 (100PV+110CSP)	6	950		EIG

On the other hand, in the analysis with the production of green ammonia (NH_3) as a conversion of H_2, which is one of the approaches in this study, the following values are obtained in the proposed low export scenario for the years 2025 to 2050:

Table 88: Proposed ammonia production values for the low export scenario

	2025	2030	2035	2040	2045	2050
NH_3 production [Tons/Year]	375,382	2,127,764	2,421,326	4,742,919	5,183,954	5,655,865

According to the current projects under development, only five of them have a clear NH_3 production target, which in the sum and taking into account the years in which these projects start operating, would cover the production foreseen in the low export scenario until 2030.

This situation presents challenges and opportunities, the challenges will be the necessary implementation of new plants, as already seen in the previous points of the value chain, and the opportunities for local development come from the existence of projects that plan the production of ammonia, developing conversion technologies in a new market for Chile.

On these technological challenges of conversion there is not much background throughout the country, but as will be seen later in the examples of projects in Magallanes, the active participation of academia in collaboration with the projects can be an opportunity to develop highly trained professionals in the field of green hydrogen in Chile.

11.1.5 Transportation / Exports / Imports

The Antofagasta region has several ports, railways and roads that can be used for hydrogen exports and distribution for national consumption.

11.1.5.1 Ports

Figure 56: Ports in Antofagasta Region. (Base map from Biblioteca del Congreso Nacional)

The ports in the region are the followings:

Coloso

Is a medium-sized Port, owns by Minera Escondida. The types of vessels regularly calling at COLOSO are Bulk Carrier (100%).

- The maximum length of the vessels recorded to having entered this port is 200 meters.
- The maximum draught is 9.9 meters.
- The maximum Deadweight is 64,247t.
- Location -23.75585° / -70.46451°

Antofagasta Port

Is a Medium-sized Port. The types of vessels regularly calling at ANTOFAGASTA are Bulk Carrier (54%), Container Ship (25%), General Cargo (13%).

- The maximum length of the vessels recorded to having entered this port is 337 meters.
- The maximum draught is 11.9 meters.
- The maximum Deadweight is 134,455t.
- Location -23.64713° / -70.40596°

Mejillones Port

is a Medium-sized Port. The types of vessels regularly calling at MEJILLONES are Oil/Chemical Tanker (30%), Bulk Carrier (27%), General Cargo (13%), Container Ship (13%), Fishing Vessel (4%).

- The maximum length of the vessels recorded to having entered this port is 367 meters.
- The maximum draught is 14.5 meters.
- The maximum Deadweight is 180,544t.
- Location -23.08002° / -70.40843°

Michilla Port

Is a Medium-sized Port. The types of vessels regularly calling at MICHILLA are Bulk Carrier (88%).

- The maximum length of the vessels recorded to having entered this port is 200 meters.
- The maximum draught is 9.5 meters.
- The maximum Deadweight is 63,878t.
- Location -22.71991° / -70.28694°

Tocopilla Port

Is a Medium-sized Port. The types of vessels regularly calling at TOCOPILLA are Bulk Carrier (93%).

- The maximum length of the vessels recorded to having entered this port is 229 meters.
- The maximum draught is 14.1 meters.
- The maximum Deadweight is 87,376t.
- Location -22.09103° / -70.21146°

11.1.5.2 Roads

The region of Antofagasta is connected by roads to the regions of Tarapacá and Atacama. The communes have road networks, the largest being those of the commune of Antofagasta. Part of the main roads of Region of Antofagasta according to the "Red Vial Nacional" (national road network) are show in the next figure.

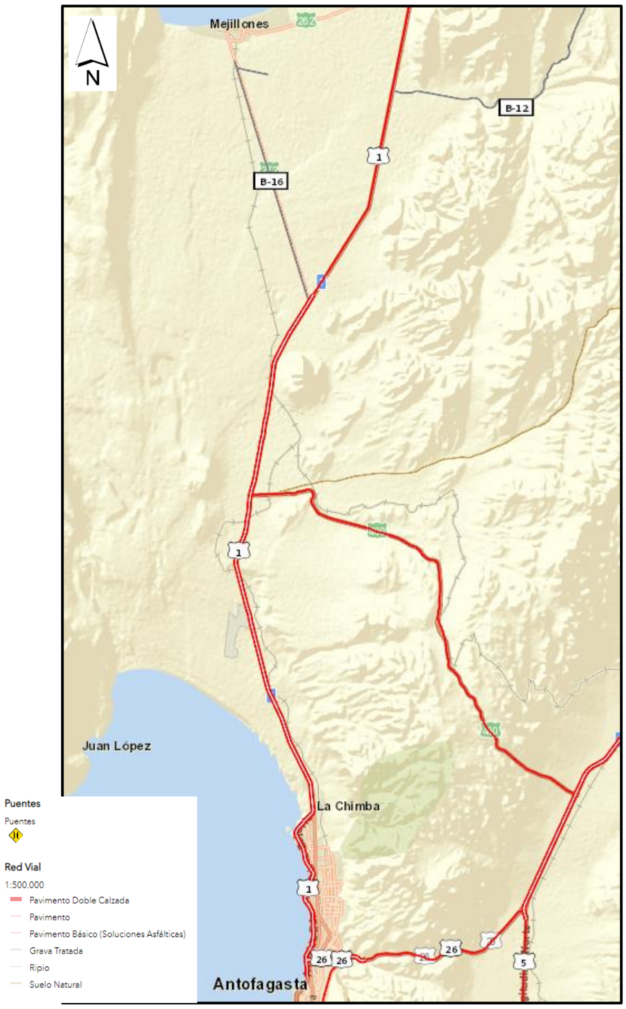


Figure 57: Roads from Antofagasta to Mejillones (Source Red Vial Nacional)

11.1.5.3 Rails

The Antofagasta region has a railroad network that transports national and international cargo. It runs through the region linking it with the Tarapacá and Atacama regions, passing through the municipalities of Antofagasta, Mejillones, Taltal, Tocopillas and others.

Figure 58: Rails on Antofagasta region. (Source https://amigosdeltren.cl/)

11.1.6 Conclusions

- Water supply by desalination plants is the most recommendable to build, the need of the region and the expanding industry makes it attractive to build and the large coastal territory gives the possibility of a lot of land to settle on.
- Import or manufacturing of electrolyzers is required, there is no development in the region, and they are needed in large capacity and quantity.
- The estimated electricity production in the region is lower than required for the development of H_2 plants, power plants are required.

- Hydrogen conditioning and transformation and the resources required for this will have to be created as there is no existing industry.
- The capacity of the means of transport used must be checked for compliance.
- There are 5 ports in the region.
- As mentioned above, due to the need to build new infrastructure in almost the entire hydrogen value chain as it is a new market for the country, the economic sector that could benefit the most is the construction industry, with 936 companies registered by 2020 in the Antofagasta region.
- This statement is based on the job creation analyzed in previous sections, which presents the construction sector as the fastest growing, especially in the construction of solar plants and transmission lines, followed by electrolysis plants.
- On the other hand, the presence of the participation of other sectors in these projects is also mentioned, such as:
  - Trade and Commerce: 1276 companies registered by 2020. They can actively participate in the import of equipment and technologies from abroad or from domestic trade.
  - Transportation: 2205 companies, participating in the movement of materials and equipment from trade centers to construction sites.
  - Professional Activities: 1330 companies, those dedicated to engineering can contribute to the planning and execution of projects.

11.2 Punta Arenas – Cabo Negro, Magallanes Region

11.2.1 Power generation

The electricity market and the production of electricity in the Magallanes Region is constituted by the Magallanes Electric System (SEM). There are three medium systems in Magallanes: Porvenir, Puerto Natales, and Punta Arenas. All three are operated by EDELMAG, while in Punta Arenas some assets belong to Pecket Energy. As of December 2020, said system has a net installed capacity of 116 MW, with 83% originating from natural gas, 14% corresponding to diesel generation, and only 3% from wind generation.[46]

As mentioned before, in this part of the value chain the interest is in the current and future development of renewable energy projects in the region, considering that Magallanes stands out for its significant wind potential (with average wind speeds of 9.6 m/s at 50 meters above sea level, 0.8 wind capacity factor, Source globalwindatlas).

In line with the above, there are currently two wind projects in Magallanes, totaling 12.9 MW of installed wind power:

46 Source: Energía Abierta, December 2020. Link: https://energiaregion.cl/region/MAG

- PE Cabo Negro 2.55 MW
- Vientos Patagónicos (New PE Cabo Negro) 10.35 MW

It should be noted that the Vientos Patagónicos project has been in operation for a little over a year and its entry allowed increasing the share of Non-Conventional Renewable Energies (NCRE) from 3%, as previously indicated, to 18% in Magallanes.

Regarding the projects under planning and development, we can highlight the Total Eren project, which plans to produce green ammonia from an electrolysis capacity of up to 8 GW, planning for this purpose the construction of a wind power plant of up to 10 GW. Its current objectives are to carry out studies in order to launch the project in 2025, with a view to producing hydrogen in 2027.

Considering the development path proposed above for the development of H_2 hubs in the Magallanes region, for the low export scenario (see chapter 4), it can be concluded that projecting electrolyzer capacities above 500 MW from the year 2025, the current wind generation projects (12.9 MW) are not sufficient.

However, the projections of projects such as Total Eren are encouraging in terms of being able to cover the energy planning. This means that the local opportunities for growth in this part of the hydrogen value chain will be in the need for the creation of new jobs to carry out the construction and operation of these new plants that will be required.

In this section of opportunities in energy generation, we should also mention the comments made by the authorities of the Regional Government of Magallanes (GORE) and the Regional Ministerial Secretariat of Energy of the Magallanes Region (SEREMI), in the meeting they held with ILF Chile.

In this regard, there are two relevant points mentioned:

- Regional Interconnected System: It is recognized the need to implement a regional interconnected system, connecting the 4 medium systems that are in the region, or at least generate 2 interconnected systems: continental (province of Magallanes and Ultima Esperanza) and insular (province of Tierra del Fuego and Antarctica). This would allow the distribution of surplus energy generated by the large wind farms to all the existing communities in the territory, cleaning the energy matrix (electrical and thermal), reducing greenhouse gases and, above all, reducing energy costs to civil society.

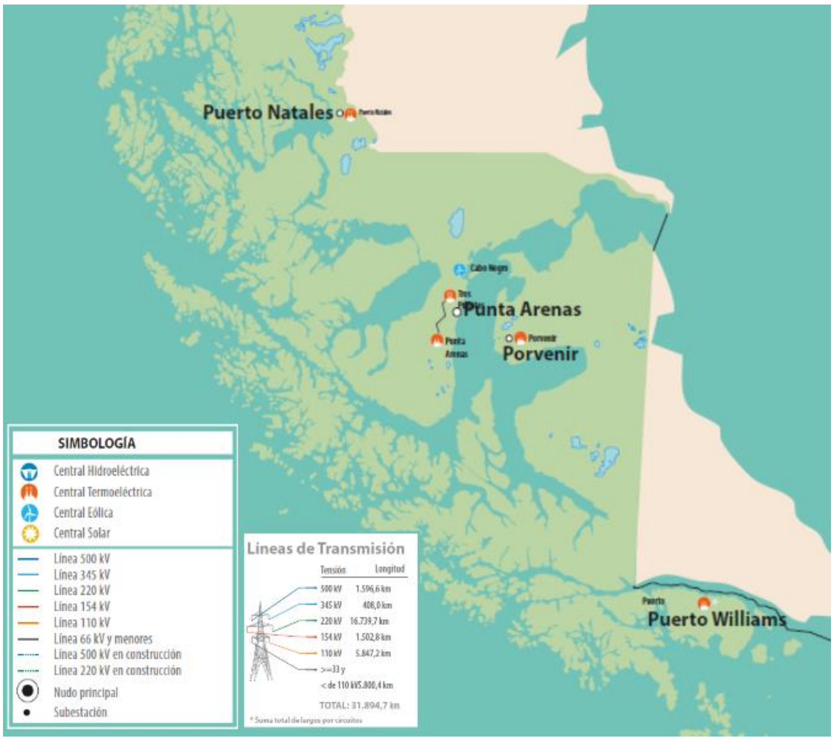


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Figure 59: Electrical network from Magallanes (Source: https://sic.coordinador.cl)

Also, this interconnected system could allow the sale of energy to Argentina and/or the use of the neighboring country's electrical grid for transmission to Chile's central interconnected system.

- Generation of local industry: The construction of wind turbine towers and blades in the region will generate a more robust local economic ecosystem and will also decompress the precarious port system of the region, considering the arrival of a large number (possibly thousands) of wind turbine parts. In addition, with this industry installed in the region, maintenance and repair costs of the blades will be facilitated and reduced.

11.2.2 Water Supply

There is no presence of seawater desalination plants in the Magallanes region. This is mainly because the bulk of desalination plants in the country is concentrated just to the north in the Antofagasta region, due to its mining activity.

Considering the development pathway proposed above for the development of H_2 hubs in the Magallanes region, for the low export scenario[47], the demand of water will be 48 L/sec in 2025, which increases progressively to 2488 L/sec in 2050. If we observe the plans of

[47] See table 15 in previous report 1, document: 1-Report_V0-1_2021-12-23

important projects in the region, such as Total Eren or Haru Oni, it is established that these projects plan the construction of new desalination plants.

Figure 60: Total Eren's H2 Magallanes Project in a projection image of what will be the infrastructure to be installed in the coming years (Source: https://www.total-eren.com/)

Therefore, the construction of desalination plants to supply the demand is an imperative need for the development of H_2 hubs in the region. This is undoubtedly a growth opportunity for local engineering and construction companies, as well as the labor force in the area, so that they can actively participate in these projects.

11.2.3 Electrolyzer

Regarding electrolyzers and associated equipment, it is observed in similar projects that their planning is oriented to the import of these technologies, so that the transportation and trade sector participates actively. As can be seen in the table "Companies, annual sales, and dependent workers in GH_2 value chain activities, by industry, Magallanes Region, 2020" identified in the characterization of the items, the transportation and commerce items have 1118 and 528 companies each respectively in the region, so there are actors available in the participation of the importation of specific technologies.

In the same line, the construction of hydrogen plants and other associated plants such as desalination plants, require the construction industry in the region. As can be seen in the same table mentioned above, there are 443 construction companies in Magallanes, which may be available to participate in the various projects related to the H_2 hubs.

11.2.4 Conditioning/ Transformation and CO_2/ N_2 supply

Analyzing the different conversions that hydrogen can have, the presence of projects such as Total Eren, which plans the production of ammonia in the region, stands out. This project contemplates strategic alliances and collaboration agreements with, for example, the

University of Magallanes, with the aim of promoting education, research, development, and innovation activities associated with green hydrogen.

This example shows the opportunity that exists with the collaboration of the academic world, taking into account the different engineering challenges that exist.

On the other hand, there is the presence of ENAP's company in the Cabo Negro sector and other strategic locations in Magallanes, with the development of the fuel industry.

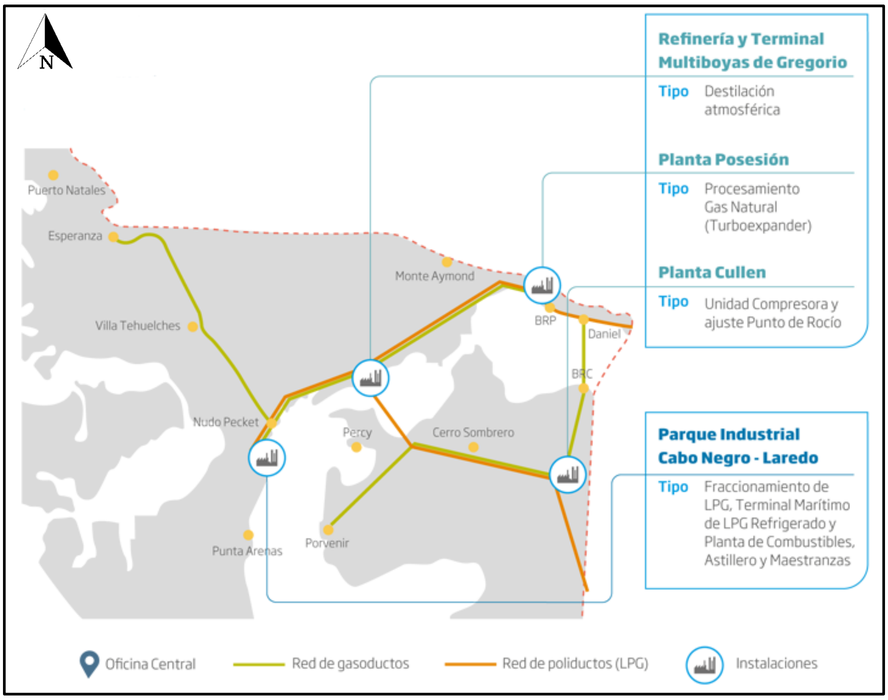


Figure 61: **ENAP Magallanes plants. Source: ENAP Web Site, Business Lines, Exploration and Production (E&P)**

In Chile, ENAP carries out exploration and production activities of hydrocarbon deposits only in the Region of Magallanes, where it has oil and gas production operations in the mainland area.

The above image shows the presence of fuel plants, in addition to the presence of fuel refining, storage and transportation areas (ENAP's R&C Magallanes).

The crude oil refining process is carried out at the Gregorio Refinery and the Raw Product fractionation process at the Cabo Negro Plant.

In logistics, R&C Magallanes' facilities are Cabo Negro, Gregorio and Clarencia terminals for receiving and shipping products. These facilities have crude oil storage, intermediate products for complementary cargoes from the refineries and finished products.

It is also important to note the presence of an important network of gas and oil pipelines that amounts to a length of 3,000 km.

All this background of economic and industrial activities with respect to fuels undoubtedly represents a strategic opportunity for the development of H_2 hubs in the region.

From the point of view of the contribution of the local industry, ENAP's experience in the handling and treatment of hazardous substances (particularly ammonia which can be consumed by the refineries), added to the pipeline transport infrastructure and port capacities, can be an important contribution for the start of the green hydrogen projects.

However, in the words of the Seremi of Energy and the Regional Government of Magallanes, the port capacities of the area should be evaluated in terms of long-term export planning.

Finally, the following are the planned GH_2 projects in the Magallanes region with their respective general characteristics:

Table 89: Main characteristics of GH_2 projects planned in the Magallanes region

Name	Location type	Location	Product(s)	Domestic/ export	COD	RES type	RES capacity	Electrolysis capacity	H2 production	Derivative production	Developer(s)
							MW	Mwe		T/a	
HIF project (Haru Oni)	Coast tbc.		Methanol, synthetic gasoline	For export	Pilot: May 2022 Phase I: 2024	Wind	300+3.4 pilot			70,000 m³ gasoline	HIF, Siemens Energy, Porsche, ENEL, GASCO, ENAP
Hnh energy	Coast tbc.		Nh₃, h₂	For export	2026	Wind	1,800		150,000	850,000	Austriaenergy, ökowind
Selknam	Coast tbc.		Nh₃	For export	2026	Wind	1,150		85,000	500,000	Albatros, alfanar, potentially enap
H1 magallanes	Coast tbc.		Nh₃, h₂	For export	2028	Wind	2,200		170,000	1,000,000	Cwp
H2 magallanes	Coast	Punta arenas/ s. Gregorio	Nh₃, h₂	For export	2027	Wind	10,000		800,000	4,400,000	Total eren
Vientos magallánicos	Coast		Nh₃, h₂	For export	2030	Wind	700		63,000		Rwe

On the other hand, in the analysis with the production of green ammonia (NH_3) as a conversion of H_2, which is one of the approaches in this study, the following values are obtained in the proposed low export scenario for the years 2025 to 2050:

Table 90: Proposed ammonia production values for the low export scenario.

	2025	2030	2035	2040	2045	2050
NH_3 production [Tons/Year]	304,568	2,617,023	5,256,861	5,435,117	6,430,665	6,928,203

According to the current projects under development, only four of them have a clear NH_3 production target, which in the sum and taking into account the years in which these projects start operating, would cover the production foreseen in the low export scenario until 2045.

The above shows an advantage with respect to the Antofagasta region, since the current planning of the projects under development for Magallanes includes a greater production of green ammonia, and therefore covers more years of the scenario studied.

With this type of commitment on the part of the companies, it is estimated that there is a need for support from local values in the region, as mentioned above, involving the academic and scientific world, as well as the rest of the companies present in the region.

11.2.5 Transport / Export / Import

11.2.5.1 Ports

Speaking of transportation and exports, there are several points to be addressed, first the issue of ports in the region, and in particular near the Cabo Negro sector in the commune of Punta Arenas.

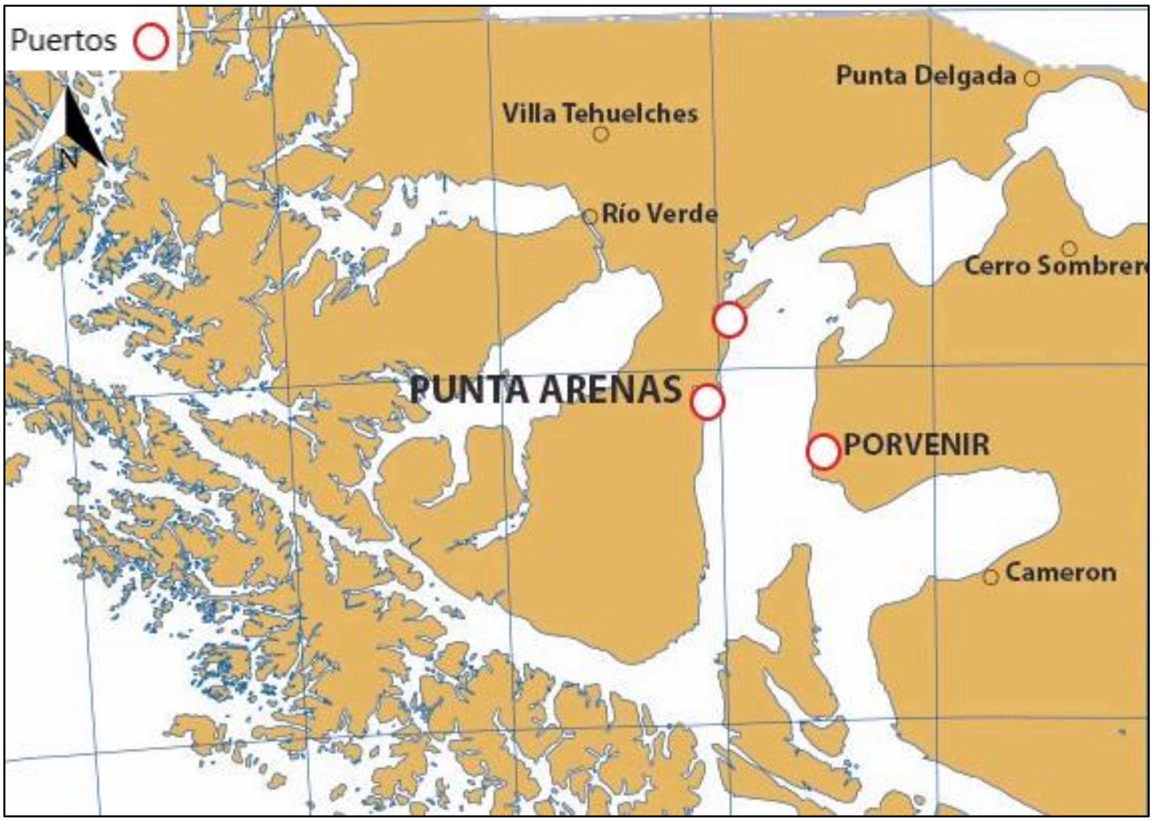


Figure 62: Location of the closest ports to the area of interest in Cabo Negro, Magallanes Region. Source: https://www.marinetraffic.com/

Near the area of interest, the presence of the ports and docks of the city of Punta Arenas, of the Empresa Portuaria Austral (EPA) stands out. On the other hand, the Cabo Negro terminal of the ENAP company stands out.

The following are the locations of the ports mentioned along with their characteristics, the information of the maps is obtained from the MarineTraffic.com website where it is possible to see in real time the location of the ports and the transit of the fleets. In particular, it is possible to see the important traffic of ships through the Estrecho de Magallanes and how this maritime route constitutes an important connection with the Pacific and Atlantic Oceans.

Port of Cabo Negro

- CABO NEGRO is a Medium-sized Port. The types of vessels regularly calling at CABO NEGRO are Oil/Chemical Tanker (63%), Tug/Supply Vessel (4%), Cargo Barge (4%).
- The maximum length of the vessels recorded to having entered this port is 205 meters. The maximum draught is 11,5 meters. The maximum Deadweight is 50.000 ton.
- CABO NEGRO is located at West South America, West South America in Chile at coordinates S 52° 55' 42.26" - W 070° 48' 00.39".

Port of Punta Arenas

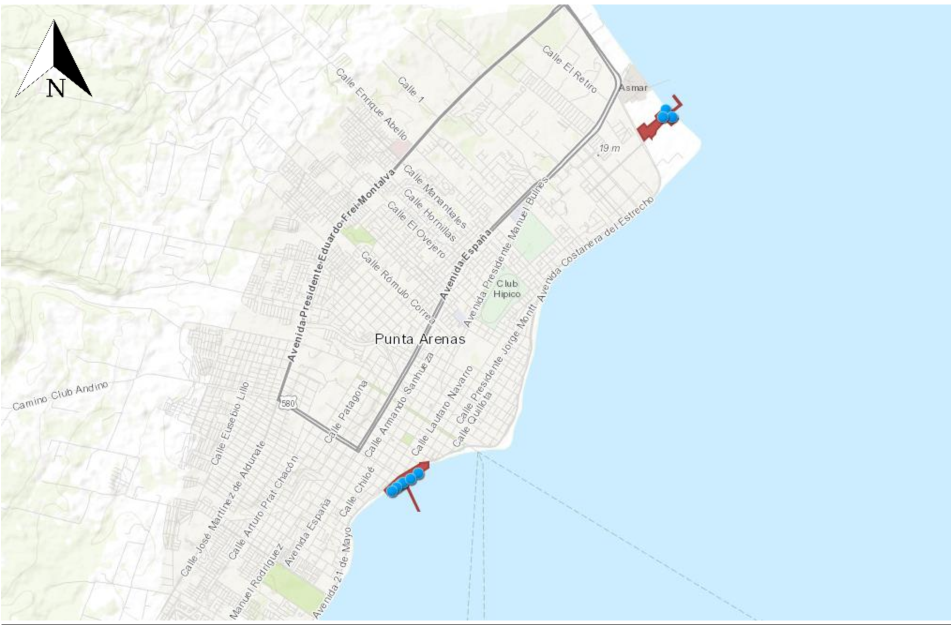


Figure 63: **Terminal locations: Terminal José de los Santos Mardones (Top of map) and Terminal Arturo Prat (Bottom of map). Source: Dirección de Obras Portuarias (DOP), Ministerio de Obras Públicas (MOP).**

- PUNTA ARENAS is a Medium-sized Port. The types of vessels regularly calling at PUNTA ARENAS are Fishing, Fishing Vessel, Passenger Ship, Passenger, Research/Survey Vessel.

- The maximum length of the vessels recorded to having entered this port is 292 meters. The maximum draught is 12.5 meters. The maximum Deadweight is 90.000 ton.
- PUNTA ARENAS is located at West South America, West South America in Chile at coordinates S 53° 08' 40.20" - W 070° 52' 35.38".

However, the information on the port of Punta Arenas obtained from MarineTraffic actually corresponds to the sum of the capacities of the Terminal Arturo Prat and the Terminal José de los Santos Mardones in the city, whose referential location is shown above.

Some characteristics of both ports are presented below:

Table 91: Characteristics of the Arturo Prat terminal.

DESCRIPTION	VALUE
Docking front	2
Docking sites	4
Linear meters of berthing	542
Dock Width [m]	18
Maximum authorized length [m]	176
Passenger lounge and Antarctic centre (m2)	1.000
Passenger receipt	1
Landing platform for tenders	2
Water supply network	1
Maximum authorized draft [m]	9
Cellars (m2)	5.000
Total area (m2)	41.423
Maximum Dwt header (ton)	40.000
Dwt maximum access (ton)	2.812

Table 92: Characteristics of the José de los Santos Mardones terminal.

DESCRIPTION	VALUE
Docking front	3
Docking sites	3
Linear meters of berthing	336
Dock Width [m]	20
Maximum authorized length [m]	250
Buoys	4
Water supply network	1
Cellars (m2)	5.590
Paved esplanade (m2)	35.108
Total area (m2)	240.000
Maximum authorized draft [m]	14
Maximum Dwt (ton)	50.000

With all this information on the ports available in the area, opportunities can be analyzed. First of all, the port of Cabo Negro is strategically located for the trade of different types of fuels, so its experience in this area makes this terminal a potential ally for the development of H_2 hhubs. In numbers, considering the almost 7 million tons of green ammonia expected to be produced in the region by 2050 according to the Development pathway for Magallanes H2 Hub based on low GHS export scenario, the capacity of the Cabo Negro port of 50,000 tons will probably have to be complemented with the construction of another port, or the expansion of the same.

On the other hand, the ports of Punta Arenas appear as an alternative for the import of the different equipment and elements for the construction of the plants of the entire value chain. From this point of view, the José de los Santos Mardones Terminal, located to the north of the city, has a more direct access to Route 9 North, which is a main access route to the Cabo Negro sector. The Arturo Prat Terminal, located to the south of the city, is a different case. Importing high tonnage items through this port would involve crossing a large part of the city of Punta Arenas with heavy loads, so it is not an option.

In the same way as with the port of Cabo Negro, taking into account only the capacity of the José de los Santos Mardones Terminal, it is important to reevaluate the amount of cargo allowed and assume a possible improvement of that port or the construction of other ports in the future.

11.2.5.2 Roads

In the Magallanes region, and particularly in the area near Cabo Negro, there is a main route called Route 9, particularly in its northern component, which connects the towns of Punta Arenas and Puerto Natales.

Figure 64: **Main roads around the Cabo Negro sector**

This route with its surrounding roads is shown in the map below, it is worth mentioning the presence of bridges that could be a logistical challenge when transporting heavy loads related to the construction of wind farms for example, in addition to mentioning the excessive dimensions that the blades of windmills may have.

11.3 Conclusions

Both regions have characteristics and deficiencies that make them interesting for the development of H_2 hubs, after the analysis made, the following results have been reached.

Antofagasta:

- Water supply by desalination plants is the most recommendable to build, the need of the region and the expanding industry makes it attractive to build and the large coastal territory gives the possibility of a lot of land to settle on.
- Import of electrolyzers is required, there is no development in the region and they are needed in large capacity and quantity.
- The estimated electricity production in the region is lower than required for the development of H_2 plants, power plants are required.
- Hydrogen conditioning and transformation and the resources required for this will have to be created as there is no existing industry.
- The capacity of the means of transport used must be checked for compliance.

Magallanes:

- The weakest development is in water sourcing; there are no desalination plants in the region, so there may be a lack of training with respect to local labour. This would be a totally new market in the region.
- Projects contemplate the development of installed wind power that could perfectly supply the local energy demand, for this it is important to develop the electrical infrastructure and the regional interconnected system, emphasize the opportunities of energy sales to Argentina and possible connection to the central interconnected system by that country.
- Ammonia production estimated by the projects under development covers the proposed scenarios.
- Ports must re-evaluate their capacities

Table 93: Conclusion of characteristics of the region with respect to the value chain

Value Chain Part	Antofagasta	Magallanes
Renewable Energy	▪Several existing generators. ▪Insufficient projection, more production is required.	▪Several existing generators. ▪Insufficient projection, more production is required.
Water	▪Current desalination plants are insufficient, more production is required.	▪Desalination plants non-existent and unknown in the region, the industry must be developed.
Transport	▪Available roads, ports and railroads. Verify that they comply with the required requirements and improve if is required. ▪Plants in the region with experience working with amonia	▪Available roads and ports. Verify that they comply with the required requirements and improve if is required.
Electrolysis	▪Non-existent industry, possibility of development.	▪Non-existent industry, possibility of development.
Conditioning / Transformation	▪Non-existent industry, possibility of development.	▪There is methanol refinery in Cabo negro.
CO_2 / N_2	▪No supply. ▪Importation or capture require.	▪No supply. ▪Importation or capture require.

Legend: sufficient | insufficient | nonexistent

12 RECOMMENDED ACTIONS TO LOCAL, REGIONAL AND NATIONAL GOVERNMENT ENTITIES

From the findings of this study, a number of recommended actions can be derived that would help advance Chile in its objective of developing a green hydrogen economy and thereby achieve environmental, social and economic goals.

The recommendations identified for this study are of five major categories: Planning, communication & consultation, studies, administration and incentives. In Table 94 we have summarized the recommendations and actions proposed to follow-up on this study and ordered them by category with some actions comprising several categories. For each recommended action the government level (national, regional, or municipal) has been identified and is indicated in the table.

Table 94: Summary of recommendations.

Category	Action	Government level
Administration	Permanent monitoring for archaeological sites	Regional
Administration	Monitoring of Gaviotín Chico/ Little Tern nesting sites	Regional
Communication/ Planning	Ensure and facilitate coexistence of Chango people at Mejillones Bay	Municipal (Mejillones)
Communication	Stakeholder dialogue: opportunities of H_2 hub for coal plant phase-out	Regional (Antofagasta)/ municipal
Communication	H_2 industry enables faster transition to pollution free energy supply	Regional

Communication	H_2 industry as national opportunity (general communication)	National
Communication	Inform and educate population about green H_2 industry	Municipal
Planning/ Communication	National H_2 project developer round-table	National
Planning	Accelerate update of regional plans	Regional / municipal
Planning	Add industrial zones specific for H_2 industry in regulations plans	Regional / municipal
Planning/ Studies	Synergies from coordinated planning of infrastructure development/ expansion	Regional
Planning	Regular reassessment and status report of GHS	National
Planning	Synchronization of PELP and GHS/this study	National
Study/ Planning	Technical and safety standards and regulations for H_2 and derivatives industry	National
Study	Regional/ Municipal level H_2 demand in central Chile, consideration of third H_2 hub development vs. decentralized H_2 production	National
Study	Mining sector: H_2 demand and supply development	Regional (Antofagasta)
Study	World market demand for Chilean H_2 & derivatives; competitors	National
Study	Monitoring of technology development H_2 transport/vector technologies	National
Incentives/ Planning/ Communication	Attraction of local green H_2 component manufacturing	National
Incentives/ Communication/ Planning	Academic research	Regional
Incentives/ Communication/ Planning	Vocational and academic education/ training	Regional
Incentives/ Study	Worker mobility in Chile	National/ regional (Magallanes)

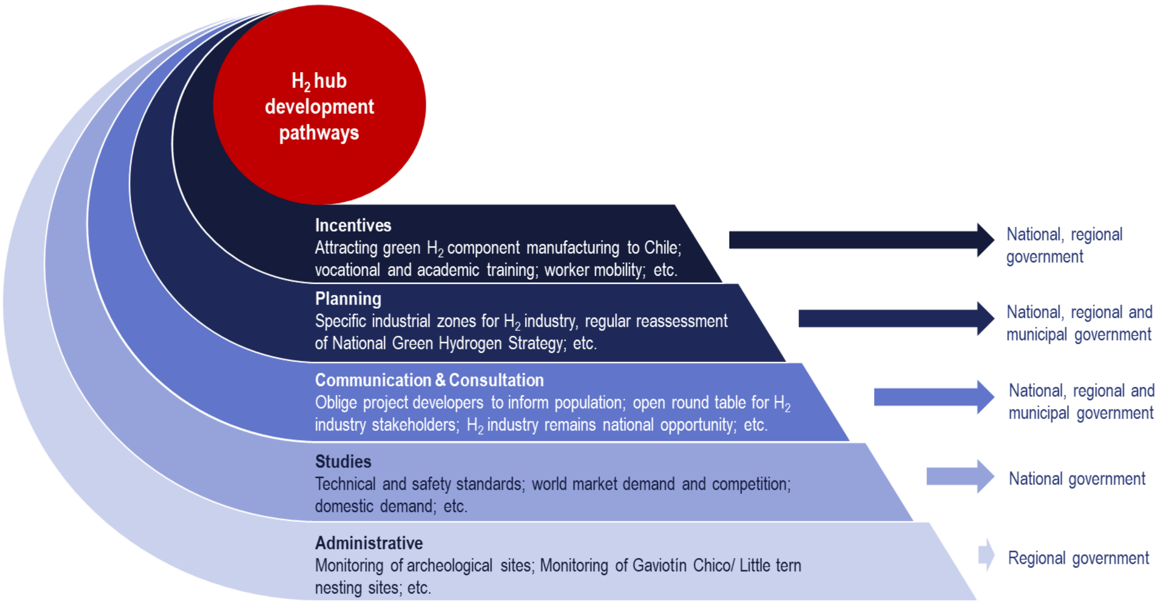


Figure 65: Schematic summary of recommendations and their different categories deduced from this study on H_2 hub development pathways.

This study identified the two regions, Antofagasta and Magallanes, with the highest potential for green hydrogen production and derivates, driven by the low levelized cost of hydrogen achievable and thus large potential for competitive entry on the green world market, and by the availability of major suitable surface areas for solar energy in Antofagasta and wind energy in Magallanes, as well as the unbeatable natural conditions of both regions, solar radiation in Antofagasta and winds in Magallanes. Upon consideration of further domestic aspects, clear additional opportunities lie also in Chilean regions other than Antofagasta and Magallanes. It is thus emphasized that an emerging H_2 industry will remain of national interest with great opportunities in all regions, not limited to Antofagasta and Magallanes. Thus, all levels of government need to be involved for the roll-out of the H_2 hubs.

In order to allow for a regular reassessment and progress reporting of the national green hydrogen strategy GHS (as for example published by the German government regarding the national hydrogen strategy "Nationale Wasserstoffstrategie"[48]), it is essential to monitor the roll-out of domestic demand in close collaboration with stakeholders from the prioritized consumption sectors, including but not limited to e.g. the mining industry, bus/coach operators, transport companies and the chemical industry. For example, in this study we identified a peak of job creation and investments in 2035. As a consequence, we suggest to adjust the GHS as to optimize the macroeconomic impacts for Chile and ensure sustainable growth throughout the coming decades. By carrying out a regular (e.g. biannual) review of

[48] https://www.bmwi.de/Redaktion/DE/Publikationen/Energie/bericht-der-bundesregierung-zur-umsetzung-der-nationalen-wasserstoffstrategie.html (in German)

the GHS, the Chilean government will have the opportunity to adjust the GHS to changing international and national circumstances, reacting to potential barriers and roadblocks, and seizing emerging opportunities. A round-table open to all stakeholders interested in participating in the green hydrogen markets is recommendable, helping increasing effectiveness and efficiency, enhancing acceptance and ensuring transparency on activities.

Our analysis revealed that it is recommendable to adapt the PELP (Planificación Energética de Largo Plazo – Long-term Energy Planning) such that large infrastructure investments are coordinated between the different industries and the development of the H_2 industry is well integrated into the overall industrial development and landscape in Chile. The anticipated long planning periods including feedback from regional and local government authorities should be accelerated, especially with respect to concrete ramp-up of GW-scale H_2 projects as developed in the GHS already by the year 2025. Especially the *Polos de Desarrollo* in Antofagasta in both María Elena (solar PV) and Taltal (wind) should be synchronized with the GHS and the H_2 hub developments described in this study. Synergies between the *Polos de Desarrollo* and the H_2 hub development should be developed actively in terms of H_2 hub geographical structure, infrastructure developments, energy system and project economics based on further enhanced utilization rates. Existing regional instruments such as the definition of an underdeveloped zone (*Zona de Rezago*)[49] and a tax-free zone (*Zona Franca*) for mining activites[50] both in Tocopilla, if adapted to a green H_2 industry, can provide the required incentives for targeted investments.

Agreements including a certain level of incentives between governments and project developers as well as local gas, electricity and water suppliers may enable synergies for improving mobility, energy and water supply for local communities and by that increase the public acceptance of the emerging H_2 industry. Notably, desalination infrastructure offers advantages to the local population, especially in the arid region of Antofagasta. Any investment in transport infrastructure such as railways and roads is essential for not only medium and large-sized companies, but also for any type of small local businesses. Sectors such as tourism or trade, may especially profit from better transportation infrastructure. A study may be conducted related to the extent this change may occur and whether investors from such sectors may be interested in supporting infrastructure development.

Generally, political support at the respective H_2 hub sites is essential for the successful roll-out of the GHS. Existing instruments such as the SEIA (Environmental Impact Assessment System) as well as specific coordination with local non-governmental organizations (such as the Fundación para la Sustentabilidad del Gaviotín Chico) need to be employed to convince authorities and the public of the H_2 industries’ opportunities, while moderating the uncertainties and risks. Project developers should be obliged to provide information and discussion forums as early as possible. The expansion of renewable energy production

49 https://www.goreantofagasta.cl/gobernador-diaz-presenta-plan-de-zonas-rezagadas-que-beneficiara-a-las/goreantofagasta/2022-01-18/172506.html

50 https://www.bcn.cl/leychile/navegar?idNorma=180816&idVersion=2020-03-01

through the H_2 industry offers the chance to accelerate the switch from carbon-based, polluting production to clean and sustainable energies for housing and other sectors.

Regarding indigenous activities, archeological findings or ecological threats, no major risks for the development of H_2 hubs have been identified in this study. After recognition as an ethnic group, however, the Changos of the Mejillones commune are in the process of claiming their interests in the marine environment. This may complicate the processing and construction of infrastructure associated with hydrogen such as desalination plants. It is recommended that a process of communication and socialization of a future green hydrogen program be carried out with fishermen and future representative organizations of Changos. Moreover, we suggest establishing permanent archeological monitoring for all H_2 related construction activities, making sure that no valuable sites of historic interest are lost. In the coastal areas of Antofagasta region, an endangered species (the Little Tern bird, *Sternula lorata*) must be monitored, best by coordination with the Fundación para la Sustentabilidad del Gaviotín Chico, especially during planning, development and construction phases of critical infrastructure such as desalination plants and port facilities.

The national government should create and implement technical and safety regulations and standards to ensure a clean H_2 industry; international best practice examples should be followed. A separate study is suggested in order to identify and define the specific regulatory environment needed for Chilean H_2 hubs (compare e.g. similar ongoing studies by GIZ for South Africa and Brazil). These regulations and standards are also of essential importance to importing markets such as Germany (see e.g. recent study on requirements for the production and export of green-sustainable hydrogen by LBST and ILF for GIZ and MoE [GIZ 2021a]). For a certified green industry, it should be considered to define special clean industry zones or specific zones for H_2 hubs and their components.

As previously mentioned, the development pathway of Chile's H_2 hubs depends strongly on both domestic and world market developments. It is thus important to understand whether hydrogen or other relevant derivatives (e.g. NH_3, methanol or synfuels) are demanded throughout the target markets, and how this demand for the individual fuels may develop over time. Furthermore, certain green products with low carbon product footprint (e.g. steel, copper products, etc.) could potentially be produced in Chile based on local green hydrogen. Such demand and related opportunities should be explored in strategic studies. Moreover, certain products and target markets might be more sensitive to transport cost, which may allow developing certain specific products and solutions for Antofagasta and Magallanes, respectively. Other factors to be assessed include the development of fuel transport technology and emerging hydrogen applications in the importing markets. Complementing the demand studies, we recommend closely observing competition from other exporting world regions, among others South Africa, Australia and the Arab peninsula.

Job creation opportunities are widely distributed in the regions around the H_2 hubs and not only tied to the specific communes were the electrolyzers are to be operated. Further opportunities may lie in manufacturing of components. Some companies involved in project development of green H_2 projects in Chile are manufacturers of electrolyzers and related components. Attracting these manufacturers to produce locally could thus add fundamentally to a sustainable macroeconomic value creation in Chile. The combined electrolyzer capacity installations per year in both the Antofagasta and Magallanes hubs alone is of the order of over 1500 MW of electrolyzers per year over the next decades (see Table 15). With a typical future output of large-scale manufacturing plants of about 1000 MW, at least one plant is required for the development in Chile as described by the GHS. As an international example, a joint venture production has recently been announced between John Cockerill (Belgian electrolyzer manufacturer) and Greenko Group (supplier of green energy) in India[51].

Specific regional opportunities, for example the phase out of coal-fired power plants in Mejillones and Tocopilla, bear great potential for the development of an H_2 hub and should be closely coordinated with all involved stakeholders. Such projects are, for example, followed in the south of Spain/Cadiz province by EDP[52], one of the largest energy providers in Europe. Here, local authorities were successful in coordinating with the energy producer a transition of the former coal plant to a new H_2 hub. A similar development from coal to H_2 hub was announced by EDP a few months earlier for its Sines coal plant in southern Portugal.[53]

Table 95: Electrolyzer capacities required by year

Module	2022-2025	2025-2030	2030-2035	2035-2040	2040-2045	2045-2050
Electrolyzer installations in Antofagasta Hubs	331 MW/Year	1,331 MW/Year	2,795 MW/Year	2,006 MW/Year	691 MW/Year	744 MW/Year
Electrolyzer installations in Magallanes Hubs	198 MW/Year	902 MW/Year	1,998 MW/Year	974 MW/Year	895 MW/Year	1,254 MW/Year
Total H_2 hubs	398 MW/Year	2,233 MW/Year	4793 MW/Year	2980 MW/Year	1586 MW/Year	1998 MW/Year

Also, the mining sector in the Antofagasta and neighboring regions is conceived to be a major driver of the H_2 hub development. We therefore suggest to further assess the multiparameter space for the mines’ hydrogen supply. Depending on the exact numbers of amortization periods, personnel costs, and distribution of demand from individual mines, it might be most economical to provide the hydrogen through a central H_2 hub, semi-

[51] https://renewablesnow.com/news/greenko-john-cockerill-create-electrolyzer-partnership-in-india-764696/

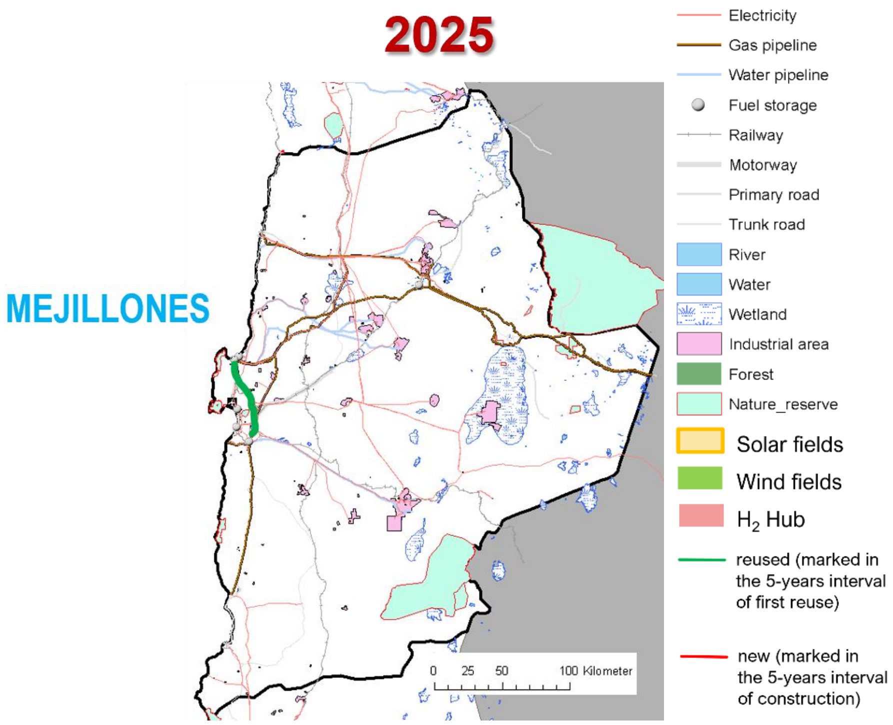
[52] https://renewablesnow.com/news/edp-to-pour-eur-550m-to-revamp-spanish-coal-fired-plant-into-green-h2-facility-754051/

[53] https://www.reuters.com/business/sustainable-business/edp-transform-sines-coal-plant-into-hydrogen-hub-by-2025-2021-10-14/

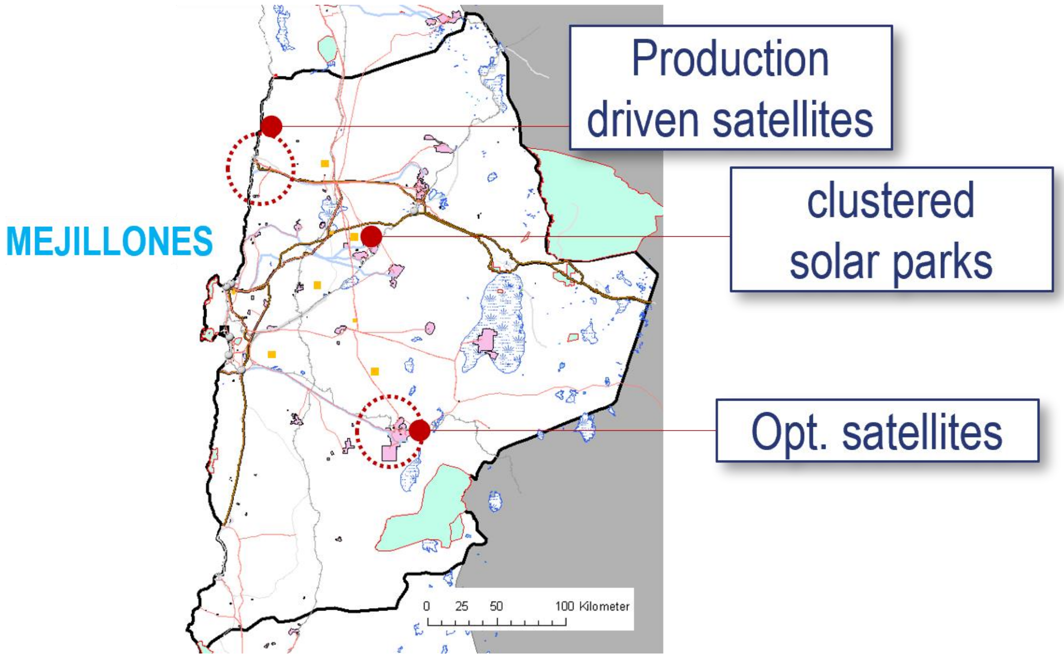
centralized H_2 hub satellites (each supplying several mines e.g. by train) or decentralized H_2 production. Potentially, also hybrid solutions are beneficial.

H_2 hubs will require skilled workers with specialized expertise. It is recommended to support actions that help incorporate or improve local capacities in relation to the competencies necessary to incorporate labor into the value chain and associated activities, promoting vocational training and capacitation of labor from other sectors. Research agreements, such as Total Eren's "H_2 Magallanes" project with the University of Magallanes, on environmental impact studies and planning for citizen participation, should be rolled out actively for education and training purposes as well. Research activities should cover any hydrogen related topics, including renewable generation, electrolysis, desalination, green copper or steel, but also ecological risks or social impact. The Magallanes region with its vast renewable energy potential, but limited population density, may be limited in the availability of skilled labor. It is therefore important to put a specific focus on local education and training in order to enhance the qualifications of local labor. Additionally, national and regional incentives may attract workers from other regions of Chile to the Magallanes region where they can establish themselves and be integrated into the social environment. If further skilled work force would be required, these could work in Magallanes on monthly or seasonal shift bases. Similar programs are known e.g. from Canada’s oil industry, where workers are incentivized to move from e.g. Nova Scotia into the remote oil sand productions on a monthly shift basis. However, societal structures would benefit most from a permanent, locally established and integrated work force; in this sense, monthly or seasonal shift schemes would rather be appropriate solutions for peak staff requirements.

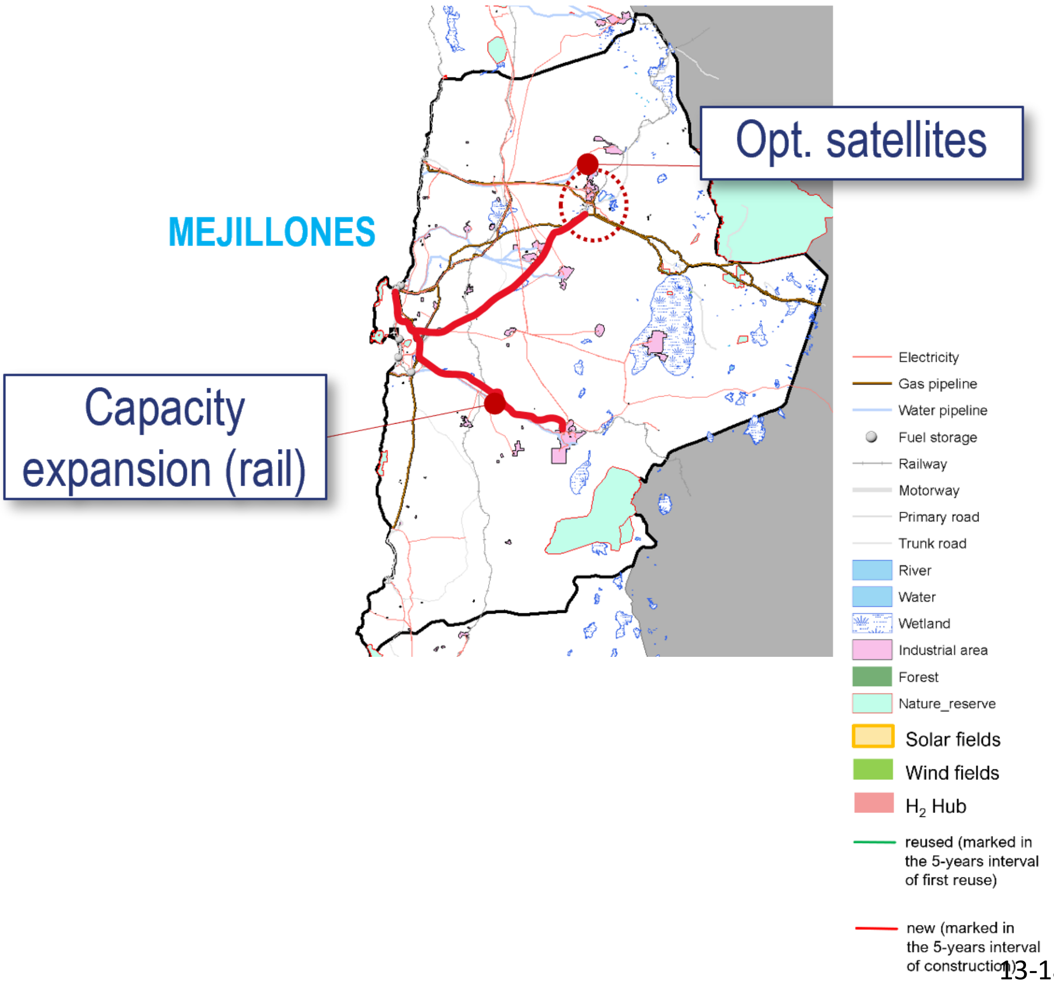
13 ANNEX A: DEVELOPMENT PATHWAYS OF H_2 VALLEYS IN 5-YEAR INTERVALS



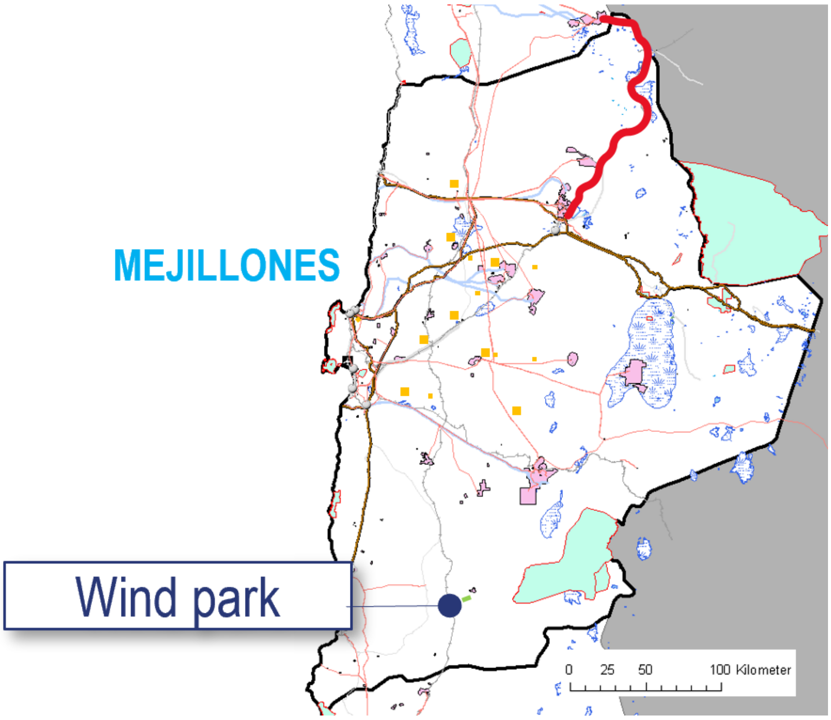
2030


Production driven satellites
clustered solar parks
MEJILLONES
Opt. satellites
0 25 50 100 Kilometer

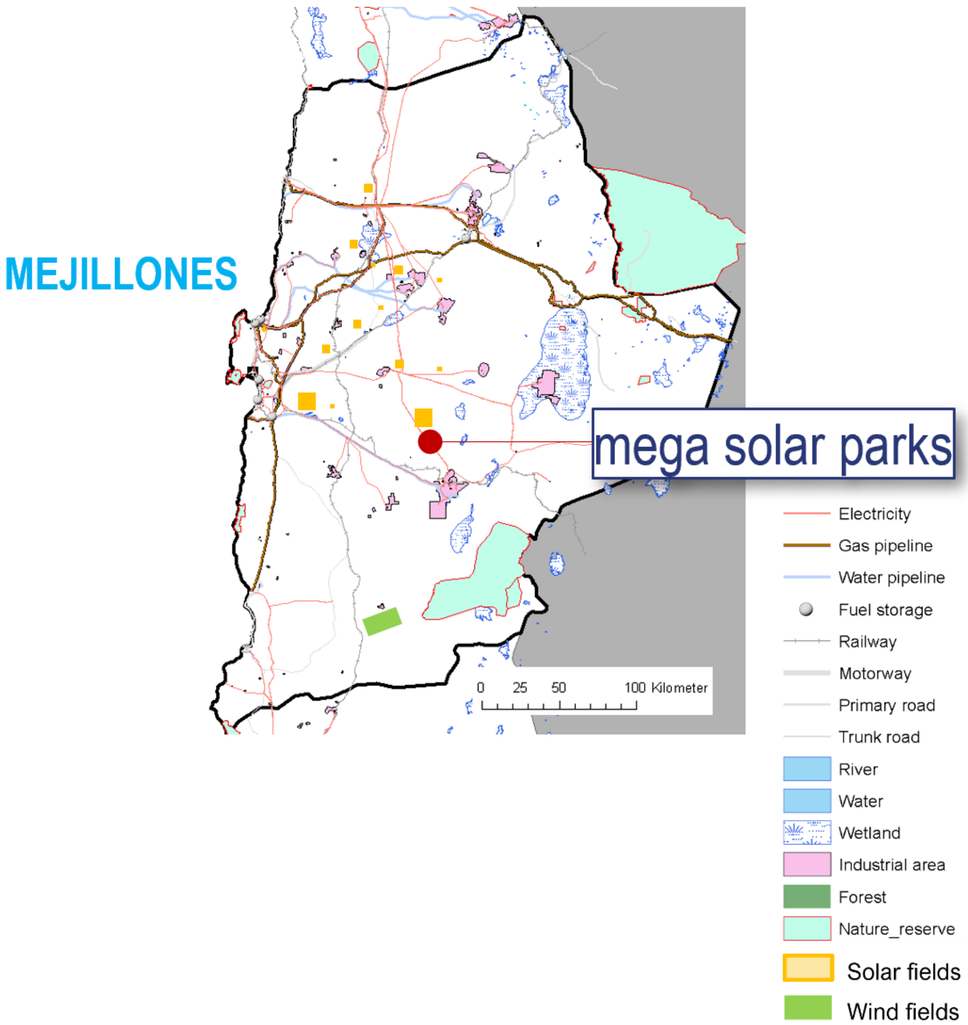
2035

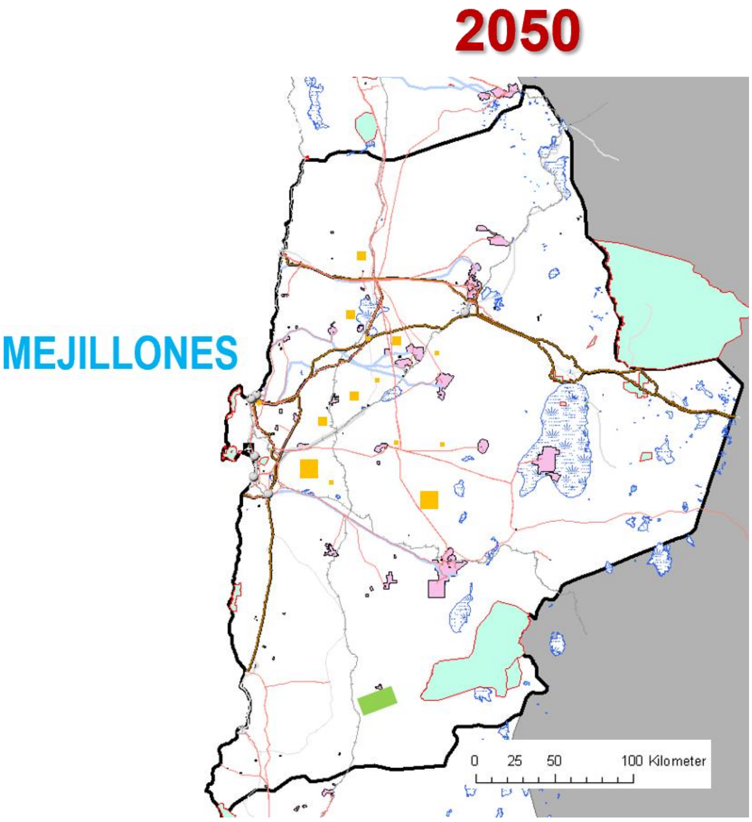

Opt. satellites
MEJILLONES
Capacity expansion (rail)
Electricity
Gas pipeline
Water pipeline
Fuel storage
Railway
Motorway
Primary road
Trunk road
River
Water
Wetland
Industrial area
Forest
Nature_reserve
Solar fields
Wind fields
H_2 Hub
reused (marked in the 5-years interval of first reuse)
new (marked in the 5-years interval of construction)

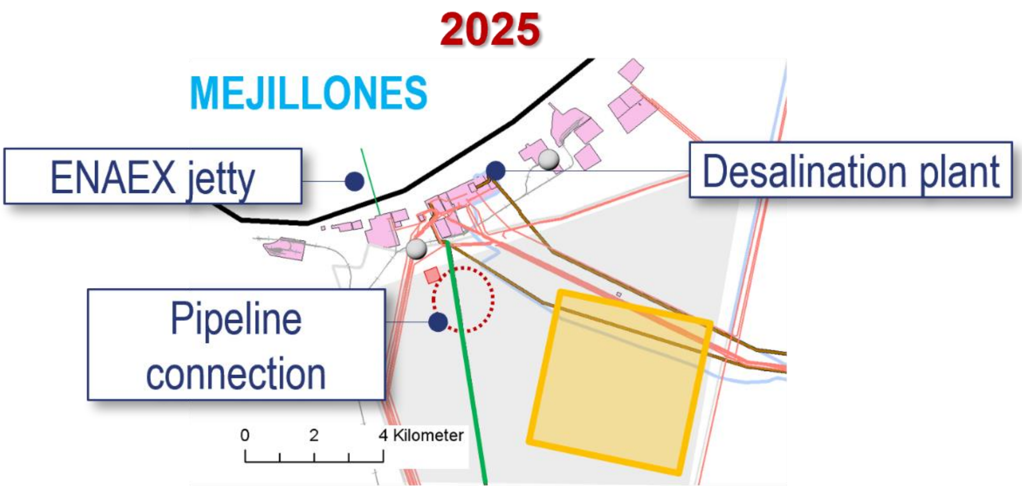
2040

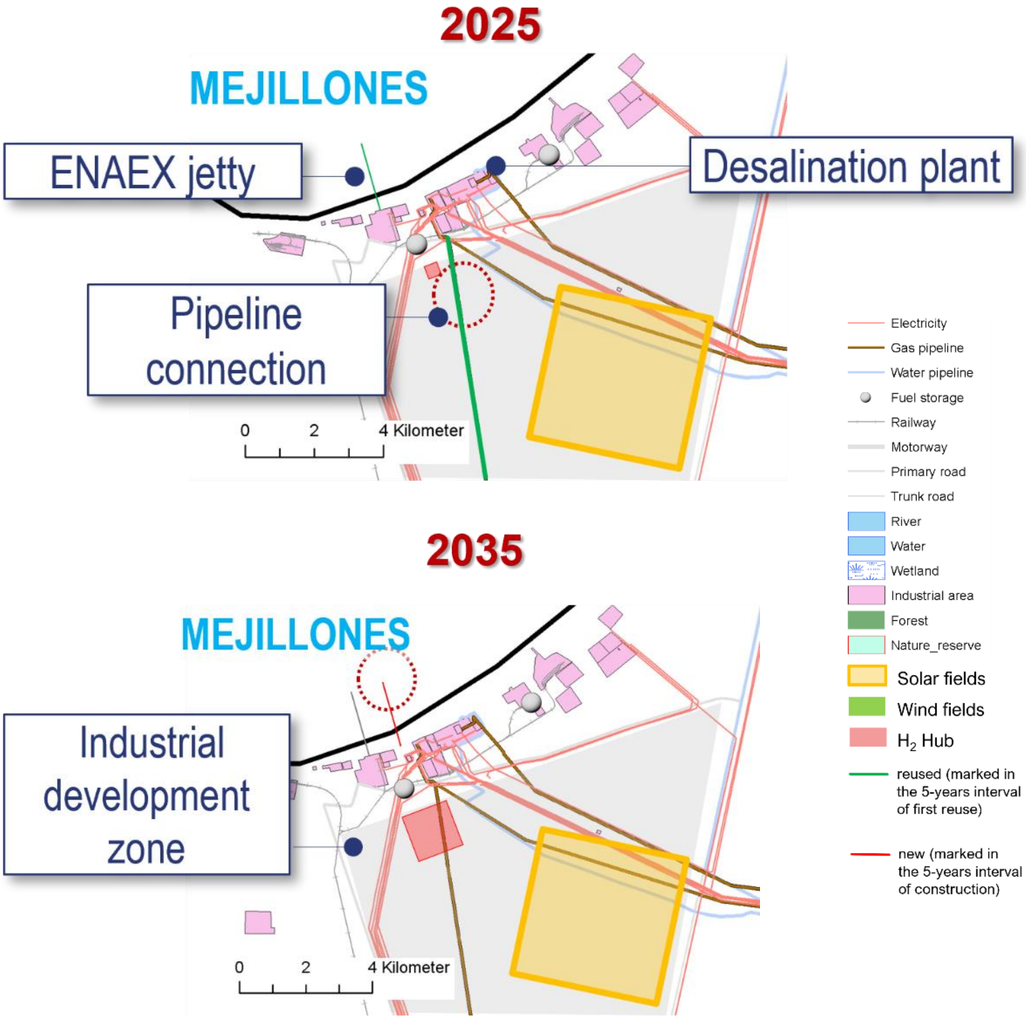

MEJILLONES
Wind park
0 25 50 100 Kilometer

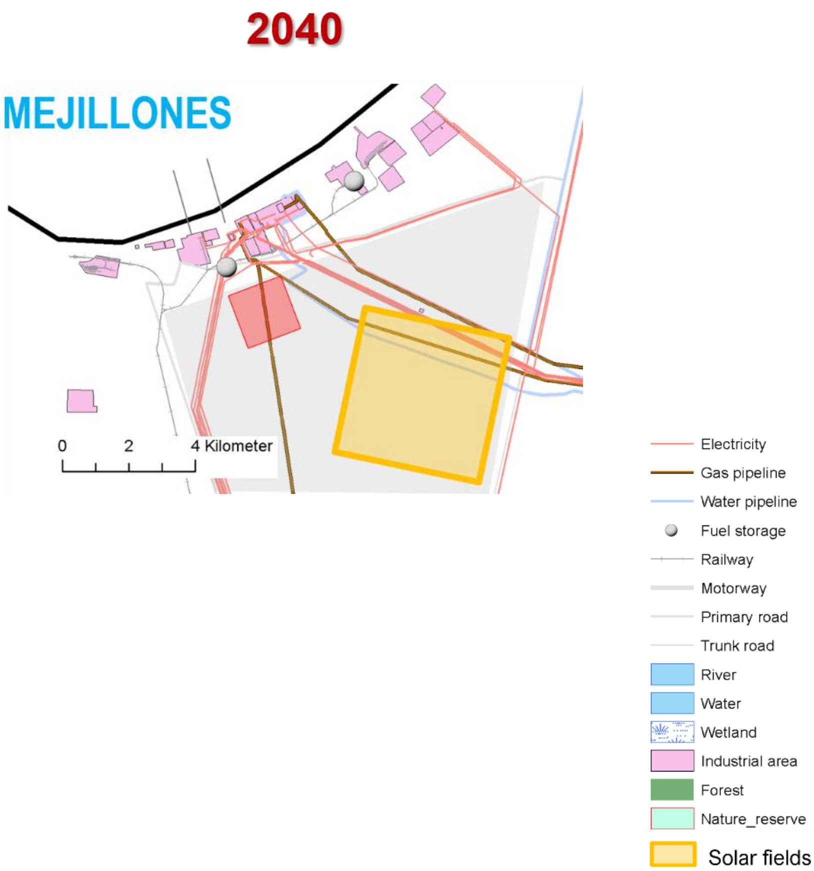
2045


MEJILLONES
mega solar parks
0 25 50 100 Kilometer
Electricity
Gas pipeline
Water pipeline
Fuel storage
Railway
Motorway
Primary road
Trunk road
River
Water
Wetland
Industrial area
Forest
Nature_reserve
Solar fields
Wind fields

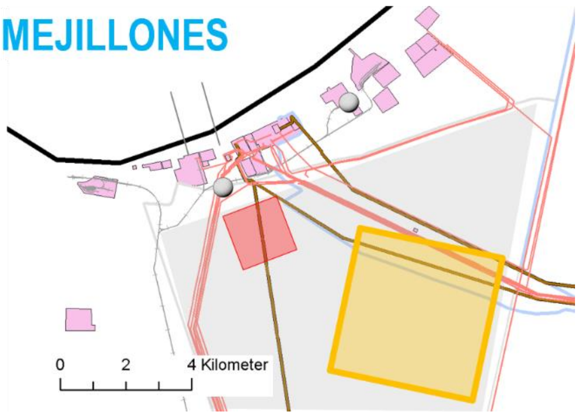

2050
MEJILLONES
0 25 50 100 Kilometer


2025
MEJILLONES
ENAEX jetty
Desalination plant
Pipeline connection
0 2 4 Kilometer

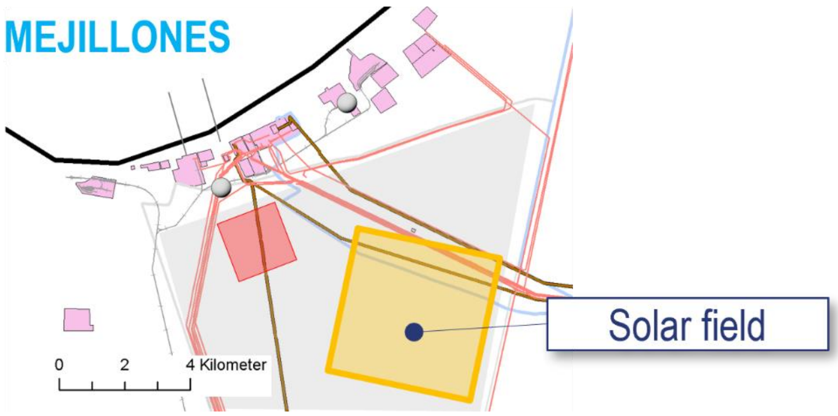

2025
MEJILLONES
ENAEX jetty
Desalination plant
Pipeline connection
0 2 4 Kilometer
2035
MEJILLONES
Industrial development zone
0 2 4 Kilometer
Electricity
Gas pipeline
Water pipeline
Fuel storage
Railway
Motorway
Primary road
Trunk road
River
Water
Wetland
Industrial area
Forest
Nature_reserve
Solar fields
Wind fields
H_2 Hub
reused (marked in the 5-years interval of first reuse)
new (marked in the 5-years interval of construction)


2040
MEJILLONES
0 2 4 Kilometer
Electricity
Gas pipeline
Water pipeline
Fuel storage
Railway
Motorway
Primary road
Trunk road
River
Water
Wetland
Industrial area
Forest
Nature_reserve
Solar fields

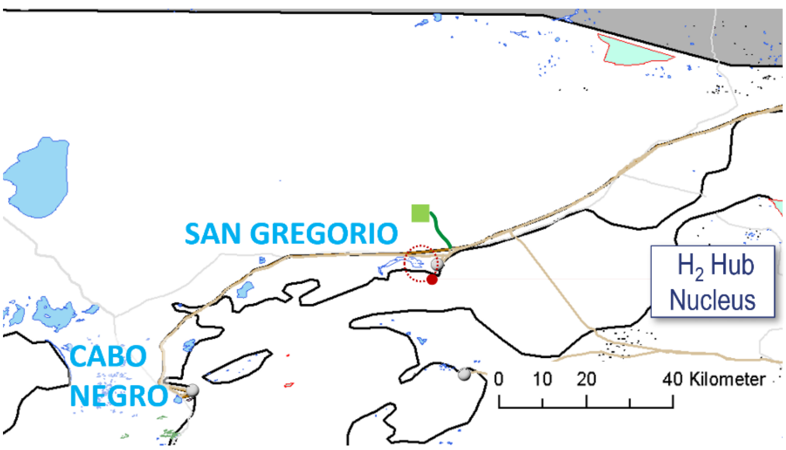
2045

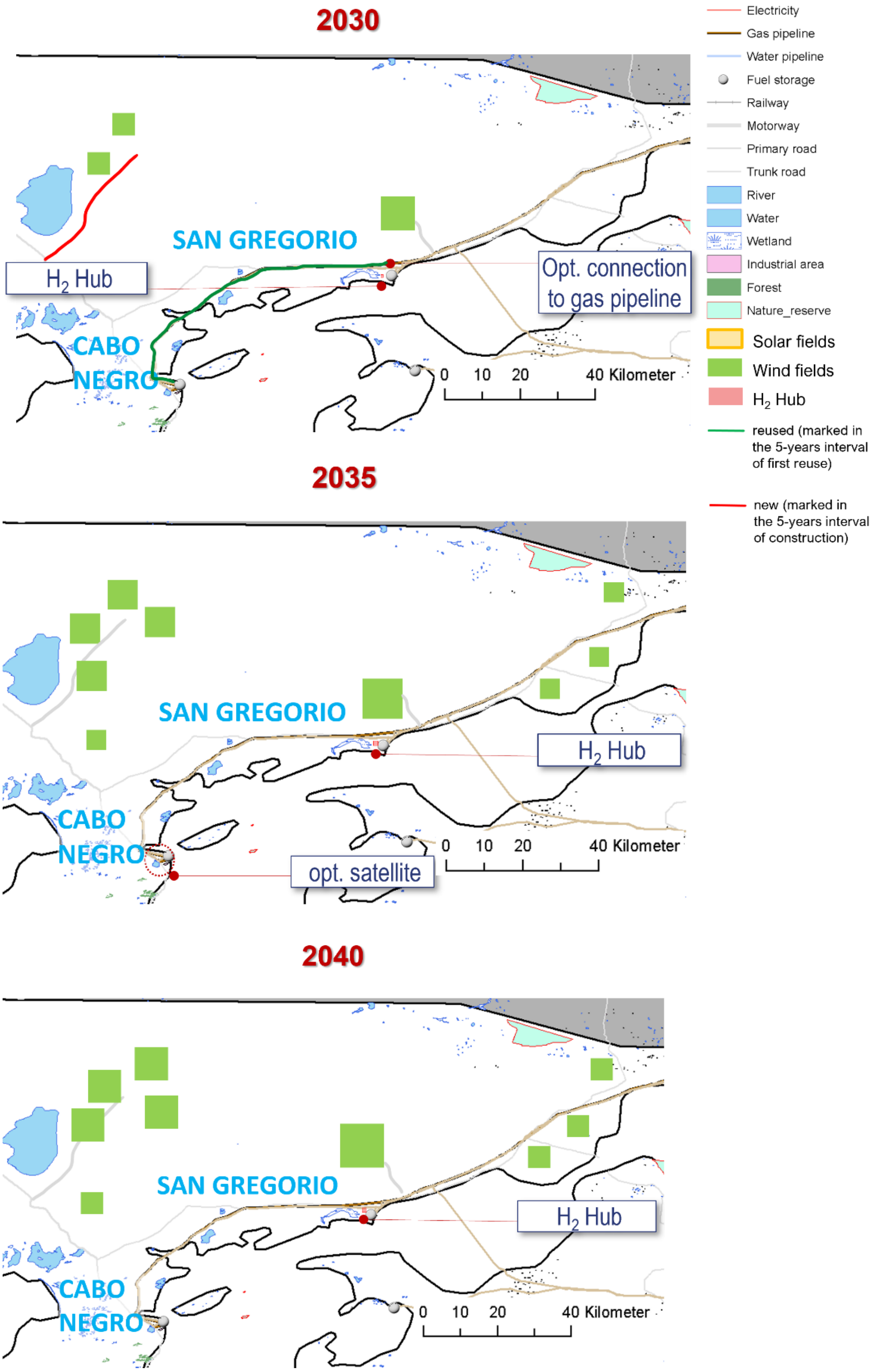


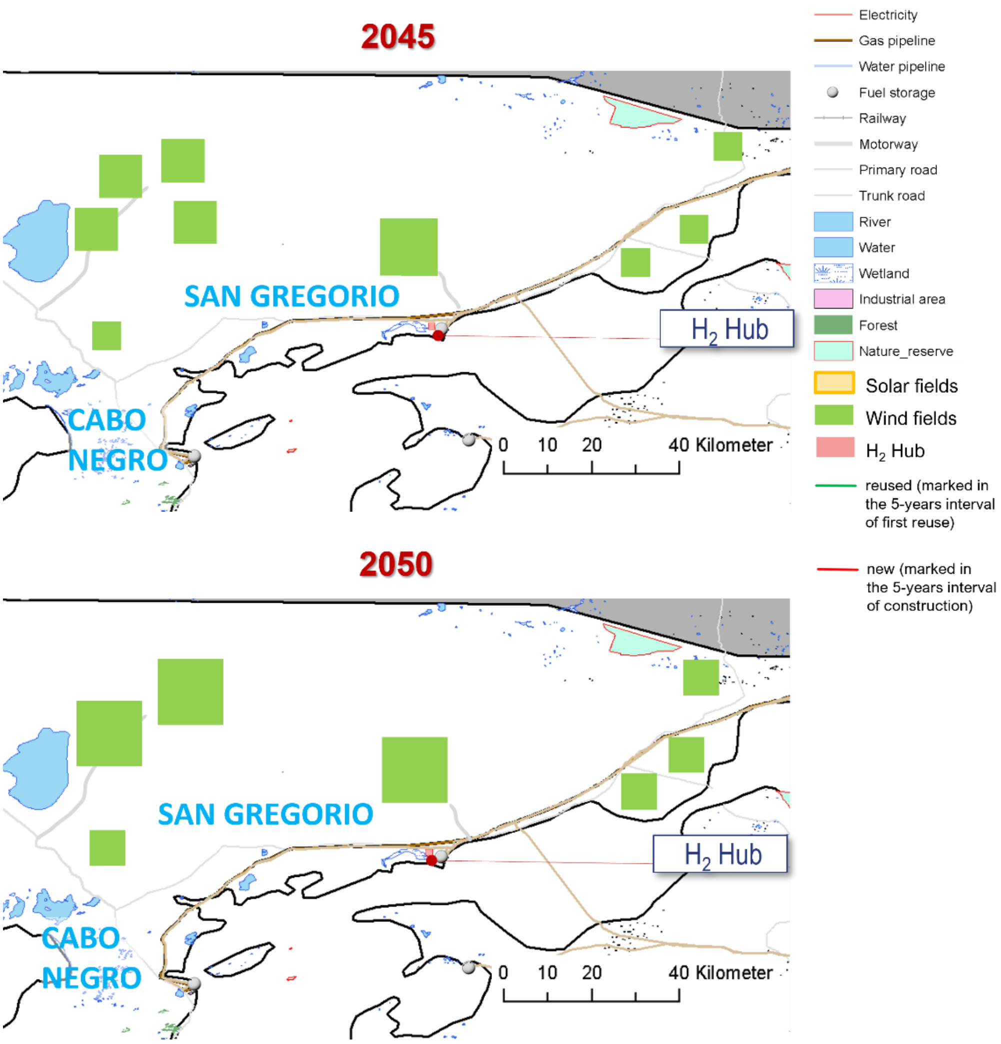
2050



2025




2030
SAN GREGORIO
H2 Hub
CABO NEGRO
Opt. connection to gas pipeline
0 10 20 40 Kilometer
2035
SAN GREGORIO
H2 Hub
CABO NEGRO
opt. satellite
0 10 20 40 Kilometer
2040
SAN GREGORIO
H2 Hub
CABO NEGRO
0 10 20 40 Kilometer
Electricity
Gas pipeline
Water pipeline
Fuel storage
Railway
Motorway
Primary road
Trunk road
River
Water
Wetland
Industrial area
Forest
Nature_reserve
Solar fields
Wind fields
H2 Hub
reused (marked in the 5-years interval of first reuse)
new (marked in the 5-years interval of construction)


2045
SAN GREGORIO
CABO NEGRO
H2 Hub
0 10 20 40 Kilometer
2050
SAN GREGORIO
CABO NEGRO
H2 Hub
0 10 20 40 Kilometer
Electricity
Gas pipeline
Water pipeline
Fuel storage
Railway
Motorway
Primary road
Trunk road
River
Water
Wetland
Industrial area
Forest
Nature_reserve
Solar fields
Wind fields
H2 Hub
reused (marked in the 5-years interval of first reuse)
new (marked in the 5-years interval of construction)

14 ANNEX B: ECONOMIC ACTIVITY OF COMPANIES WITH POTENTIAL TO INTEGRATE THE GH_2 VALUE CHAIN

Item	Economic activity
Manufacturing industry	251100 - Fabricación de productos metálicos para uso estructural
	259900 - Fabricación de otros productos elaborados de metal n.c.p.
	261000 - Fabricación de componentes y tableros electrónicos
	262000 - Fabricación de computadores y equipo periférico
	271000 - Fabricación de motores, generadores y transformadores eléctricos, aparatos de distribución y control
	279000 - Fabricación de otros tipos de equipo eléctrico
	329000 - Otras industrias manufactureras n.c.p.
Supply of electricity, gas, steam, and air conditioning	351011 - Generación de energía eléctrica en centrales hidroeléctricas
	351012 - Generación de energía eléctrica en centrales termoeléctricas
	351019 - Generación de energía eléctrica en otras centrales n.c.p.
	352020 - Fabricación de gas; distribución de combustibles gaseosos por tubería, excepto regasificación de GNL
Construction	410020 - Construcción de edificios para uso no residencial
	429000 - Construcción de otras obras de ingeniería civil
	431200 - Preparación del terreno
	432100 - Instalaciones eléctricas
	432900 - Otras instalaciones para obras de construcción
	439000 - Otras actividades especializadas de construcción
Wholesale and retail trade; repair of motor vehicles and motorcycles	451001 - Venta al por mayor de vehículos automotores
	451002 - Venta al por menor de vehículos automotores nuevos o usados (incluye compraventa)
	452002 - Mantenimiento y reparación de vehículos automotores
	453000 - Venta de partes, piezas y accesorios para vehículos automotores
	465909 - Venta al por mayor de otros tipos de maquinaria y equipo n.c.p.
	466302 - Venta al por mayor de materiales de construcción, artículos de ferretería, gasfitería y calefacción
	466902 - Venta al por mayor de desechos metálicos (chatarra)

Item	Economic activity
Transport and storage	492300 - Transporte de carga por carretera
	501200 - Transporte de carga marítimo y de cabotaje
	521009 - Otros servicios de almacenamiento y depósito n.c.p.
	522190 - Actividades de servicios vinculadas al transporte terrestre n.c.p.
	522200 - Actividades de servicios vinculadas al transporte acuático
	522400 - Manipulación de la carga
Professional, scientific, and technical activities	691001 - Servicios de asesoramiento y representación jurídica
	702000 - Actividades de consultoría de gestión
	711002 - Empresas de servicios de ingeniería y actividades conexas de consultoría técnica
	711003 - Servicios profesionales de ingeniería y actividades conexas de consultoría técnica
Administrative and support services activities	801001 - Servicios de seguridad privada prestados por empresas
	811000 - Actividades combinadas de apoyo a instalaciones
	812100 - Limpieza general de edificios
	812909 - Otras actividades de limpieza de edificios e instalaciones industriales n.c.p.
	821100 - Actividades combinadas de servicios administrativos de oficina
	821900 - Fotocopiado, preparación de documentos y otras actividades especializadas de apoyo de oficina

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