Chile’s Green Hydrogen Strategy and investment opportunities

June, 2021
Alongside the world, committed to reach carbon neutrality
We are phasing-out all coal power plants by 2040

50% by 2025
In 2021: We are **doubling** our solar & wind capacity

+ 6 GW
Green hydrogen holds the key to reach net zero

Source: Ministry of Energy
The power of green hydrogen

An industrial gas used widely for more than a century, elemental hydrogen (H₂) can be produced today from water with increasing scale and efficiency. In green hydrogen production, water can be separated into its constituents, hydrogen and oxygen, using renewable power.

Historically, it has been produced from fossil fuels in processes that emit greenhouse gases. It has mostly been used in chemical industries and for the refining processes of crude oil.

It is a means for using the inexhaustible renewable energy found in various forms on the planet. It functions as an energy carrier that emits no greenhouse gases when used. It can replace the use of fuels in the production of electricity, heat, and multiple materials.

Decarbonization potential of green hydrogen

Source: adapted from Siemens, Power-to-X

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The time for hydrogen has arrived

Almost 90% of global GDP has put forward hydrogen support policies or initiatives

Source: LBST

Global energy demand supplied by hydrogen (PWh)

Source: Hydrogen Council

- Power generation and storage
- Transportation
- Heating and residential uses
- Industry
- New uses
- Existing uses

Almost 90% of global GDP has put forward hydrogen support policies or initiatives.

Global energy demand supplied by hydrogen (PWh): 18% of final energy demand.
The green hydrogen economy is building momentum

Projected electrolyser capacity (GW)

12.9 GW
December 2019

16.6
December 2020

27.5 GW
June 2020

43.9 GW
December 2020

CAGR 70%

Announced projects

240

Large-scale industrial usage:
refinery, ammonia, power, methanol, steel and industry feedstock

97

Transport: trains, ships, trucks, cars and other hydrogen mobility applications

55

Integrated H₂ economy:
cross-industry, and projects with different types of end-uses

47

Giga Scale production: renewable H₂ projects > 1 GW and low-carbon H₂ projects >200 kt/year

17

Infrastructure projects: H₂ distribution, transportation, conversion and storage

24

Source: based on Hydrogen Council
“I believe that water will one day be employed as fuel, that hydrogen and oxygen which constitute it, used singly or together, will furnish an inexhaustible source of heat and light, of an intensity of which coal is not capable.”

Jules Verne, 1874
A country with abundant renewable resources

Renewable energy potential (GW)

Source: Ministry of Energy

- **Concentrated solar power**:
  - 587 GW

- **Solar photovoltaic**:
  - 879 GW

- **Run of river hydro**:
  - 15 GW

- **On-shore wind**:
  - 295 GW

Levelized cost of renewable electricity (USD/MWh)


- **Center (Solar photovoltaic, Metropolitan Region)**
- **South (On-shore wind, Magallanes Region)**
- **North (Solar photovoltaic, Antofagasta Region)**

The most powerful solar radiation on the planet is found in northern Chile. Capacity factors of up to 37% can be achieved in monofacial solar photovoltaic plants with 1-axis tracking.

Solar generation in the central part of Chile is already more competitive than fossil-powered electricity generation. This renewable potential is located close to large consumption centers, gas grids, and logistical hubs, such as ports and distribution centers.

Winds in the far south end of the country are as strong inland as they are off-shore. 120-meter-high wind turbines are able to achieve capacity factors of up to 75% on-shore, equivalent to off-shore performance in other countries.
Chile is poised to become the leading producer of green H₂

### Capacity factors per country in best areas (%)

*Source: Ministry of Energy of Chile, McKinsey & Co*

<table>
<thead>
<tr>
<th></th>
<th>Chile</th>
<th>Australia</th>
<th>Germany</th>
<th>USA</th>
<th>Europe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar PV</td>
<td>~30%</td>
<td>~30%</td>
<td>~25%</td>
<td>20-25%</td>
<td></td>
</tr>
<tr>
<td>Wind Off shore</td>
<td>&gt;75%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wind On shore</td>
<td>70-75%</td>
<td>30-35%</td>
<td>40-50%</td>
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</tbody>
</table>

Our narrow territory (average 180 km width) ensures proximity of production points to maritime ports.

Hydrogen valleys

Main ports of Chile

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Latest estimations put Chile around 1 USD/kg by 2030

Levelized cost of production
(USD/kg H₂)


Potential for a 160 Mtonne yearly green hydrogen production according to IEA

Levelized cost of production by 2030
(USD/kg H₂)

Does not consider conditioning, transport, storage nor distribution costs

Despite distance to markets, Chile remains competitive in H2

Cost of liquid H₂ at port of destination, 2030 (USD/kg H₂)


Renewable energy carriers considered by developers and investors

- LH2: Liquid hydrogen
- NH3: Green ammonia
- CH₃OH: Green methanol / eFuels
- Cu: Green copper and other green exports

Despite distance to markets, Chile remains competitive in H₂
Ammonia total landed cost at destination site for prioritized countries
USD/Mton of NH3;  Year 2030

<table>
<thead>
<tr>
<th>Country</th>
<th>Cost (USD/Mton)</th>
<th>Cost (USD/Mton)</th>
<th>Cost (USD/Mton)</th>
<th>Cost (USD/Mton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chile South</td>
<td>390-415</td>
<td>~95</td>
<td>430-455</td>
<td>~100</td>
</tr>
<tr>
<td>Chile North</td>
<td>380-405</td>
<td>~85</td>
<td>420-445</td>
<td>~90</td>
</tr>
<tr>
<td>Australia</td>
<td>370-395</td>
<td>~80</td>
<td>410-435</td>
<td>~95</td>
</tr>
</tbody>
</table>

1. Includes liquefaction | 2. Relative differences in WACC vs. Chile estimated from country specific renewable project financing | 3 WACC assumption for Morocco

For easier to transport derivatives such as ammonia, Chile has a clear cost advantage

Insights
Chile’s competitive advantage in low-cost green ammonia production makes it the most competitive importer option for prioritized markets

These results remain similar until 2040
A unique opportunity: green hydrogen could be a clean industry as big as our mining sector

**Projection of Chilean markets for green hydrogen and its derivatives (BUSD)**


<table>
<thead>
<tr>
<th>Year</th>
<th>Domestic applications</th>
<th>Exports</th>
<th>CAGR +15%</th>
<th>Cumulative necessary investment (BUSD)</th>
<th>Associated renewable capacity (GW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2025</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>8</td>
<td>5-8</td>
</tr>
<tr>
<td>2030</td>
<td>5</td>
<td>5</td>
<td>11</td>
<td>45</td>
<td>40</td>
</tr>
<tr>
<td>2035</td>
<td>11</td>
<td>7</td>
<td>16</td>
<td>145</td>
<td>145</td>
</tr>
<tr>
<td>2040</td>
<td>16</td>
<td>8</td>
<td>28</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>2045</td>
<td>19</td>
<td>9</td>
<td>33</td>
<td>250</td>
<td>250</td>
</tr>
<tr>
<td>2050</td>
<td>24</td>
<td></td>
<td>300</td>
<td>330</td>
<td>300</td>
</tr>
</tbody>
</table>

The competitiveness of Chile in renewable energy production and the global need for clean energy carriers will open the door to the creation of an economic sector that could rival the size of the Chilean mining sector.

If timely and effective action is taken, the use of green hydrogen in domestic applications will generate an industry prepared to compete in international export markets. Investment in green hydrogen will lead to significant national capabilities and the creation of dynamic economic ecosystems throughout the country.
The addressable market for green hydrogen and derivatives produced in Chile exceeds 20 Bn USD in 2030, with EU/UK accounting for roughly half

<table>
<thead>
<tr>
<th></th>
<th>In 2030, B USD</th>
<th>In 2040, B USD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Domestic market</strong></td>
<td>1 – 4</td>
<td>4 – 7</td>
</tr>
<tr>
<td>Hydrogen and hydrogen derivatives sold for domestic use (example: mining haul truck, heavy duty trucks and gas blending)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Hydrogen exports</strong></td>
<td>1.5 – 2</td>
<td>7 – 10</td>
</tr>
<tr>
<td>Export opportunities in Transportation and Feedstock applications</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Ammonia exports</strong></td>
<td>2 – 7</td>
<td>20 – 32</td>
</tr>
<tr>
<td>Export opportunities in Power and Maritime shipping applications</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fertilizers' export</strong></td>
<td>5 – 8</td>
<td>15 – 19</td>
</tr>
<tr>
<td>Chile can produce and export downstream products such as fertilizers by leveraging the inexpensive production cost of green ammonia</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>DRI Sponge Steel Export</strong></td>
<td>3 – 4</td>
<td>18 – 23</td>
</tr>
<tr>
<td>Chile can produce and export downstream products such as green DRI sponge by leveraging the inexpensive production cost of green hydrogen</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Synfuel exports</strong></td>
<td>8 – 24</td>
<td>42 – 86</td>
</tr>
<tr>
<td>Chile could produce and export inexpensive synfuels (Jet Fuel, Diesel, Methanol and Gasoline) to address the green fuels market</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total (B USD)</strong></td>
<td>20 – 50</td>
<td>105 – 175</td>
</tr>
<tr>
<td><strong>Total (GWs)</strong></td>
<td>55 – 175</td>
<td>390 – 700</td>
</tr>
</tbody>
</table>

1. Part of this opportunity may in reality become an ammonia export opportunity with fertilizer production realized elsewhere. Green ammonia cost represents 55% of green fertilizer production costs on average.

Range reflects base case and accelerated case scenarios

We developed a long-term strategy with broad political support

Advisory board

Ricardo Lagos  
Former President of Chile

Vivianne Blanlot  
Former Head of Energy Regulator

Marcelo Mena  
Former Minister of the Environment

Jeannette von Woltersdorff  
Economist

Klaus Schmidt Hebbel  
Former Chief Economist of the OECD

Gonzalo Muñoz  
COP25 High Level Climate Action Champion

Green hydrogen ‘ambassadors’

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The path to a participatory strategy

Technical roundtables
Roundtables were carried out with participation from companies, universities, research institutions, and industry associations. Barriers to the development of hydrogen were identified, and actions to solve them were prioritized.
4 sessions throughout June and July 2020
Participants: 66 organizations.

Citizen workshops
Interactive workshops were carried out with representatives from NGOs and citizen associations. Local concerns and perceptions regarding the role of the State in green hydrogen development were raised.
3 sessions in August 2020
Participants: 90 representatives.

Interinstitutional roundtable
Discussion roundtables took place between key public stakeholders to refine a diagnosis, propose objectives, and construct a common vision for the development of green hydrogen in Chile.
4 sessions between April and October 2020
Participants: The Ministries of Energy; Science, Technology, Knowledge, and Innovation; Mining; Economy; Transportation and Telecommunications; Environment; Foreign Affairs; as well as CORFO, InvestChile, and the German agency GIZ.

Advisory Board
A board was formed with experienced public policy and climate action experts to advise the Ministry of Energy on high-level strategic issues regarding green hydrogen public policy making.
4 sessions between May and August 2020
Members: Former President Ricardo Lagos, Vivianne Blanlot, Marcelo Mena, Gonzalo Muñoz, Klaus Schmidt-Hebbel, Jeannette von Wolfersdorff.

Public Consultation
This document is currently under public consultation. To participate, please visit the Ministry of Energy’s website at energía.gob.cl.
We have set clear goals to lead the way

**2025**
- **5 BUSD**
  - Top destination for green hydrogen investment in LATAM
- **5 GW**
  - Electrolysis capacity operating and under development
- **200 ktonne/year**
  - Production in at least 2 hydrogen valleys in Chile
- **2.5 BUSD/year**
  - Leaders in export of green hydrogen and derivatives
- **<1.5 USD/kg**
  - The cheapest green hydrogen on the planet
- **25 GW**
  - Leaders in production of green hydrogen via electrolysis

**2030**
And we have defined an action plan to cover 8 key fronts

1. **Strategy and targets**
   Establish a vision and mission to align public and private stakeholders.
   Drive action and commitment by investors, developers, regulators, and civil society towards defined goals.

2. **Regulation and permits**
   Develop a clear, stable, and coherent regulation on markets and safety issues, so uncertainty is reduced and projects are accelerated. Streamline permitting to accelerate deployment of technologies.

3. **Coordination and alliances**
   Reduce market failures: information assymetries, high transaction costs, barriers for new entrants. International cooperation to overcome technological capability gaps, commercial, regulatory and cultural challenges together.

4. **Value chain development**
   Enable the development of manufacturing and services to capture increased shares of the market value domestically.

5. **Incentives and financing**
   Help in bridging the remaining cost gap relative to fossil solutions, especially reducing the cost of capital.

6. **Infrastructure**
   Plans for developing adequate and coordinated port, electrical, and distribution infrastructure to foster the growth of hubs.

7. **Research & development**
   Deploy technologies and solve local implementation issues, in order to reduce costs, unlock markets, and increase competition in the sector.

8. **Human capital**
   Develop local talent and technical capabilities to accelerate project deployment and generate green jobs.
The first wave will include domestic usage with existing large energy or hydrogen demand
The shorter-term opportunities are replacing imported ammonia for local production, and replacing grey hydrogen used in oil refineries. The use of green hydrogen for heavy and long-distance transportation also becomes attractive for fleets and machinery operating in concentrated zones.

The start of export activities and extended local uses will be seen before the decade is over
A clear opportunity for green ammonia exports exists in the medium-term, as well as for the first hydrogen exports. A more competitive production of green hydrogen will also replace an increasing share of liquid fuels in land transportation, whereas blending into grids becomes economical.

New export markets open in the long-term, enabling a massive scale-up of production
Fuels derived from green hydrogen will be key to decarbonize the shipping and aviation sectors, both in domestic and international routes. Export markets will continue to grow as other nations take action to deeply decarbonize their economies.

Projected development of green hydrogen applications
Uncertainty level, market size, and estimated year of breakeven for some applications of hydrogen in Chile. Does not consider carbon price. List of applications not exhaustive.

Wave I: Local applications will ramp up hydrogen demand and activate a domestic industry

We will accelerate the deployment of green hydrogen in 6 prioritized applications to build local supply chains and acquire experience.

Public action will kickstart the local hydrogen industry by incentivizing production and create a tangible demand for this clean element and its derivatives. Uses with the earliest economic breakeven and largest concentrated demand will be targeted first. These actions will generate know-how, develop talent, deploy infrastructure, and attract financing. In doing so, the country will be better positioned to tap into export markets.

<table>
<thead>
<tr>
<th>Application</th>
<th>Total potential market¹ (BUSD by 2050)</th>
<th>2025</th>
<th>2030</th>
<th>2035</th>
<th>2040</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Oil refineries</td>
<td>0.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Ammonia</td>
<td>0.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Mining haul trucks (CAEX)</td>
<td>1.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Heavy-duty trucking</td>
<td>2.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Long-range buses</td>
<td>0.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 Blending into gas grids (up to 20%)</td>
<td>0.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹ Annual sales. Considers the full transition to hydrogen of the energy demand in each application.

Targeted breakeven through action and start of piloting. Estimated breakeven without additional action. Potential adoption curve to achieve 100%.
Wave II: We will leverage our domestic base to scale into a key player in export markets

An industry of green ammonia production and exportation will be put in place through support for GW-scale consortiums. Offtake and investment commitments for ammonia and hydrogen exports will be secured.

Wave III: We will exploit synergies and economies of scale to expand as a global supplier of clean fuels

As countries take action to decarbonize their economies and new technologies are developed, the export markets for clean fuels will scale and diversify, opening opportunities for further growth. Future applications for ammonia in shipping and synfuels in aviation are promising opportunities for additional scale-up.
In 6 months, we have achieved 5 key milestones for hydrogen

**50 MUSD**
- **First call for financing green hydrogen projects**
  - Funding round for 10+ MW electrolizer facilities

**265 MUSD**
- **Clean Technologies Institute**
  - Open Innovation platform for clean energy and mining technologies

**International outreach**
- **MoUs for collaboration and co-leadership of MIH2**
  - MoUs with Singapore and Port of Rotterdam

**Fast-track piloting**
- **3 guides for H2 tech in production, mining, and transport**
  - Streamlined approval processes for pilot initiatives

**Energy Efficiency Law**
- **Energy efficiency standard for vehicles**
  - Hydrogen and battery electric vehicles count x3. Accelerated depreciation.
We are committing public resources to accelerate green hydrogen projects

50 million USD funding round

- Grant for up to 30 million USD per awarded applicant
- Focuses on electrolyser installation for green hydrogen production
- Considers both local and international players
- Aims to accelerate production costs reduction and enable market competitiveness, along with developing local technical capabilities
- Development of big, executable, cost-efficient projects

Funding round launch
April 21st, 2021

Consultations until
July 9th, 2021
via hidrogenoverde@corfo.cl

Application deadline
September 6th, 2021

More information: https://www.corfo.cl/sites/cpp/hidrogeno-verde-chile

10 MW Minimum electrolyser capacity
December 2025 Latest possible COD
40+ projects have already sprung in Chile

**Atacama Hydrogen Hub Project**
Large-scale electrolysis facility with export potential and hydrogen fuel cell powered freight train.

**Green Steel Project**
Green hydrogen blending into CAP’s blast furnaces to reduce consumption of coke and eventually replace it entirely in their production of steel.

**HyEx Project**
Green ammonia production in the north of Chile for domestic and international consumption, replacing ENAEX ammonia imports.

**Quintero Bay H₂ Hub Project**
Production of green hydrogen in the central zone of Chile, close to potential offtakers.

**HNH ENERGY Project**
Large scale green ammonia production in Magallanes for export.

**HIF Project**
Industrial-scale plant in Magallanes that will produce synthetic climate-neutral fuels for export.

- **+15** USD billion projected investment by 2030
- **+1,200** kTonne H₂ projected yearly production by 2030
- **+500** kTonne H₂ projected yearly local consumption by 2030
- **+15** Projects have already defined their operations start date

Source: Ministry of Energy
SELECTED PRIVATE PROJECTS
UNDER DEVELOPMENT –
One-page summaries
HIF is expected to yield the world’s first industrial-scale plant that will produce synthetic climate-neutral fuels for export.

**PRODUCTION**
A wind plant will power an electrolyzer which will produce green hydrogen. This will be combined with captured carbon dioxide to produce synthetic methanol. A portion of this methanol will be converted into synthetic gasoline (eGasoline).

**PROJECT OWNER AND PARTNERS**

**PROJECT OWNER**

Team of Companies

- **SIEMENS ENERGY**: Co-developer and technology provider.
- **ENEL**: Renewable power developer.
- **ENAP**: Chilean National Oil company. Infrastructure provider.
- **GASCO**: Co-developer and offtaker.
- **PORSCHE**: Co-developer and offtaker.

Siemens received an **8 million euros grant** from the German Federal Ministry for Economic Affairs and Energy to develop this project.

**OFFTAKE**

**PORS R C E** is planning to use the eFuels from Chile in pilot projects. These include using eFuels in Porsche’s Experience Centers and sports cars.

**MABANAFT**, the Marquard & Bahls trading division which focuses on oil, announced an MoU highlighting the purchase of up to **500 million liters of carbon neutral eGasoline per year** from this project.

**LOCATION**

**CHILE**

**GERMANY**

**PROJECTIONS**

<table>
<thead>
<tr>
<th>Project</th>
<th>Phase I</th>
<th>Pilot</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>131 m³ eGasoline per year</strong></td>
<td><strong>70,000 USD investment</strong></td>
<td><strong>3.4 MW wind energy</strong></td>
</tr>
<tr>
<td><strong>755 million USD investment</strong></td>
<td><strong>300 MW expected year for operation start</strong></td>
<td></td>
</tr>
<tr>
<td><strong>51 million USD investment</strong></td>
<td><strong>2022 expected year for operation start</strong></td>
<td></td>
</tr>
</tbody>
</table>

**STATUS**

Pilot phase started construction and is expected to enter operations by May 2022. Phase I is currently in development and the environmental assessment is being prepared.
The HNH Energy project aims to produce green ammonia on a large scale in Magallanes for export, leveraging abundant wind resources present in the region.

**PRODUCTION**

Wind energy is used to power an electrolysis plant, which uses desalinated water to obtain oxygen and hydrogen. Hydrogen will then be combined with nitrogen captured from the air through the Haber-Bosch process, to produce green ammonia. The project also contemplates the construction of port infrastructure for export.

**PROJECT OWNER AND PARTNERS**

**PROJECT OWNER**

AUSTRIAENERGY focuses on utility scale energy project development, construction, operation and management, with close to 1 GW developed in Chile, thereof 300 MW in operation and close to 300 MW under construction. It is a partner in the project and the developer.

ÖKOWIND, his partner, is dedicated to the development and operation of wind, hydro and solar power plants with over 100 MW installed capacity and over 500 MW in development in Europe.

**OFFTAKE**

Trammo DMCC, a subsidiary of Trammo, Inc., a global company that markets, trades, transports and distributes key raw materials used in industrial processes and fertilizer production announced an MoU highlighting the purchase the entire output from this project.

**HOW IT WORKS**

Wind energy + Desal. water → Green hydrogen + Nitrogen captured from the air → Green ammonia

**STATUS**

The project is in a conceptual engineering development stage and holds a lease over the terrain. Wind capabilities are being measured and environmental baselines are being defined.

**3,000 million USD**

Total investment, starting operation in 2026

**PROJECTIONS**

- **1,800 MW**
  - Wind energy installed capacity
- **850,000 Tonnes green ammonia** per year
- **150,000 Tonnes of green hydrogen** per year for ammonia production

**LOCATION**

Magallanes Region

Chile

**Exportation**

**PROJECTIONS**

- **1,800 MW**
  - Wind energy installed capacity
- **850,000 Tonnes green ammonia** per year
- **150,000 Tonnes of green hydrogen** per year for ammonia production
Taking advantage of strong winds and solar radiation in Chile, the project aims to produce green ammonia on a large scale for export and maritime transportation fueling.

**PRODUCTION**

Using renewable energy and water from a desalination plant, the project will produce green hydrogen through an electrolysis process, which combined with nitrogen captured from the air will be used to produce green ammonia.

**PROJECT OWNER AND PARTNERS**

**PROJECT OWNER**
AES ANDES

**PARTNER COMPANIES**

AES ANDES is a subsidiary of AES Corporation, a global energy company with over 5 GW of installed capacity. For over 2 years, the company has been developing ammonia related initiatives in countries such as Brazil, Argentina and Colombia, as well as Chile.

AES ANDES has a (BBB-) credit rating and over 3.5 GW of installed capacity in Chile. It is a partner in the project and will be the developer and technology provider.

**POWER TO AMMONIA**

AES ANDES PROJECT

**HOW IT WORKS**

Wind energy + Solar energy + Energy from the grid + Desal. water → Green hydrogen + Nitrogen captured from the air → Green ammonia → Applications

**STATUS**
Studies are being executed to define the right set up for the desalination and production plants. Target markets are being assessed.

**PROJECTIONS**

1,500 million USD Total investment, starting operation in 2025

**OFFTAKE**

AES ANDES has signed an MoU with its undisclosed investment grade partner. It is a world-class hydrogen producer and exporter.

In the MoU they have committed 100% of the green ammonia production for maritime fuel and international export for a tenor of up to 30 years.

**LOCATION**

Chile

Exportation
HyEx seeks to produce green ammonia in the North of Chile for domestic and international consumption, replacing imports.

**PRODUCTION**
Using renewable energy and desalinated water, the project will produce green hydrogen through an electrolysis process. Hydrogen will be then combined with nitrogen, captured from the air, and through Haber-Bosch process will produce green ammonia. During the pilot phase, all production will be sent by truck to ENAEX’s plant, replacing some of its current imports. The second phase considers large scale ammonia production for ENAEX consumption, export and additional applications.

**PROJECT OWNER AND PARTNERS**

**PROJECT OWNER**
ENGIE

**PROJECT OWNER**
ENAEX

ENGIE is a global reference company in low-carbon energy and services, having a Business Unit dedicated to renewable hydrogen since 2018. The current portfolio of renewable H₂ projects under development and in construction is over 70 projects in 10 countries over four continents.

ENAEX is the main ammonium nitrate producer and supplier of comprehensive rock fragmentation services for the mining industry in Latin America. With over 100 years of experience and presence in 10 countries, ENAEX is actively committed to sustainability.

**STATUS**
A feasibility study of the project is being conducted.
An environmental impact study is currently being carried out to be presented to the Chilean Environmental Assessment Service by 2021.

**PROJECTIONS**

**Pilot**
- 18,000 Tonnes green ammonia per year
- 26 MW Electrolysis capacity
- 200 million USD investment
- 2025 expected year for operation start

**Industrial Plant**
- 700,000 Tonnes green ammonia per year
- 2.0 GW Electrolysis capacity
- 2,000 million USD investment
- 2030 expected year for operation start

**OFFTAKE**
ENGIE has a strategic commercial partnership with ENAEX, which will utilize 350,000 tonnes of ammonia per year for its ammonium nitrate Prillex plant, replacing the current grey ammonia import.

Remaining production will be commercialized in local markets for mining applications and fertilizer production, as well as exported to international offtakers.

**LOCATION**
Antofagasta Region

Exportation

Chile

HyEx PROJECT Green Hydrogen Project Sheet
The ATACAMA HYDROGEN HUB project aims to build a large-scale electrolysis facility with export potential in the northern Antofagasta Region.

**PRODUCTION**
Solar energy is used to power an electrolysis plant, which uses desalinated water to obtain oxygen and hydrogen. The pilot involves an electrolysis facility and a dedicated off-grid solar PV plant to supply a hydrogen powered freight train. Industrial phase contemplates large scale hydrogen production. It is being considered to include the production of ammonia and/or the liquefaction of hydrogen.

**PROJECT OWNER AND PARTNERS**

**PROJECT OWNER**

**PARTNER COMPANIES**

**HUMBOLDT HIDROGENO VERDE (H2V)** is a company created by Chilean entrepreneurs for the development of hydrogen production, transportation and application projects in the north of Chile. It is the developer of the project.

**COMPLEJO PORTUARIO MEJILLONES (CPM)**, subsidiary of Codelco, Chile's national copper corporation, is a port located in the Antofagasta Region. It will provide infrastructure for the project.

**OFFTAKE**
The pilot considers the adaptation of an existing train engine to be powered by hydrogen fuel cells. Negotiations with train operators that provide transport to mining facilities within the region are underway.

The industrial phase considers a large scale hydrogen production and aims to foster efficient supply chains such as shared gas pipelines in collaboration with other players to enable large scale exportation.

**STATUS**
The first phase is in pre-feasibility and conceptual engineering stage. It will request approval from the Environmental Assessment Service during 2021.

**PROJECTIONS**

<table>
<thead>
<tr>
<th>Year</th>
<th>Pilot</th>
<th>Industrial Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>2022</td>
<td>550 ton green hydrogen per year (metric tons)</td>
<td>110 kton green hydrogen per year (metric tons)</td>
</tr>
<tr>
<td>2030</td>
<td>10 MW electrolysis capacity</td>
<td>gas pipeline in collaboration with players</td>
</tr>
</tbody>
</table>

**LOCATION**

**Exportation**

**Atacama Hydrogen Hub**

AtacamaHydrogenHub.com
Leveraging their expertise in power generation and hydrogen technologies, Aker and Mainstream have joined forces to develop a large-scale green ammonia project in Chile.

**PRODUCTION**

Using renewable energy and water from a desalination plant, the project will produce green hydrogen through an electrolysis process, which combined with nitrogen captured from the air will be used to produce green ammonia.

**PROJECT OWNER AND PARTNERS**

**PROJECT OWNER**

AKER Clean Hydrogen (ACH) and MAINSTREAM Renewable Power (MRP) are subsidiaries of AKER Horizons, a company dedicated to incubating and developing companies that solve fundamental challenges to sustainable existence.

**PARTNER COMPANIES**

ACH is a developer and operator of clean hydrogen production at industrial scale. With a proven execution model and unique end-to-end asset integration and optimization capabilities.

MRP is one of the renewable mayor in Chile and has a worldwide pipeline of 12,1GW of wind and solar energy, with over 1,4 GW under construction and 1,1 GW in operation.

**OFFTAKE**

AKER Clean Hydrogen has signed an MoU with its undisclosed investment grade partner.

**STATUS**

Studies are being executed to define the right set up for the desalination and production plants. Target markets are being assessed.

**FINAL PHASE PROJECTIONS**

- **3,000 MW** Renewable energy
- **1 million NH₃** Tons of green ammonia per year
- **180,000 H₂** Tons of green hydrogen per year to be used for green ammonia production

**LOCATION**

Chile

**HOW IT WORKS**

Wind energy + Solar energy + Energy from the grid + Desal. water → Green hydrogen + Nitrogen captured from the air → Green ammonia → Applications

**PRODUCTION TO AMMONIA**

**ACH – MRP PROJECT**

**PRODUCTION**

**PROJECT OWNER AND PARTNERS**

**PROJECT OWNER**

**PARTNER COMPANIES**

**OFFTAKE**

**STATUS**

**FINAL PHASE PROJECTIONS**

**LOCATION**

North of Chile

Exportation
HUACHIPATO steel mill (CAP Acero) is part of the integrated iron and steel CAP Group and is the main steel producer in Chile. The company is planning to reduce CO2 emissions from its steel production processes developing technology that allows the incorporation of green hydrogen along its value chain.

**PRODUCTION**

Production of green hydrogen in the south-central zone of Chile for three purposes. Blending into CAP’s blast furnaces to reduce consumption of coke and eventually replace it entirely. Use of hydrogen for direct reduction of pellets (DRI) and green steel production. Finally, hydrogen will be used to decarbonize transport – trucks and rail in its supply chain. Whether the green hydrogen will be produced with off-grid renewable plants or with green power from the grid is still under study.

**PROJECT OWNER AND PARTNERS**

CAP and Paul Wurth, an SMS Group company, signed a Technological Cooperation Agreement (March 2021), to explore the feasibility of reconverting CAP’s operations to produce green steel, and intensified their cooperation with a new agreement (July 2021).

**TECHNOLOGY**

Production of Direct Reduced Iron (DRI) through green hydrogen has the potential to dramatically reduce CO2 emissions in the steelmaking industry. Several pilots are under planning in Europe. A 100% green hydrogen steel pilot plant is even set to begin operations in Sweden by 2024.
CWP Global is developing the “H1 Magallanes” project in Chile with the assistance of its regional company H1 America with the target to build a world-scale green hydrogen and ammonia production facility. [https://www.cwp.global/](https://www.cwp.global/)

**PROJECT CONCEPT**

The project will consist of upstream wind power generation, and downstream green hydrogen & green ammonia production. Ancillary systems will be installed for water desalination, intelligent hydrogen storage, back-up power, ammonia storage and export facilities. The aim is to construct a world-scale ammonia synthesis train which will enable economies of scale and competitive cost.

**PROJECT OWNER / DEVELOPER**

CWP has 15 years of experience from large-scale renewable power generation projects with a successful track record of over $3 US bn of financed assets. CWP Global is part of the Green Hydrogen Catapult initiative.

CWP Global is one of the main shareholders in the 26 GW Asian Renewable Energy Hub project in Australia. This project is one of the most advanced PtX sites in the world in terms of development and permitting - it has received “Major Project Status” recognition from the government and environmental approval for the first phase.

**OFFTAKE**

CWP Global and its Group team have decades of experience in global commodity trading and are using this know-how to structure long-term bankable ammonia off-take agreements with various partners around the world.

**PHASE ONE PRODUCTION CAPACITY**

- Wind energy installed capacity: 2,200 MW
- Tonnes green ammonia per year: 1,000,000
- Tonnes of green hydrogen per year: 170,000

This first phase is expected to be expanded in tandem with global market growth.

**LOCATION**

- **GLOBAL EXPORT MARKETS**: Magallanes
G NL Quintero, the largest LNG regasification terminal in Chile located in the Quintero bay, aims to take advantage of its proximity to industrial areas with high energy demand and grey hydrogen consumption to produce green hydrogen for the domestic market.

PRODUCTION
Production of green hydrogen in the central zone of Chile, even though facing higher energy prices, could be competitive due to closeness to potential offtakers. This could make hydrogen a competitive alternative to replace fossil fuel consumption and local demand for grey hydrogen, reducing emissions in several industries.

Whether the energy supply will be off-grid or with green power from the grid is still under study.

PROJECT OWNER

GNL Quintero presents strategic advantages such as experience in pipe and on road gas transport and access to gas grids, transmission lines and port infrastructure.

STATUS
A prefeasibility study and conceptual engineering for the pilot phase were carried out. The company is currently exploring potential offtake agreements.

GNL Quintero

PROJECTIONS
Replacing ~1% of the whole hub’s energy needs

Tonnes of green hydrogen per year

OFFTAKERS IN THE HUB

*Their participation in the project is under negotiation.
The San Pedro de Atacama project has the ambitious goal of incorporating green hydrogen and renewable energy into existing fossil fuel generation systems in isolated areas such as the one located in San Pedro de Atacama in the north of Chile, with the highest radiation levels in the world.

**PRODUCTION**

The project aims to modify the existing isolated power system operated by "Cooperativa Eléctrica de San Pedro de Atacama (CESPA)”, to incorporate solar photovoltaic generation, battery storage, hydrogen technologies to provide a high-renewable share power supply to the cultural and tourist hotspot of San Pedro de Atacama.

**PROJECT OWNER**

**PROJECT OWNER**

Chile

**KEY POTENTIAL PARTNER**

CESPA

**CUMMINS** is a leading company that provides power solutions, working with diesel, natural gas, biogas, battery and hydrogen (production and fuel cells). It is the project owner and developer.

**HOW IT WORKS**

**STATUS**

The project has completed a pre-feasibility study, where the configuration of the technology mix was optimized with promising results.

The study was carried out by HINICIO, a strategic consulting firm focused on sustainable energy, transportation, and hydrogen.

**2022-2023** expected year operation start

**PROJECT DETAILS**

- **Hydrogen production**
- **Hydrogen storage**
- **Fuel cell**
- **LiFePo Battery**
- **Diesel**
- **LPG**
- **Power for San Pedro de Atacama**

**OFFTAKE**

The clients and beneficiaries would be the residents and visitors of the community of San Pedro de Atacama, who would enjoy a cleaner supply of 24/7 electricity.

The generator and energy distributor would be CESPA, the local utility for the isolated grid.

**LOCATION**

Antofagasta Region

**POWER TO POWER**

**SAN PEDRO DE ATACAMA PROJECT**

Antofagasta Region

- **2022-2023** expected year operation start

**Tonne green hydrogen per year**

143

**2.2 MW**

Electrolyzer

**500 kg**

Hydrogen storage

**600 kW**

Fuel cell

**1.3 MW**

Diesel engines

**4.2 MW**

Solar PV plant

**2.6 MW**

LiFePo Battery

**$10 million**

USD investment
The HOASIS Project, in the Antofagasta region, promotes hydrogen as a solution that contributes to energy self-sufficiency and supports local development based on a circular economy model.

**PRODUCTION**
Large-scale production of green hydrogen and oxygen to produce fertilizers, which will be used in reforestation, precision agriculture, waste recovery and creation of synergies with local industries.

HOASIS also contemplates the construction of 2,000 Ha of greenhouses to produce local crops and the reforestation of the area from the planting of 100 Ha of tree crops.

**PROJECT OWNER AND PARTNERS**

**PROJECT OWNER**

**PARTNER COMPANIES**

TCI GECOMP specializes in renewable energy projects, with more than 1 GW installed in Europe and Latin America. Currently, TCI is expanding its business to develop projects and services related to green hydrogen in Europe, Africa and Latin America.

**HOW IT WORKS**

**STATUS**
The project is undergoing a pre-feasibility analysis. Lands are being evaluated for acquisition, and the project is in the consortium formation phase.

**PROJECTS**

- 250,000 Tonnes of green ammonia per year
- 102,000 Tonnes of green hydrogen per year
- 140,200 Agricultural products per year

**OFFTAKE**
The project considers the formation of a consortium during 2021 and it has identified potential offtakers in the mining and chemical industries, plus nearby utilities running on fossil fuels.

HOASIS also considers the production of fertilizers and agricultural products, to support the development of a local ecosystem with positive impacts on the implementation zone.

**LOCATION**

[Map showing Antofagasta region]
The project seeks to develop an ecosystem for zero-emission commuting of mining workers from the cities to the mine sites in the Andes Mountains.

**PRODUCTION**

Solar power will be used to produce green hydrogen by electrolysis. This hydrogen will be stored in a hydrogen refueling station to supply buses for the commute of mining workers.

The project aims to deploy Fuel Cell Electric Buses that can meet the desert conditions such as altitude, extreme temperatures, among others.

**PROJECT OWNER AND PARTNERS**

**PROJECT OWNER**

AirLiquide

ATAMOSTEC

**PARTNER COMPANIES**

AIRLIQUIDE: Co-developer and technology provider. Hydrogen production and refueling station infrastructure.


ANTOFAGASTA UNIVERSITY: Co-developer. Technical local capacity building.

ATAMOSTEC: Solar energy laboratory. Co-developer. Integration of energy supply and hydrogen production.

**HOW IT WORKS**

- **Solar energy** + **Desal. water** → **Green hydrogen** → **Hydrogen Storage** → **Refueling station** → **Fuel Cell Electric Buses**

**STATUS**

Pilot project is under development working on a pre-feasibility study.

- **10 million USD**
  - Est. investment of the pilot phase
  - **2022**
  - expected start of operations

**PROJECTIONS**

- **Pilot**
  - 48 Tonnes of green hydrogen per year
  - 10 million USD investment
  - **2023**
  - 20 Buses under operation

- **Second Phase**
  - **1.2 MW**
  - Solar energy
  - **2025**
  - 50 Buses under operation

- **Third Phase**
  - **1-3 Buses under operation**
  - **2023**
  - **2025**

**LAND AND RESOURCE**

The 1.2 MW solar plant called Lalcktur belongs to CDEA.

It was constructed for research purposes and is already in operation.

**OFFTAKE**

The H2 SOLAR project is looking for a vehicle supplier partner to develop the pilot and for mining companies that would be willing to decarbonize their Scope 3 emissions.

**LOCATION**

The location of the project is in the Antofagasta Region.
SELKNAM will use the strong winds in Tierra del Fuego island, with over 60% measured capacity factor, to produce green ammonia for export.

**PRODUCTION**

Wind energy is used to power an electrolysis plant to obtain oxygen and hydrogen. Hydrogen will then be combined with nitrogen captured from the air through a Haber-Bosch process, to produce green ammonia.

The project is located on Tierra del Fuego Island and contemplates reusing ENAP existing facilities such as pipelines and the Clarencia port for export.

**PROJECT OWNER AND PARTNERS**

**PROJECT OWNER**

Sociedad de Inversiones Albatros Ltda.

**PARTNER COMPANIES**

ALBATROS has been involved in the real estate market in the Magallanes region for over 30 years and is committed to the promotion of renewable energies and energy efficiency. The company holds possession of over 20,000 hectares of land in Tierra del Fuego.

ALFANAR is engaged in manufacturing a wide range of low, medium and high voltage electrical products, EPC solutions for conventional and renewable power plants worldwide and engineering services. It will contribute as developer, investor and EPC contractor.

**ENAP** is the Chilean National Oil company. Their participation in the project is under negotiation.

**HOW IT WORKS**

Wind energy + Well water + Desal. water → Green hydrogen

Green nitrogen captured from the air → Green ammonia → Applications

**STATUS**

The project counts with conceptual engineering and prefeasibility study developed by Engie Impact.

2 billion USD total investment of the project

2026 year operation start

**PROJECTIONS**

1,150 MW Wind energy

500,000 NH3 Tonnes of green ammonia per year

85,000 H2 Tonnes of green hydrogen per year for ammonia production

**LAND AND RESOURCE**

20,000 hectares of land are in control of the company

Over 60% wind capacity factor has been obtained by 3 measuring towers operating for over one year

**OFFTAKE**

The SELKNAM project is looking out for partners to establish offtake agreements.

**LOCATION**

Magallanes Region

Chile
The HYDRA project aims to decarbonize the mining sector by developing fuel cell + battery power trains to retrofit mining haul trucks and replacing diesel consumption.

**THE PROJECT**

The Hydra project considers replacing the internal combustion engine of large capacity mining haul trucks (> 200 tonnes) with a hybrid system of hydrogen fuel cells and batteries. This will replace about 3,000 liters of diesel consumption per truck per day, equivalent to a daily hydrogen consumption of up to 1 metric ton.

**PROJECT OWNER AND PARTNERS**

**PROJECT OWNER**

ENGIE is a global reference company in low-carbon energy and services, having a Business Unit dedicated to renewable hydrogen since 2018. The current portfolio of renewable H₂ projects under development and in construction is over 30 projects in 10 countries over four continents. ENGIE is also developing a mining project in South Africa (Rhyno Project).

MINING3 is a mining research organization led by the global mining industry to develop and deliver transformational technology to improve the mining industry’s productivity, sustainability, and safety.

**PARTNER COMPANIES**

A consortium is being set up with partners along the value chain.

**OFFTAKE**

A key pillar for the development of the HYDRA Project is the early engagement of mining companies and OEMs, as they will be the end users and providers, respectively.

This project has received a subsidy of 330,000 USD from the Chilean Economic Development Agency, CORFO, for the development of Phase 2.

**LOCATION**

Antofagasta Region, Chile

**PROJECT IMPLEMENTATION**

**Phase 1**

2018-2019
Business case validation

**Phase 2**

2020-2021
Prefeasibility study
Fuel cell power train prototype development
Prototype laboratory test
18 months duration
2 million USD budget

**Phase 3**

Minimum Viable Product of H₂ supply chain and H₂ power system
Proof of concept within a mining vehicle
18-24 months duration
40 million USD budget

**Phase 4**

Scale up of H₂ in mining
Industrialization with OEM’s Trigger H₂ export

**HOW IT WORKS**

Solar energy + Energy from the grid (green PPA) + Desal. water → Green hydrogen → Refueling station → Mining haul trucks

**STATUS**

The project is on its second phase of development. Prefeasibility study is undergoing.

Design and construction of a modular fuel cell and battery powertrain prototype (100-200 kW) to assess performance under mining conditions is expected to be ready during 2021.

**GREEN HYDROGEN PROJECT SHEET**

This project has received a subsidy of 330,000 USD from the Chilean Economic Development Agency, CORFO, for the development of Phase 2.
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ANNEX
Chile at a glance

**GDP (PPP) p/capita 2020**
USD 23,366

(#2 in LATAM)

**Exports 2020**
USD 71 bn

**Imports 2020**
USD 54 bn

**GDP 2020 (E)**
USD 253 bn

**Inflation 2020**
3.1%
(2010-2019: 3.1% average)

**Corp. tax rate**
27% (35% foreign)

**Population 2019**
19 million

**Exports 2020**
USD 71 bn

**Imports 2020**
USD 54 bn

**GDP 2020 (E)**
USD 253 bn

**Inflation 2020**
3.1%
(2010-2019: 3.1% average)

**Corp. tax rate**
27% (35% foreign)

**Population 2019**
19 million

**FDI Flow**
USD 17 bn
(annual average 2010-2019)

**FDI stock**
USD 280 bn
A country with an open economy

Chile has free trade/tax agreements with over 80% of the world’s GDP, more than any country on the planet

**Equal Treatment**
Foreign companies based in Chile enjoy the same rights and obligations as Chilean companies in the country

**Free Flow of capital & profits**
National legislation allows the entry and repatriation of capital without costs

**Pro-business environment**
Simple tax structure. Ease to set up companies

Source: OECD, World Bank, WTO
Chile has experienced sustained economic growth

**GDP (PPP) per capita**

**GDP (PPP) per capita in select countries**

Source: IMF
As well as consistent reduction in poverty and income inequality

Poverty rate & Gini Index

Changes in Gini Index & poverty rate across economies

Source: UN-ECLAC, World Bank, OECD, Ministry of Finance
Economic progress and cultural transformations have reshaped Chile

**Middle class has expanded (% of total population)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Middle class</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>34.8%</td>
</tr>
<tr>
<td>2006</td>
<td>39.1%</td>
</tr>
<tr>
<td>2009</td>
<td>43.2%</td>
</tr>
<tr>
<td>2011</td>
<td>45.7%</td>
</tr>
<tr>
<td>2013</td>
<td>48.9%</td>
</tr>
<tr>
<td>2015</td>
<td>56.6%</td>
</tr>
<tr>
<td>2017</td>
<td>61.0%</td>
</tr>
</tbody>
</table>

**Access to higher education has increased (% of total population)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Access to higher education</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>5%</td>
</tr>
<tr>
<td>2006</td>
<td>15.3%</td>
</tr>
<tr>
<td>2017</td>
<td>45.2%</td>
</tr>
</tbody>
</table>

**Progress has attracted immigration**

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of immigrants</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>154,643</td>
</tr>
<tr>
<td>2009</td>
<td>208,722</td>
</tr>
<tr>
<td>2011</td>
<td>243,978</td>
</tr>
<tr>
<td>2013</td>
<td>354,581</td>
</tr>
<tr>
<td>2015</td>
<td>465,319</td>
</tr>
<tr>
<td>2017</td>
<td>784,685</td>
</tr>
<tr>
<td>2018</td>
<td>1,251,225</td>
</tr>
</tbody>
</table>

**Women have increased participation in the workforce (% of workforce)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Women participation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>0.9%</td>
</tr>
<tr>
<td>2009</td>
<td>1.2%</td>
</tr>
<tr>
<td>2011</td>
<td>1.4%</td>
</tr>
<tr>
<td>2013</td>
<td>2.0%</td>
</tr>
<tr>
<td>2015</td>
<td>2.6%</td>
</tr>
<tr>
<td>2017</td>
<td>4.3%</td>
</tr>
<tr>
<td>2018</td>
<td>6.7%</td>
</tr>
</tbody>
</table>

**Source:** LyD (2019), Casen (2017), Census (2017), INE, Dirección del Trabajo
Covid-19 pandemic and economic recovery
The Government responded with one of the largest fiscal stimulus packages globally

Covid-19 relief public spending (% of GDP)

Source: Ministry of Finance, IMF
As well as a timely mass vaccination campaign

Covid-19 vaccination in selected countries (% of total population, at least one dose)

Source: Our World in Data

58% by June 5
These efforts will foster a rapid economic recovery

“The economic activity recovery has been surprising in the first months of 2021, reflecting strong macroeconomic momentum and a better adaptation of the economy to sanitary restrictions” (Central Bank, June 2021)

Source: Chilean Central Bank, INE
Chile’s Green Hydrogen Strategy and investment opportunities