2023

National Strategy for the Development of the **Hydrogen** Economy

Argentina
Presidency

Secretariat for
Strategic Affairs

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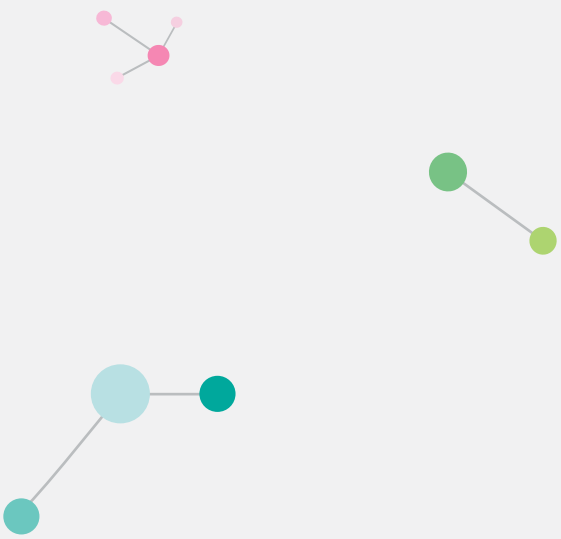
Acronyms

ADIMRA	Argentine Metal Workers' Association
AHK	Argentine-German Chamber of Industry and Commerce
IBD	Inter-American Development Bank
CAF	Development Bank of Latin America and the Caribbean
CAPEX	Capital expenditures
CAPMIN	Argentine Chamber of Mining Suppliers
CCS	Carbon capture and storage
CCUS	Carbon capture, utilisation and storage
CEARE	Centre for Studies on Energy Regulation Activities
CEMA	Business Chamber of Environment
CFI	Federal Investment Council
CH30H	Methanol
CIPIBIC	Chamber of Capital Goods Projects and Engineering Industrialists
CITEC	Provincial Science, Technology and Innovation Institute of Santa Cruz
UNFCCC	United Nations Framework Convention on Climate Change
CNEA	National Atomic Energy Commission
CO2	Carbon dioxide
CONICET	National Scientific and Technical Research Council
S&T	Science and technology
SEA	Strategic Environmental Assessment
RE	Renewable Energy
ENARGAS	National Gas Regulatory Agency
ENH	National Hydrogen Strategy
EPSE	Provincial Energy State Society
GHG	Greenhouse gas
GIZ	German Agency for International Cooperation (Deutsche Gesellschaft für Internationale Zusammenarbeit)
GW	Gigawatt
H2	Hydrogen
I&D	Innovation and development
IEA	International Energy Agency

Acronyms

FDI	Foreign Direct Investment
INGEI	National Inventory of Greenhouse Gases
INTI	National Institute of Industrial Technology
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency
IRAM	Argentine Institute of Standardization and Certification
LCOE	Levelized Cost of Energy
LCOH	Levelized Cost of Hydrogen
MERCOSUR	Southern Common Market
MINCyT	Ministry of Science, Technology and Innovation
Mt	Million tons
NH3	Ammonia
NOA	Northwest Argentina
NDC	Nationally Determined Contributions
SDGs	Sustainable Development Goals
PEM	Proton Exchange Membrane
SAF	Sustainable Aviation Fuels
SMR	Small Modular Reactor
SNCT	National Science and Technology System
TRL	Technology Readiness Level
Y-TEC	YPF-Technology



Developing strategic sectors requires active public policies

By Mercedes Marcó del Pont*

The global climate and ecological crisis is the driving force of a technological and productive revolution that has been called energy transition. In the face of global warming, many countries assumed ambitious decarbonization commitments, which were accelerated by the energy crisis and tensions in supply chains caused by the pandemic and the war in Ukraine. Faced with this scenario, the world's main industrial economies are promoting public policies around new energies to achieve a triple objective: meet the greenhouse gas reduction goals, guarantee energy security and promote technological and productive development around transition industries.

However, in many countries the needs for clean energy exceed their generation possibilities, due to the quality of renewable resources and the size of their territories. Low-emission hydrogen represents a peculiar opportunity for decarbonization, because it will allow the power of wind and sun from places like Patagonia and northern Argentina to contribute to reducing emissions from different parts of the planet.

The excellent conditions for the production of low-emission hydrogen that exist in Argentina, mainly due to the quality of wind, solar, gas and biomass resources, make our country an attractive destination for investments. No less important is the opportunity that opens up for pink hydrogen, taking advantage of the Argentine nuclear tradition and especially the CAREM project, a small modular reactor that can be applied to the production of hydrogen. The richness and diversity of our resources allow us to design a multicolor strategy.

The hydrogen economy is, however, much more than the development of natural resources. Hydrogen is an industrial product and an energy vector. And, therefore, Argentine capabilities and knowledge are a key element of competitive advantages for successful insertion into this new market. Hand in hand with skills in chemistry, petrochemistry, metalworking, geology, metallurgy and steel, it is possible to foresee that the new hydrogen economy will be an opportunity for investments aimed at export and also for the construction of a dense industrial network that will allow the creation of quality employment and contribute to our industry taking the path towards decarbonization, gaining competitiveness in global markets.

With the deployment of this economy, new industrial poles will emerge aimed at the production of hydrogen and its derivatives, such as ammonia, methanol and even green steel. New sectors will also emerge, such as critical equipment in this value chain: electrolyzers, and capital goods linked to the generation of renewable energy.

To achieve these results, public policies are required. The global energy transition scenario opens up an immense opportunity, but it is necessary to twist the natural course that limits the participation of countries with abundance and quality of resources to the role of mere exporters of raw materials. We must know how to take advantage of the country's industrial and technological capabilities, which are our competitive differential.

This is the horizon pursued by the National Strategy for the Development of the Hydrogen Economy, which recognizes Argentina's opportunities to contribute to the global energy transition and to leverage its industrial, technological and territorial development.

September, 2023

*** Secretary of Strategic Affairs, Presidency**

Argentina has the conditions to promote the entire value chain of the hydrogen economy

By Flavia Royón*

The Energy Transition Plan for 2030 drawn up by Argentina was prepared with a view to social inclusion and strengthening the country's development capacities. From this perspective, the energy transition will occur through a progressive path of acquisition of techno-productive skills leveraged mainly on the strategic complementarity of the country's capabilities and resources, within a window of opportunity for Argentina's insertion into dynamic global value chains that can collaborate in the resolution of climatic, social, economic and dependency problems on the external sector.

The strategic guidelines for the energy transition in Argentina specifically contemplate low-emission hydrogen. The geographical, industrial and scientific peculiarities of Argentina position it in a privileged place when it comes to facing the industrialization of hydrogen and becoming an international supplier of this new source of energy.

And, in this sense, Argentina has great potential for the generation of green, pink and blue hydrogen. The first is due to the optimal conditions to generate renewable energies such as solar, wind and hydroelectric, with the country being recognized globally as one of the potential suppliers of hydrogen. Pink hydrogen due to the capabilities acquired in terms of energy that does not produce emissions like nuclear energy.

In the case of blue hydrogen, it has the second most important unconventional gas reservoir in the world. In particular, Argentina has the possibility of leveraging the production of blue hydrogen from its vast gas resources, converting the current production of gray hydrogen towards the production of blue hydrogen, with carbon dioxide capture and storage and measurement of emissions.

Argentine competencies in the gas and oil industry position the country in a privileged place for the development of technologies for the storage and use of carbon dioxide, key to the energy transition.

There is no doubt that the country is in favorable conditions to promote the hydrogen economy and its entire value chain: Argentina, with a consolidated industry, capable of developing electrolyzers and other elements that the hydrogen industry requires and, in Patagonia, there are deep water ports and conditions conducive to activity.

However, to encourage these intensive capital investments, a promotional and legal certainty framework is necessary. For this reason, at the request of the Ministry of Energy, the Executive Branch submitted to Congress in 2023 the bill for the Promotion of Hydrogen low in carbon emissions and other greenhouse gases, which defines a regulatory framework of fiscal and regulatory stability for the development of the hydrogen economy and its vectors, seeking to guarantee the

necessary investment conditions and promote the diversification of the industrial and technological framework of Argentina.

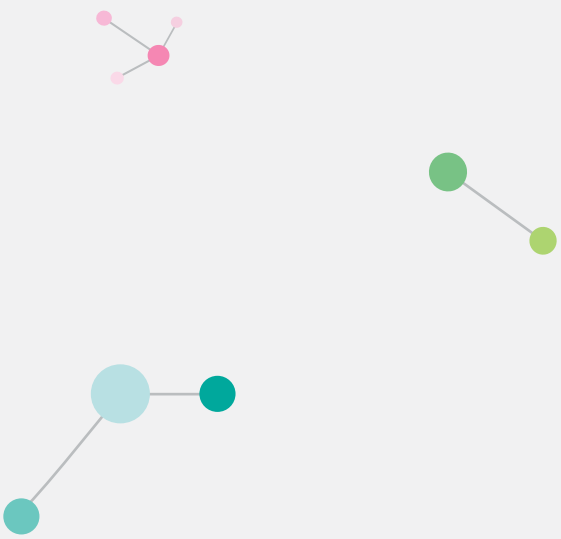
The regulatory project, together with the National Hydrogen Strategy, are the result of hard interdisciplinary work by different bodies of the national and provincial governments, and the close collaboration of representatives of academia, science and industry. But, above all, it is a roadmap drawn up with a federal perspective that contemplates public-private coordination and the strategic dialogue of associated industries together with the scientific-technological sector, in order to develop the hydrogen economy in line with the great potential of the country.

These actions are complemented by the sustainability framework that seeks to be developed through the Strategic Environmental Assessment. With this, it is proposed that the deployment of this new activity is consistent with the climate, environmental and respect for communities objectives.

The progress made positions Argentina among the few countries that have a roadmap that reflects the policy, a hydrogen economy bill that is aimed at providing predictability in an incipient sector; and a sustainability framework for harmonious development with job creation and national industry.

September 2023

***Secretary of Energy at the Ministry of Economy**



Hydrogen: An Opportunity for Development

Global warming and the proliferation of its adverse impacts have placed the climate crisis at the centre of public agendas around the world. The Paris Agreement signed in 2015 and the commitments made by countries in their Nationally Determined Contributions (NDCs) bear witness to this and to society's interest in creating a new paradigm based on Sustainable Development Goals (SDGs). The COVID-19 pandemic, the pressure exerted on supply chains, and the energy crisis caused by the war in Ukraine resulted in a more complex scenario and **hastened the process of transition towards a cleaner energy matrix,** with fossil fuels playing an increasingly minor role.

Since then, **the world's leading economies have implemented industrial policies aimed at ensuring environmental sustainability, energy security, and the resilience of value chains.** Some examples of these policies are the US Inflation Reduction Act and the US Infrastructure Investment and Jobs Act, aimed at advancing energy transition and fostering industrialization in strategic technologies; or the European Union's Green Deal and its Industrial Plan, which promote enhanced industrial competitiveness and the transition towards carbon neutrality.

In response to the challenges posed by the energy transition and geopolitical tensions, the world's leading economies have implemented industrial policies aimed at ensuring environmental sustainability, energy security, and the resilience of value chains.

Argentina has shown a firm commitment to environmental protection and the fight against climate change. In addition, it aims for this transition to strengthen its industrial competitiveness. Given the wealth and variety of its natural resources alongside its industrial and technological capacities, we anticipate that Argentina will play a key role in the decarbonisation of economic activities, not only within its own territory but also in other regions.In this context, **Argentina has embarked on a public policy development process of which sustainable development** is one of the central pillars. In its second Nationally Determined Contribution, published in 2020 along with its 2021 updated version, Argentina committed not to exceed a net emission of 349 million tons (Mt) of carbon dioxide equivalent by 2030. The Long-Term low-emissions Resilient Development Strategy, developed by the Ministry of Environment and Sustainable Development, acknowledges the need to make every effort to achieve GHG emissions neutrality by 2050.

Furthermore, various government bodies have developed guidelines and strategic plans addressing these challenges while also dealing with the objective of building technology and production capacities, such as the National Climate Change Adaptation and Mitigation Plan; the 2030 Energy Transition Plan and its 2050 Guidelines; the National Sustainable Transport Plan; the 2030 Productive Argentina Plan; and the 2030 Science, Technology and Innovation Plan. The energy transition guidelines prepared by the Argentine Secretariat for Energy provide that **this transition must be just, affordable and sustainable, and that it must simultaneously address decarbonisation and productive development goals from a federal perspective.**

> Given the wealth and variety of its natural resources alongside its industrial and technological capacities, we anticipate that Argentina will play a key role in the decarbonisation of economic activities, not only within its own territory but also in other regions.

In line with international experience, the hydrogen value chain is key for coordinating public policy towards a just energy transition.

For Argentina, **promoting the hydrogen value chain has consequences beyond a reduction in emissions, as it offers an opportunity for reindustrialization.** Hydrogen is an industrial product the generation of which critically depends on the quality of natural resources. In this regard, **Argentina's competitiveness in this new economy is based on combining natural advantages with built advantages by means of industrial, scientific, and technological capabilities, as well as Argentina's labour.**

Due to this new value chain, Argentina will be able to **increase its exports, decarbonize economic activities, create new high-quality jobs, and strengthen the industrial sector.** This process will especially take place in locations with resources for sustainable and competitive hydrogen production, thereby contributing to a harmonious territorial development.

Public Policies for Advancing the Hydrogen Economy

As part of a process to advance this new sector, the Argentine Executive has placed strategic importance on hydrogen. The first actions, aimed at promoting public-private dialogue, were taken in 2021 and led to the establishment of the **Hydrogen Intersectoral Roundtable** in February 2023. This forum, created within the framework of the Economic and Social Council and **led by the Secretariat for Strategic Affairs of the Argentine Presidency**, has worked on the coordination of efforts between the private sector and various federal and provincial government bodies in order to develop the **National Hydrogen Strategy (ENH).** The outcomes of this process are presented in this document.

On national strategies

National strategies are a public policy instrument that enables an outline of action plans and targets in order to provide certainty regarding the development path of a sector of the economy. As of the completion of this document in August 2023, a total of 21 countries and the European Union had published their strategies for the hydrogen sector. Another 27 countries were working towards that goal, and at least another 34 had initiated discussions about public policies on hydrogen and the role it plays in energy transition.

Around 70 representatives from over 30 public and private organizations participated in the Hydrogen Intersectoral Roundtable, including the governments of the provinces of Buenos Aires, Chubut, Neuquén, Río Negro, Santa Cruz, and Tierra del Fuego, Antarctica and South Atlantic Islands; public organizations and institutions such as ENARGAS, INTI, CNEA, CEARE, and CFI; and mixed-ownership companies such as YPF Tecnología (YTEC), EPSE, and INVAP. As for the private sector, participants included business associations dealing with renewable energy, hydrogen production and consumption, and the manufacturing of capital goods, such as **Consorcio H2Ar and ADIMRA. In addition, other representatives from the private, academic and union sectors participated due to its strong connection with the Economic and Social Council.**

Acknowledging the existing opportunities and the need for an incentive framework to promote this activity, in May 2023, the Argentine Executive introduced the **"Promotion of Hydrogen Produced with a Low Emission of Carbon and Other Greenhouse Gases" bill** in Congress. This bill was drafted by the Secretariat for Energy of the Ministry of Economy together with other entities in the Argentine Executive, such as the Secretariat for Industry and Productive Development, the Ministry of Environment and Sustainable Development, the Ministry of Transport, and the Secretariat for Strategic Affairs of the Argentine Presidency. The governments of the provinces of Río Negro and Tierra del Fuego, Antarctica and South Atlantic Islands were also involved.

This legislative initiative aims to promote low-emissions hydrogen production projects, advance governance in the sector, and encourage productive and technological development across the entire value chain.

Lastly, the Secretariat for Strategic Affairs, in coordination with the Ministry of Environment and Sustainable Development, is conducting a **Strategic Environmental Assessment in order to provide the ENH with a sustainability framework, plan the territorial arrangement of this new activity, and ensure the goals of a just transition.**

A Vision towards a National Hydrogen Strategy

The guiding vision of the National Hydrogen Strategy is based on three pillars. **First, it acknowledges the importance of advancing technological and productive development across the entire value chain, including the production of critical capital goods and the provision of technological services.**

Second, acknowledging the various resources and capacities available in the Argentine territory, **it considers the production of low-emissions hydrogen using different technologies:** renewable sources (green hydrogen), nuclear energy (pink hydrogen), or fossil fuels with carbon capture (blue hydrogen).

Third, it establishes two pillars for advancing the hydrogen economy: the domestic market, which is essential for creating initial conditions, assessing prototypes, and developing national technology; **and export markets,** oriented towards highly competitive large-scale production, thereby leveraging the quality of natural resources and developed capabilities.

> The three pillars guiding the vision of the National Hydrogen Strategy are the promotion of technological and productive development throughout the value chain, the choice of different technologies capacities, and the development of domestic demand and the export market.

The new low-emissions hydrogen economy is still under development. Markets have not yet consolidated, and their full scope remains uncertain. For this reason, the targets and actions outlined in this strategy for the period 2030-2050 may be regularly reviewed as determined by the relevant authority of the regulatory framework, **guided by this shared vision of the Hydrogen Intersectoral Roundtable.**

Main Findings

The main findings of the ENH are the following:

- **By 2050, Argentina's total annual domestic production of low-emissions hydrogen will be at least 5 Mt.** 20% will be allocated to the domestic market, for both decarbonizing current hydrogen applications (steel, petrochemical, and refining industries) and meeting new demands (mainly synthetic fuels). The remaining 80%, i.e. around 4 Mt per year, will be allocated to the international low-emissions energy vector market through exports.

- **In order to meet these production targets, at least 30 GW of electrolysis capacity and 55 GW of renewable electricity generation will need to be installed,** which entails an elevenfold increase in current renewable generation and more than a twofold increase in total electricity generation in Argentina.

- **Hydrogen production will revolve around production hubs,** which will be located based on the quality of resources and proximity to domestic markets and ports for export

- **Connections between these hubs and the network of universities and local technological centres** will be key to the development of new technologies, as well as to early adoption and adaptation to local production conditions.

- Meeting the established objectives will require a **major transformation of infrastructure into critical road corridors and ports.**

- This new activity **will result in the creation of over 80,000 qualified jobs.**

- **Argentina aims to participate in the international hydrogen market, thereby advancing productive development across the entire value chain.**

Participatory process 2021-2023

2021

- Constitution of the **Hydrogen Interministerial Roundtable** within the framework of the Economic and Social Council
- Public-private dialogue meetings: **"Opportunities for Hydrogen in Argentina and Potential Promotion Regime"**
- Forum and document **"Towards a National Hydrogen Strategy 2030"**

2022

- **National Hydrogen Strategy 2030** - Bariloche.
- **Y-TEC meeting** with provincial and national energy secretaries
- **Public-private dialogue** with representatives from the government areas, H2AR Consortium and other relevant stakeholders

2023

- Formalising the **Hydrogen Intersectorial Roundtable** in Argentina.
- **Vision and Foundation** Documents
- Technical Meetings: **Hydrogen Intersectorial Roundtable**
- **National Hydrogen Strategy**

Hydrogen Intersectorial Roundtable

3 Plenary meetings of the Hydrogen Intersectorial Roundtable

+70 participants	**+30** public and private organizations	**+40** meetings (working groups + bilaterals)	**+60** collected questionnaries

Economic and Social Council

Provincial governments

- Buenos Aires
- Chubut
- Neuquén
- Río Negro
- Santa Cruz
- Tierra del Fuego, Antártida e Islas del Atlántico sur

National institutions

- CNEA
- INTI
- ENARGAS

Public companies and institutions

- INVAP
- EPSE
- CEARE
- YTEC
- CFI

Private organisations

- Consorcio H2Ar
- CEMA
- ADIMRA
- CIPIBIC
- AHK Argentina
- Eurocámara Argentina
- CAPMIN
- GIZ
- Other renewable energy companies and hydrogen developers

What is Hydrogen and How is it Produced?

Hydrogen is the first element in the periodic table, the simplest atom of all, and the most abundant element in the universe. However, it is not freely available but is bound to other atoms, forming compounds such as water (H2O) and methane (CH4), among many others.

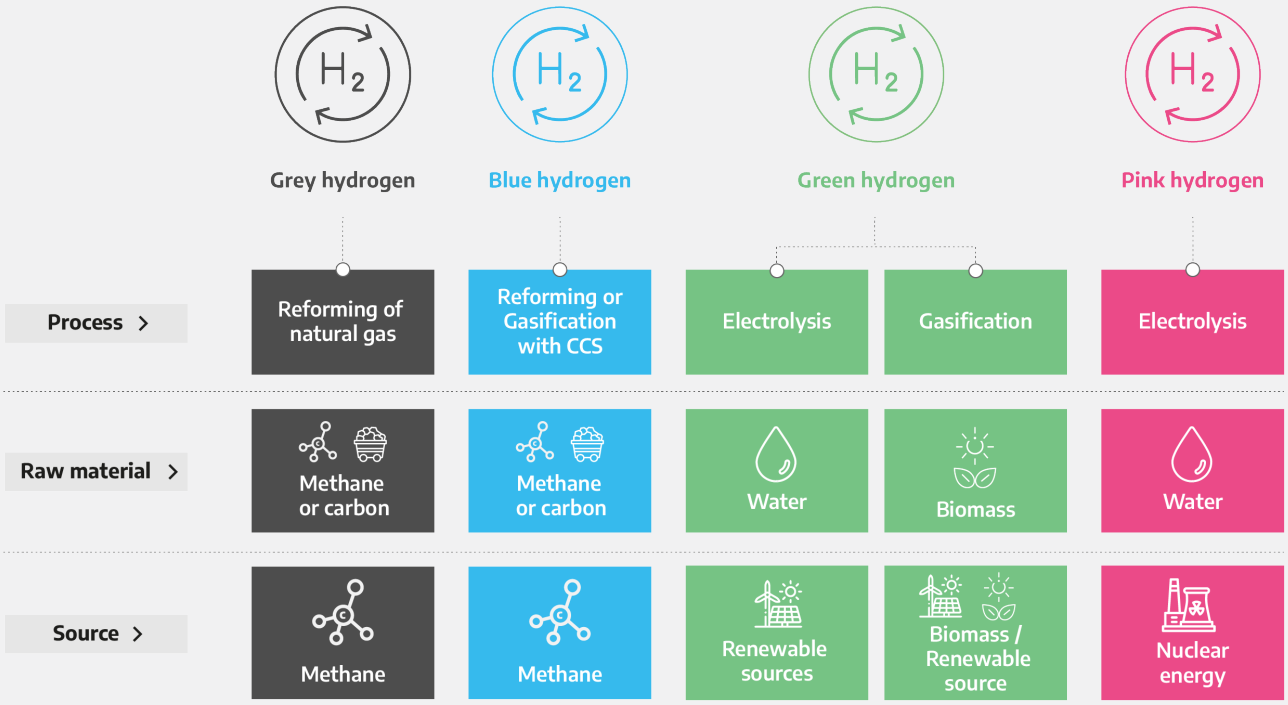
In order to obtain hydrogen molecules (H2), an energy-consuming process is required. Therefore, **hydrogen is considered an energy vector used to store and transport energy, although it is also used as a supply in various industrial processes** such as iron and steel production, hydrocarbon refining, and fertiliser production. Since the use of hydrogen does not produce CO2 emissions, **it can contribute to various decarbonisation goals, in both the energy and production sectors.**

Carbon Capture, Utilisation and Storage

CCUS stands for Carbon Capture, Utilisation and Storage. It is a set of processes which, associated with hydrogen production from fossil sources, reduces emissions, resulting in low-emissions hydrogen. In the cases in which there are no planned uses for the CO2 captured, this technology is called Carbon Capture and Storage (CCS).

Industrial hydrogen is currently obtained from natural gas or other fossil fuels through processes that produce GHG emissions (such as steam reforming of natural gas). However, low-emissions hydrogen is the one obtained through water electrolysis using renewable energy (green hydrogen) or nuclear energy (pink hydrogen); or the one that incorporates CO2 capture, utilisation and storage (CCUS) technologies into existing methods (blue hydrogen). Low-emissions hydrogen reduces up to 100% of the emissions associated with hydrogen production compared to current H2 production processes.

Types of Hydrogen by Process and Energy Source

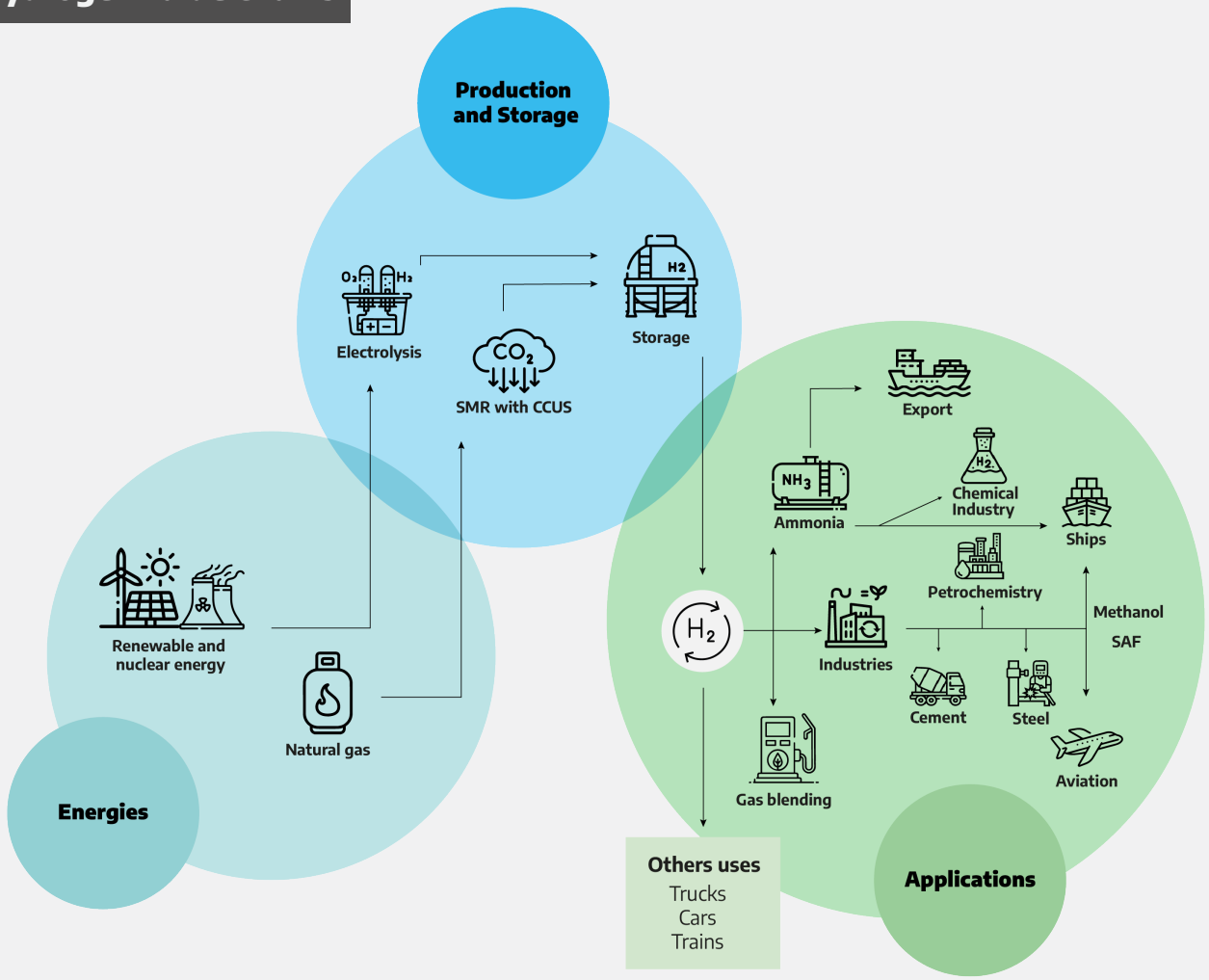


Low-emissions hydrogen can be used as a direct fuel (its combustion produces water vapour) or in other compounds such as methanol or ammonia. Transforming hydrogen into other molecules facilitates it being used as fuel and, especially, its transportation.

Low-emissions Hydrogen Value Chains

Low-emissions hydrogen encompasses several value chains, including in connection with energy generation; the production and storage of hydrogen and any by-products and derivatives, and those related to the uses of hydrogen and its applications.

Hydrogen Value Chains

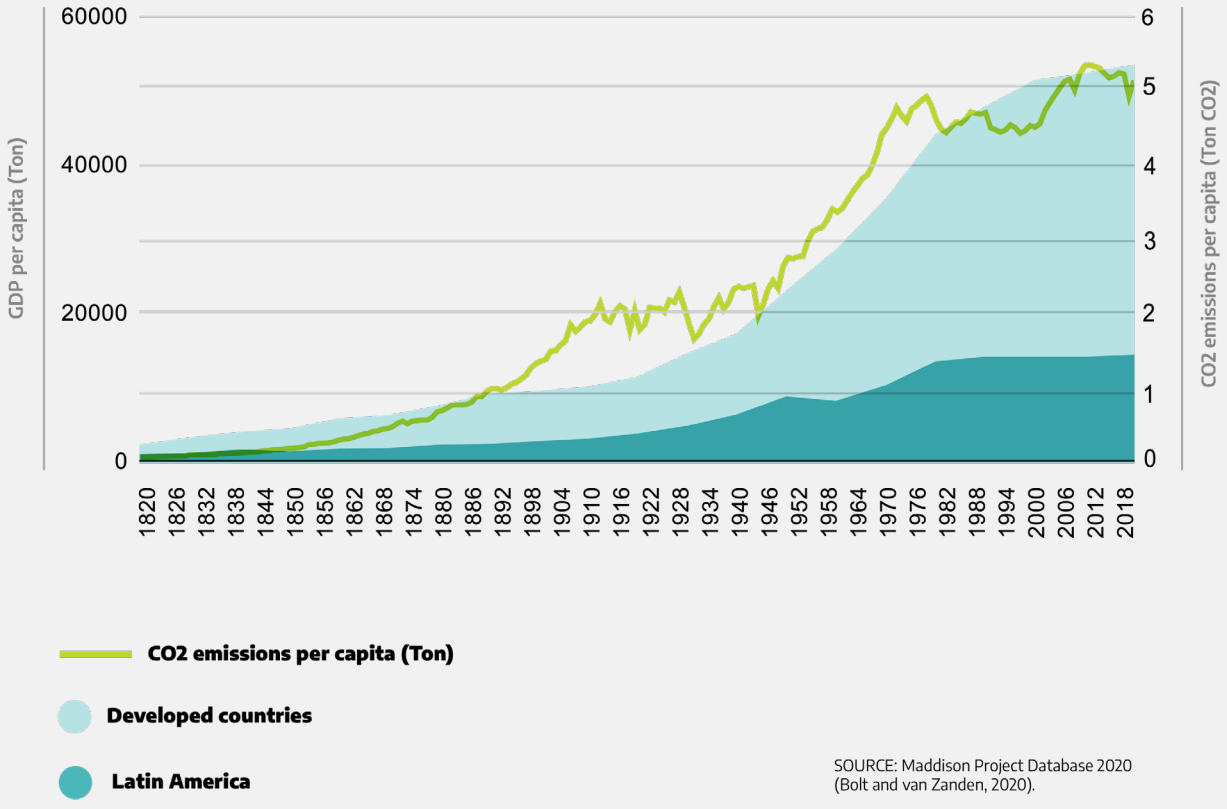


Each of these chains is, in turn, made up of specific segments that require a wide array of technological and industrial capabilities, including (i) the provision of supplies and critical materials; (ii) the production of fixed assets, as well as their parts and pieces; (iii) the construction of infrastructure for transport and storage; (iv) the provision of knowledge-intensive services, ranging from engineering services to research and development; (v) the adjustment of goods and services for the use of low-emissions hydrogen; (vi) the production of hydrogen derivatives, such as synthetic fuels, and (vii) the production of industrial goods using low-emissions hydrogen for access to new markets, including low-emissions steel or fertilisers.

The Role of Hydrogen in the Energy Transition

In modern history, increased per capita income levels and productive transformations have also brought along a significant increase in GHG emissions and environmental degradation. In this context, the challenges that productive development currently faces call for changes in productive structures, goods transport and consumption patterns that are in line with the achievement of the SDGs, the Paris Agreement goals and other environmental goals undertaken by States.

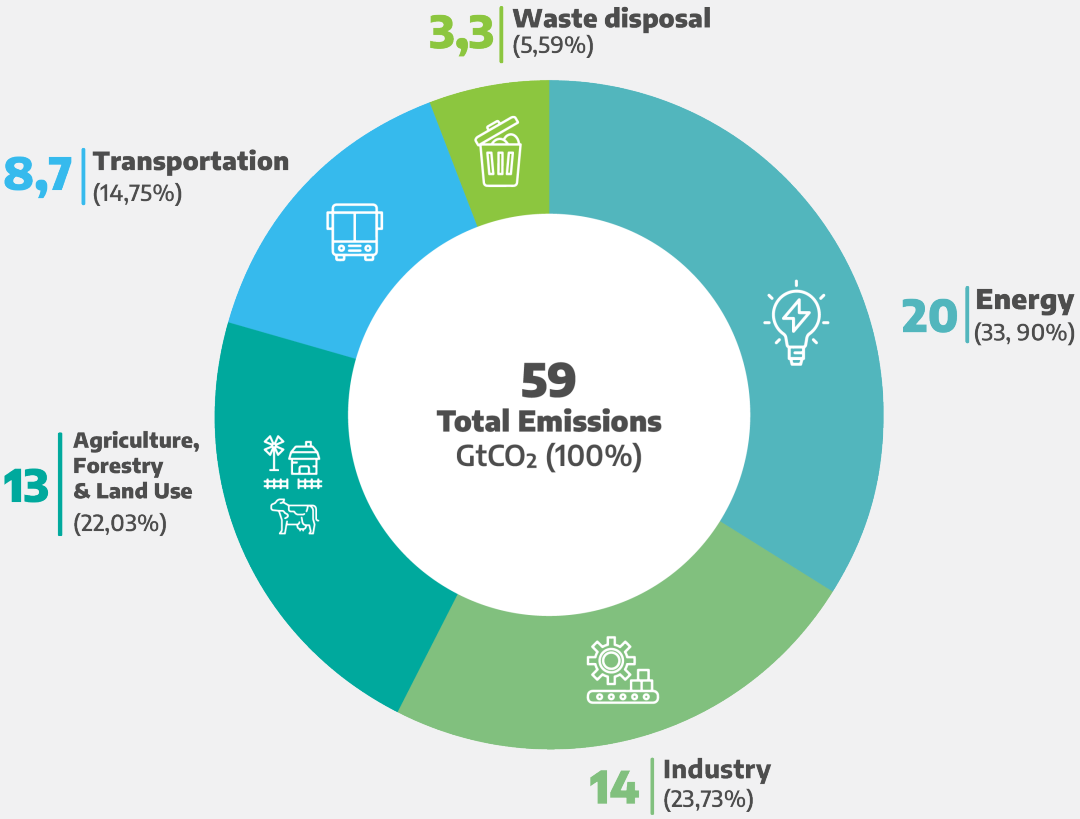
Increase in GDP per capita and CO2 emissions



SOURCE: Maddison Project Database 2020 (Bolt and van Zanden, 2020).

From 1820 to date, GHG emissions per capita have increased over 100 times. Nowadays, among the sectors accounting for the most part of emissions are energy generation, with 33.9% of total emissions; industrial processes, with 23.7% of total emissions, and agriculture, livestock production, forestry and other land uses, accounting for 22% of emissions, as per the data published by the IPCC in 2023. **In the first two sectors, hydrogen can contribute to reducing GHG emissions.**

GHG emissions by sectors of the global economy

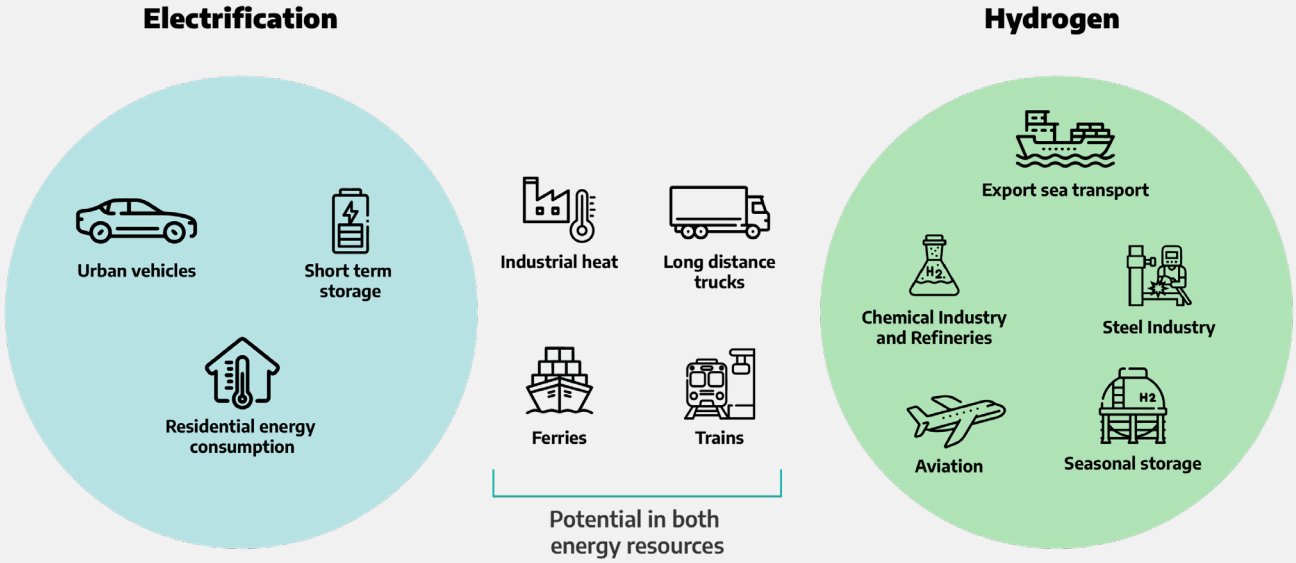


In this context, **low-emissions hydrogen is an energy vector that offers a concrete solution for the decarbonisation of sectors which, because of their characteristics, are hard to electrify and for the replacement of fossil fuel-derived industrial supplies.**

In addition, it allows for seasonal energy accumulation, which contributes to improving efficiency in renewable energy production and to lessening the intermittency that is characteristic of traditional energy sources, such as wind power and photovoltaic solar power. This gives hydrogen a key role within a country's decarbonisation strategies, not only because of the amount of emissions that are prevented, but also because it is, in some cases, the only vehicle that can be used to reduce GHG emissions.

One of the most relevant features of the hydrogen economy is that international trade in hydrogen, whether directly, through other energy vectors (such as ammonia or methanol) or in products decarbonized at the outset (such as steel or fertilisers), makes it possible to transport low-emissions energy across different regions. Thus, production and trade in low-emissions hydrogen can contribute to accelerating decarbonisation in countries with greater energy needs which cannot be met using their own resources.

Competitiveness and contribution to the reduction of CO2 emissions

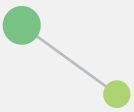


Uses of Low-emissions Hydrogen and its Contribution to Decarbonisation

It is **expected that demand for low-emissions hydrogen will grow on the basis of two components: i) because of its contribution to the decarbonisation of existing industries and ii) because of new uses arising in activities where it can be introduced to reduce emissions.** In both cases, such demand will be **boosted by new regulatory requirements, corporate or shareholder strategies, consumer behaviour and access to financing.**

Some countries and regions have put in place certain regulations which, in the mid-term, will affect international trade in energy-intensive products. This is the case of border carbon adjustment mechanisms and requirements with respect to the level of emissions generated throughout the production chain. **In this context, there are ever more companies undertaking emission reduction commitments, which opens a window of opportunity for new players to join the hydrogen value chain early on.**

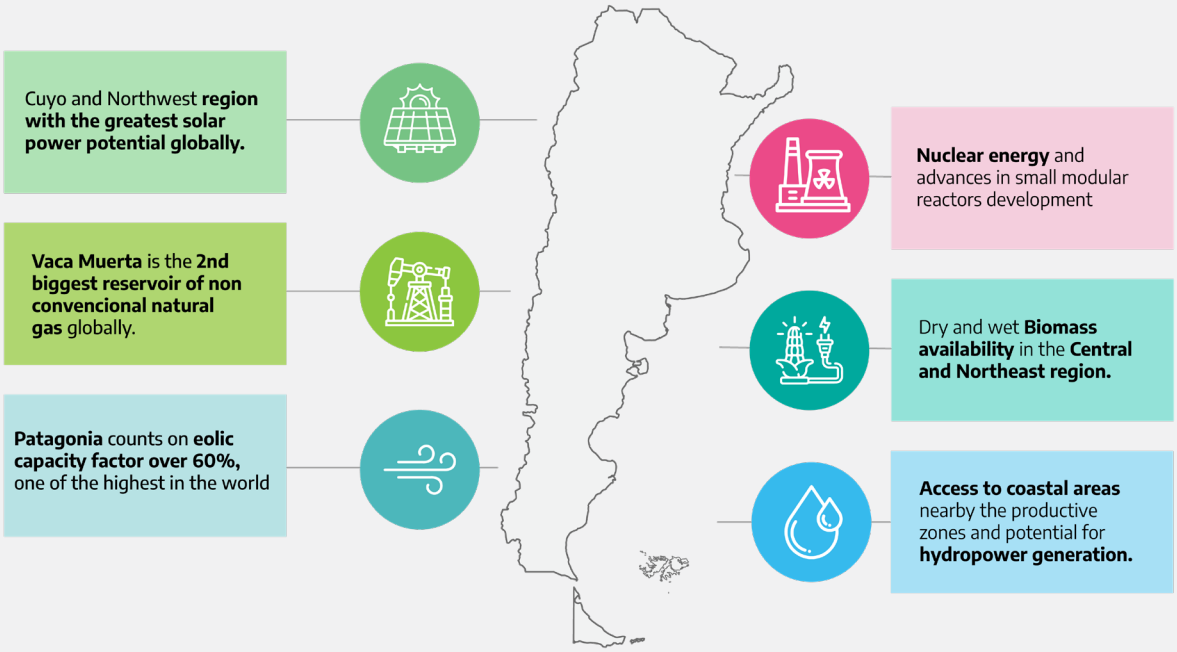
It is forecast that by 2050 there will be a global production of 500 Mt of low-emissions hydrogen a year, out of which 415 Mt will be allocated to the supply of local and surrounding markets and 85 Mt will be exchanged on a long-distance basis annually. Argentina expects to contribute 4 Mt annually by 2050 and thus supply 5% of the long-distance international market. **The availability of natural resources of excellent quality and synergy of industrial and scientific capabilities are the main advantages based on which Argentina can offer its energy resources to the world in a competitive fashion, while developing its internal market and the associated value chains.**



Argentina's Competitiveness

Argentina has an array of advantages that make it a potential competitive producer of low-emissions hydrogen (green, blue and pink hydrogen) for the international and the internal markets. These advantages, both natural and man-made, are distributed across the country, which enables the deployment of the activity with a strong territorial anchoring

Argentina´s Competitiveness



+ 17.000 graduates in applied sciences yearly.

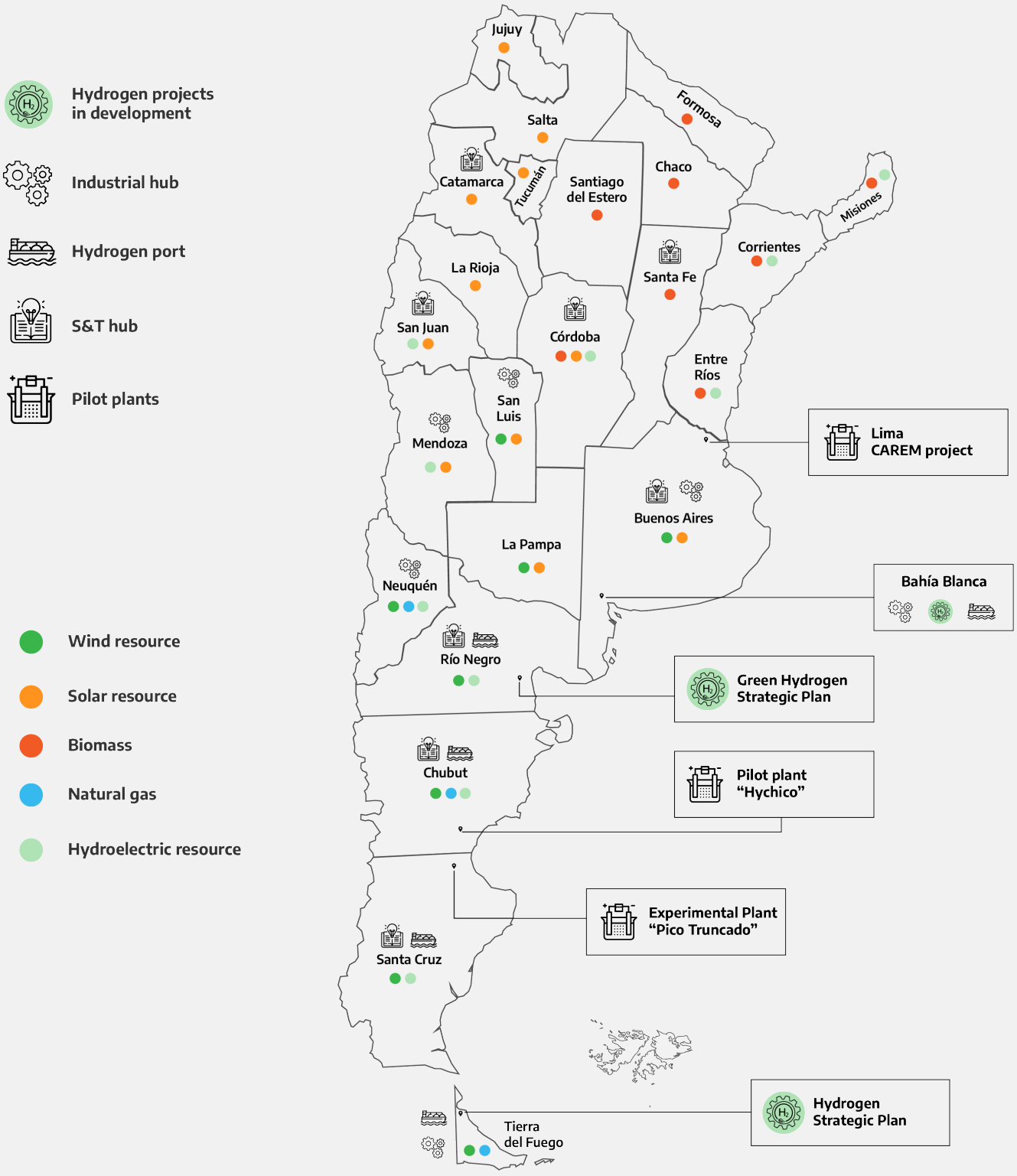
+ 3.500 in engineering.

Scientific and technological system with experience in **H2**

+ 50 years of trajectory in petrochemical industry and petroleum refining.

Network of suppliers and labor skills related to the hydrogen chain and capital goods.

Capabilities across the Argentine territory



Low-carbon hydrogen and other greenhouse gases bill

Its objective is to promote productive projects, organize governance bodies and promote technological development throughout the value chain

Strategic environmental assessment

It incorporates environmental aspects into planning, establishes a sustainability framework for territorial deployment and provides better information for decision-making. In this way, it contributes to the reduction of risks associated with the implementation of projects and the identification of opportunities, incorporating local communities in decision-making.

Hydrogen Strategic Plan - Tierra del Fuego, Antartic and South Atlantic Islands

It aims to develop investment projects for the production and commercialization of blue and green hydrogen, as well as other derivatives. Its objective is to generate the tools to organize hydrogen production in the province, respecting socio-environmental criteria throughout the value chain.

Green hydrogen strategic plan - Río Negro Province

It highlights the natural resources, capacities and existing infrastructure in the Province, which positions it as a competitive possibility for the development of green hydrogen production projects. Its objective is the industrialization of the value chain, the export of green hydrogen from Sierra Grande and the visibility of Rió Negro as a place for national and foreign investments. It takes the issue of low-emission hydrogen as a strategic tool for mitigating the effects of climate change, for which it has an inventory of greenhouse gases which, together, promotes the expected virtuous circle.

Productive hubs

Bahía Blanca is one of the main petrochemical hubs in the region, concentrating the largest production of hydrogen and ammonia in the country. In addition, its port stands out for being the only one in Argentina that ships ammonia. Mendoza and Campana are two hydrogen production centers of great importance. All linked to a network of long-established suppliers.

CAREM Project- Buenos Aires Province

It consists of the development of a nuclear power reactor entirely designed and built in Latin America. The first model is under construction, located in Lima, Province of Buenos Aires. More than 1,000 companies are directly or indirectly linked to the project. 70% of the inputs, components and related services will be provided by Argentine companies certified under the demanding international quality standards, supervised by the National Atomic Energy Commission (CNEA).

Hychico pilot plant - Chubut Province

Hychico has been producing high-purity green hydrogen since 2008, with a 2.3-kilometer pipeline system and a geological storage facility. The production is experimentally applied to mixtures with natural gas and a 1.4 MW generator, it is also suitable for use in fuel cells.

Experimental Plant Pico Truncado - Santa Cruz Province

Experimental green hydrogen plant. Human resources training center for technology development and testing in a real environment. Nearby, the Scientific and Technological Energy Pole for Southern Patagonia will be built, promoted by the Ministry of Science, Technology and Innovation of the Nation (MINCyT), the Institute of Science, Technology and Innovation of the Province of Santa Cruz (CITEC) and the R&D Agency.

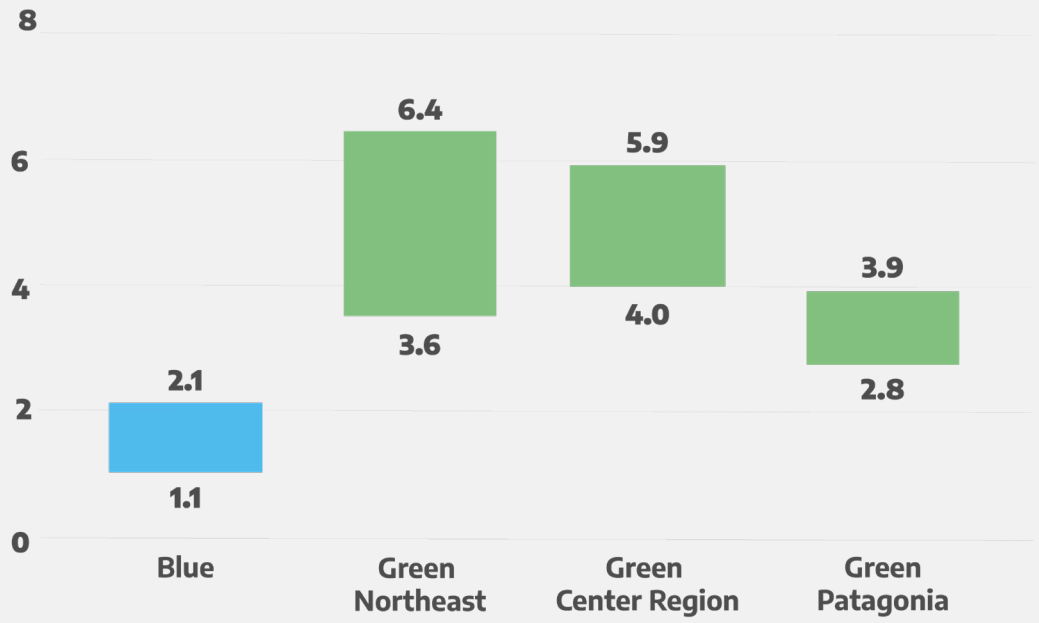
Targets and Actions of the National Strategy for the Development of the **Hydrogen** Economy

Costs

The main challenge faced by the hydrogen economy on a global level lies in production costs. Hydrogen is currently seen as one of the main technological solutions for the decarbonisation of many sectors. For this vector to be able to effectively contribute to the energy transition, its costs need to be competitive as compared to other alternatives.

Argentina may offer competitive costs for hydrogen production. The cost of blue hydrogen ranges between 1.1 and 2.1 USD/kg, as per estimates calculated at the time this National Hydrogen Strategy was prepared (based on the price of natural gas). The cost of green hydrogen ranges between 6.4 and 2.8 USD/kg, considering the quality and availability of renewable resources in different locations, with the Patagonia region being the most competitive in current conditions.

Current Costs in Argentina (USD/kg)



Cost Targets 2030-2050

Argentina has the possibility of developing large-scale projects, because of its territorial extension as well as the availability of infrastructure and capacity for the provision of services associated with industrial activity. The costs estimated at the time this document was prepared are the starting point which lays bare Argentina's competitiveness.

When considering the efficiency gains of electrolyzers and CCUS technologies, as well as competitiveness gains associated with industrial learning in the operation of hydrogen production plants, it is possible to forecast a cost reduction curve that places Argentina among the most competitive regions in the world in low-emissions hydrogen production. A relevant factor in the process of improving green hydrogen production costs is the scale of production: estimates show that scale-related competitiveness gains are obtained in projects generating at least 2 GW of renewable energy. The territorial extension would allow for several large-scale projects to coexist in different locations across the country.

How are hydrogen production costs measured and what are the main determinators?

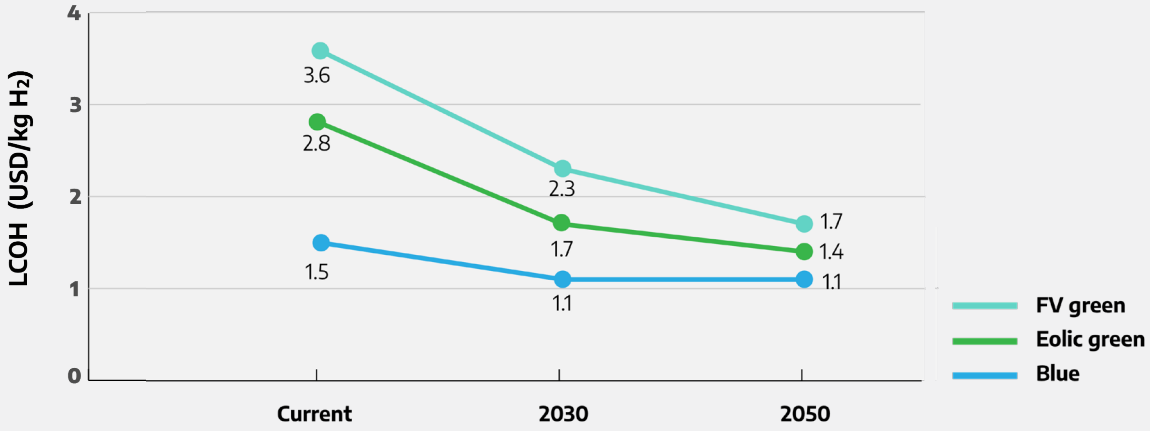
The LCOH indicator (levelized cost of hydrogen) is the tool most widely used globally for measuring hydrogen production costs. It is estimated to compare the amount of hydrogen produced throughout the useful life of a given project, plus fixed and operating costs. The variable that has the most impact on the LCOH indicator is the cost of energy, whether it is natural gas (for blue H2) or renewable electric power (for green H2).

Depending on the price, natural gas accounts for 50% and 70% of the LCO of blue hydrogen, while CAPEX of hydrogen plants and CO2 capture plants account for 30-35% of the LCOH. The levelized cost of renewable electric power (LCOE) is the variable that affects the LCOH of green hydrogen the most. It is estimated that the LCOE accounts for nearly 70% of the LCOH.

It is estimated that, by 2050, green hydrogen could be produced based on the use of wind resources in Patagonia at 1.4 USD/kg and, by 2030, at 1.7 USD/kg. In the case of blue hydrogen, a cost of 1.1 USD/kg will be achieved by 2030.

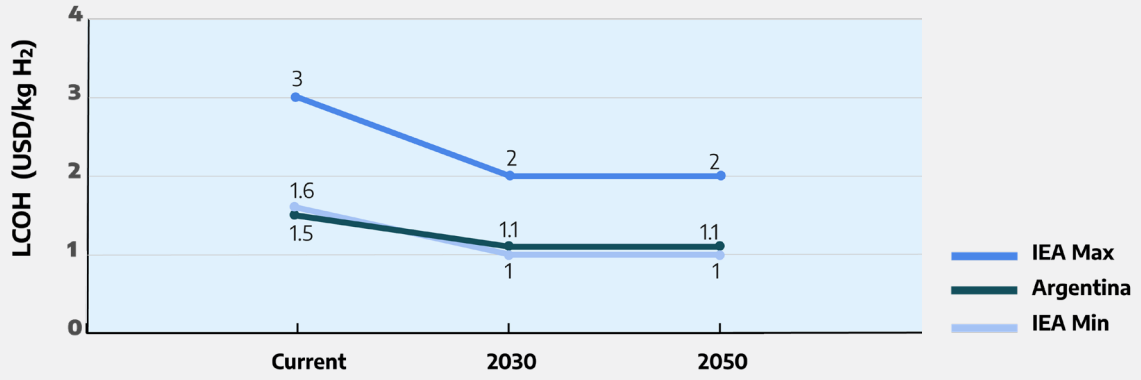
There is also a potential for the production of pink hydrogen on the basis of nuclear capabilities, especially thanks to the CAREM project, a small modular reactor that can be applied to the production of low-emissions hydrogen.

Cost Forecasting in Argentina

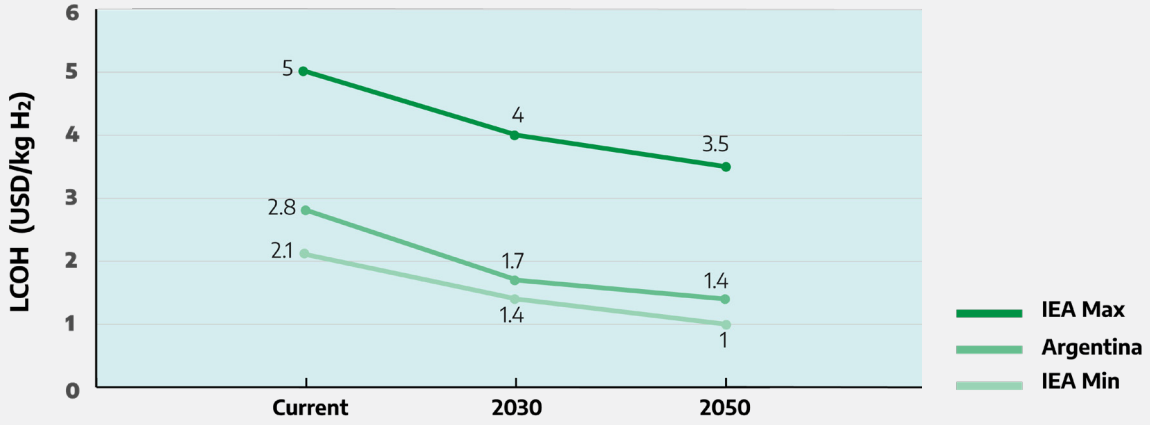


Estimates for 2030 and 2050 place Argentina among the ranks of the countries with the lowest production costs as forecast by the International Energy Agency (IEA).

Forecasting of Blue Hydrogen Costs

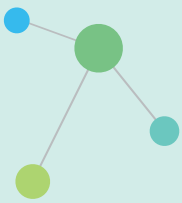


Forecasting of Green Hydrogen Costs



Actions to Develop a Competitive Offer

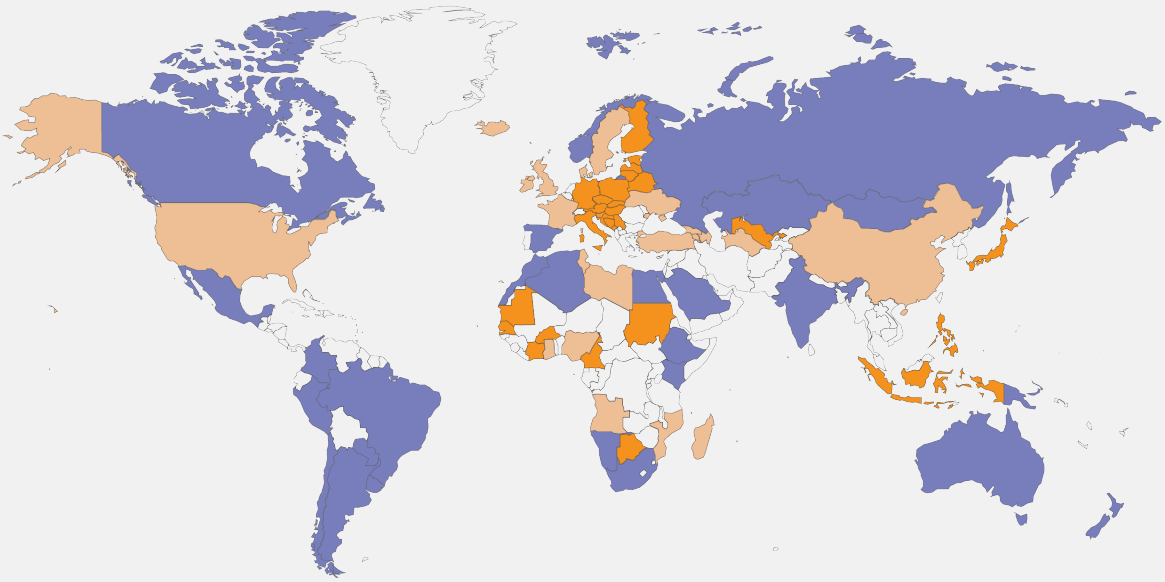
- **Encouraging competitiveness in hydrogen production hubs to create and promote an internal market and an export market.**
- **Promoting the development of local suppliers of fixed assets, supplies and equipment, and of knowledge-based services, especially in association with the demands of production hubs.**
- **Promoting pilot-scale demonstrative projects which allow for an estimation of real costs of low-emissions hydrogen production using different technologies, at different locations and considering logistics.**
- **Improving the efficiency of critical technologies for the production of low-emissions hydrogen, such as electrolysis and CCUS technologies, on the basis of technology transfer and innovation.**
- **Increasing renewable energy generation at competitive costs.**



Export Markets

The International Renewable Energy Agency (IRENA) has estimated that, in a scenario of an advanced energy transition, low-emissions hydrogen will cover 12% of total energy consumption and account for 10% of reduced GHG emissions by 2050. The IEA estimates that, in order to achieve these targets, global low-emissions hydrogen production should reach 140 Mt a year by 2030 and 500 Mt a year by 2050.

Country Ranking in the Global Hydrogen Market



Exporter

Self-sufficient

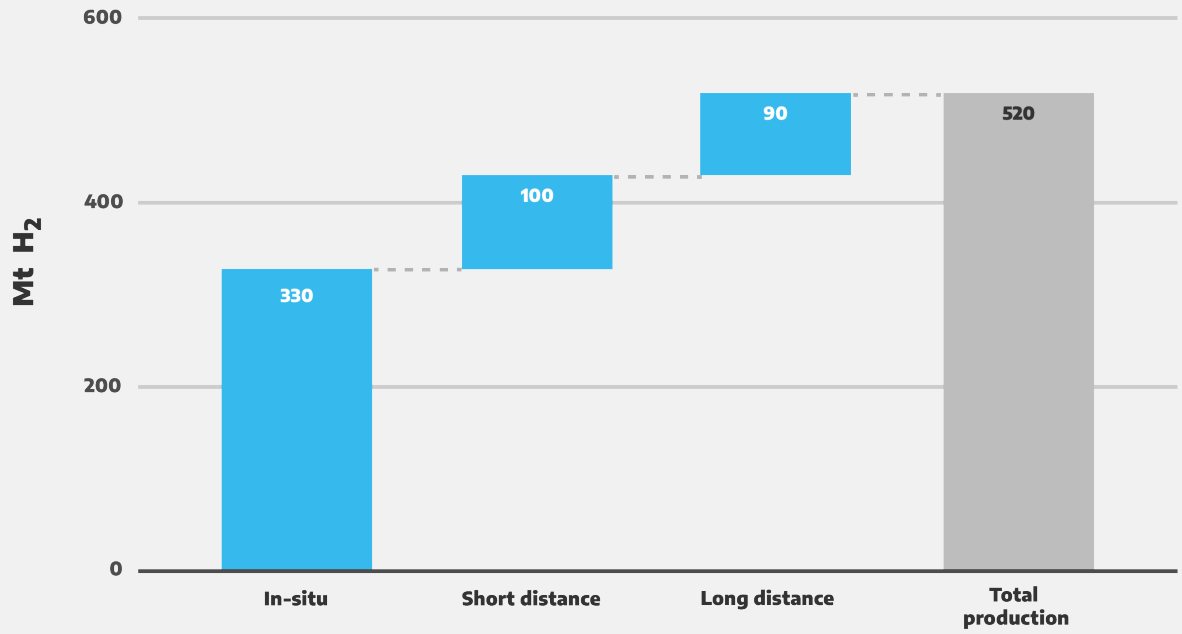
Importer

Source: World Energy Council

Available forecasts indicate that 64% of global demand will be covered by production located near consumption centres, while at least 36% will have to be outsourced from other locations. Europe is one of the regions that does not have enough natural resources or territory available to produce all the energy it needs, so it will need to import around 50% of the hydrogen it will consume, while Asian countries, including South Korea and Japan, are planning on acquiring over 80%. **Thus, countries with available natural resources will produce low-emissions hydrogen and other vectors to supply markets affected by scarcity.**

The main technological challenge that international trade in hydrogen will face is transport. Different alternatives are being considered, including using hydrogen as a gas or a liquid, or the use of other chemical products, such as ammonia (NH3) and methanol (CH3OH), which contain hydrogen and whose transport technologies are already established and mature.

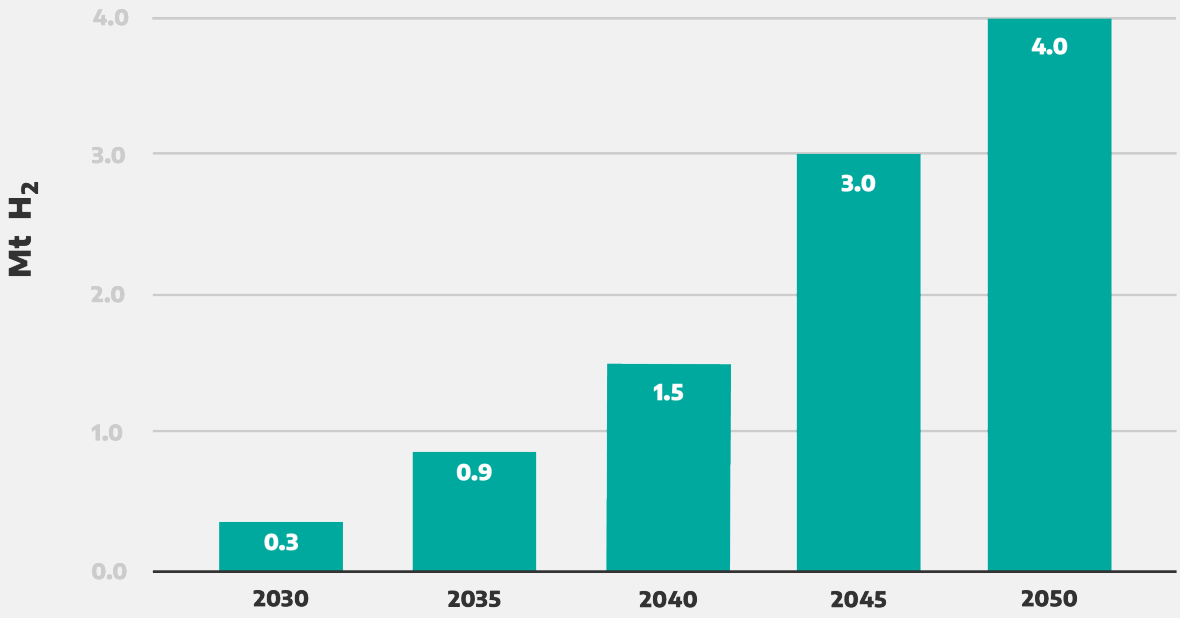
Production and International Trade by 2050



By 2050, it is expected that countries will be trading around 180 Mt of hydrogen. Forecasts indicate that such commercial exchange will be distributed across short distances through pipes (accounting for around 95 Mt) and across long distances by ship (accounting for around 85 Mt). **Argentina will participate in the international market in a competitive fashion, especially in the long-distance segment.** The experience of the Argentine industry in the production and management of chemical products, plus the fact that the country has a port specific to this type of trade (Bahía Blanca), could lead the country to enter the international market early on.

Export Targets 2030 - 2050

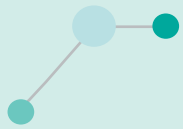
Argentine Low-Emissions Hydrogen Exports for 2030 -2050



Argentina's competitive advantages make it possible to forecast a significant share in international trade as from 2030 with 0.3 Mt a year, while getting to supply 5% of the global market as forecast by 2050, accounting for a production of at least 4 Mt yearly.

Actions to Develop Export Markets

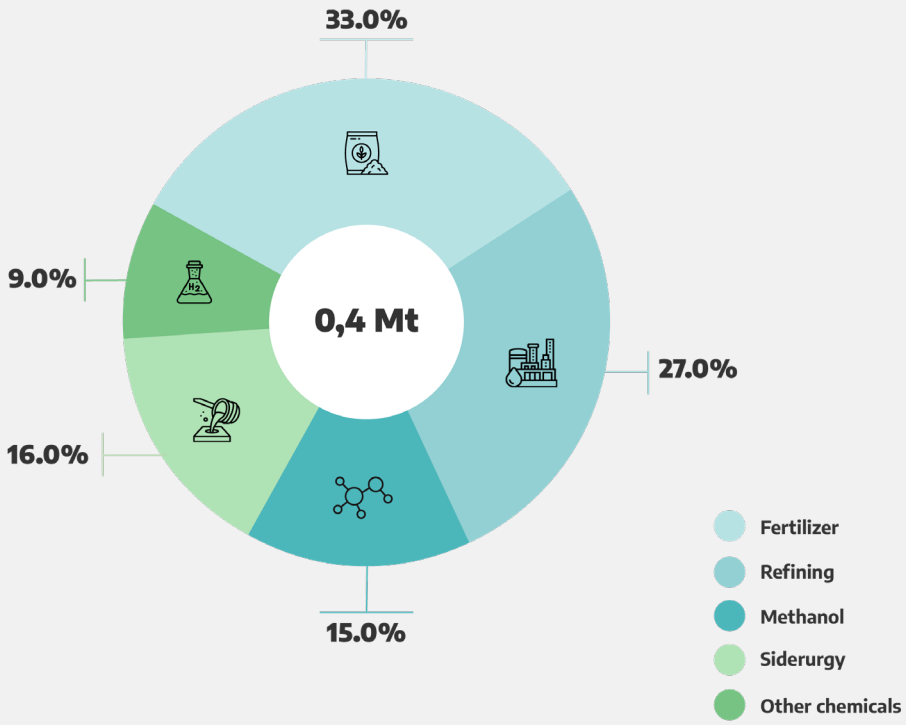
- **Implementing demonstrative projects to calculate the real costs of low-emissions hydrogen production with different technologies and at different locations, with a view to improving costs and reaching competitive costs.**
- **Placing Argentina among the ranks of competitive and trustworthy producers of low-emissions hydrogen and its derivatives.**
- **Accessing hydrogen export markets on the basis of commercial initiatives.**
- **Developing a low-emissions hydrogen certification and building capacity for an agile and transparent internationally-accepted certification.**



The Internal Market

Argentina currently produces 0.4 Mt of grey hydrogen for internal consumption, which accounts for 9% of Latam's market (4.4 Mt) and around 0.4% of global demand (94 Mt). Due to transport and storage costs, production is located near consumption centres and aimed at the production of fertilisers, methanol—in the iron and steel industry—, and fuel refining, in addition to other chemical industries.

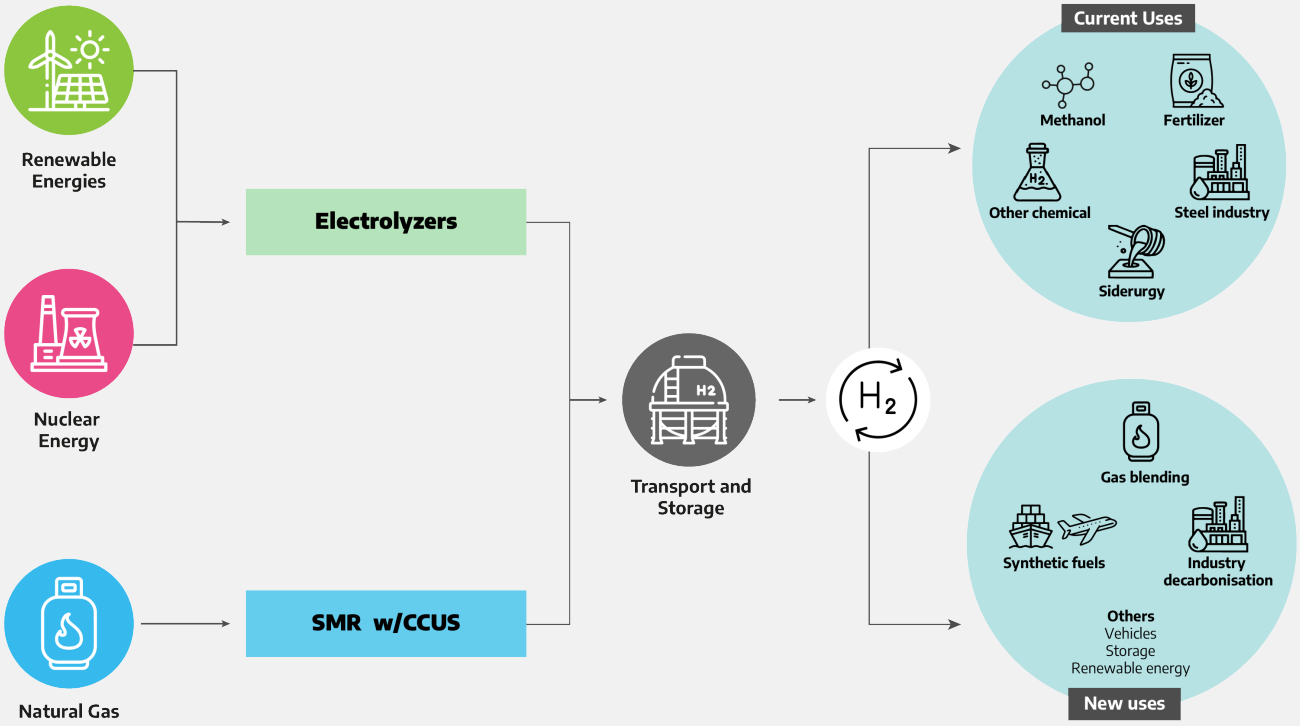
Current Uses of Hydrogen in Argentina



The existence of a mature local market is one of the strengths Argentina has in order to boost the low-emissions hydrogen economy. This domestic market favours the development of prototypes and small-scale production. Its productive background plus its local producers and scientific and technological hubs place Argentina in a good position to: (i) participate in the different segments of the hydrogen value chain, (ii) incorporate low-emissions hydrogen into current and new uses and (iii) create this market early on.

In the short term, the production of synthetic fuels, such as methanol, sustainable aviation fuels (SAF) and hydrogenated vegetable oil (HVO), **will demand low-emissions hydrogen for the decarbonisation of the maritime and air transport sector.** It will also be applied, but to a lesser extent, to electromobility, mainly on heavy vehicles that use hydrogen-fed fuel cells.

Current and New Uses of Hydrogen



The **steel industry** will incorporate low-emissions hydrogen in the short term as the technology to produce steel from direct reduction is competitive. Other energy-intensive industries are analysing the technical and economic feasibility of incorporating hydrogen for decarbonisation.

In addition, domestic demand could grow from the creation of a voluntary gas blending market, a stable demand that provides certainty to local suppliers. This type of market enables users interested in acquiring a greater proportion of clean hydrogen, virtually and voluntarily, to finance the system and meet decarbonisation targets without making modifications to installations. However, prior technical studies on the feasibility of the existing infrastructure are essential.

As technological conditions allow, **part of the current production could be gradually adapted to low-emissions solutions** by incorporating CCUS and/or incorporating green hydrogen to meet the demands of the domestic market.

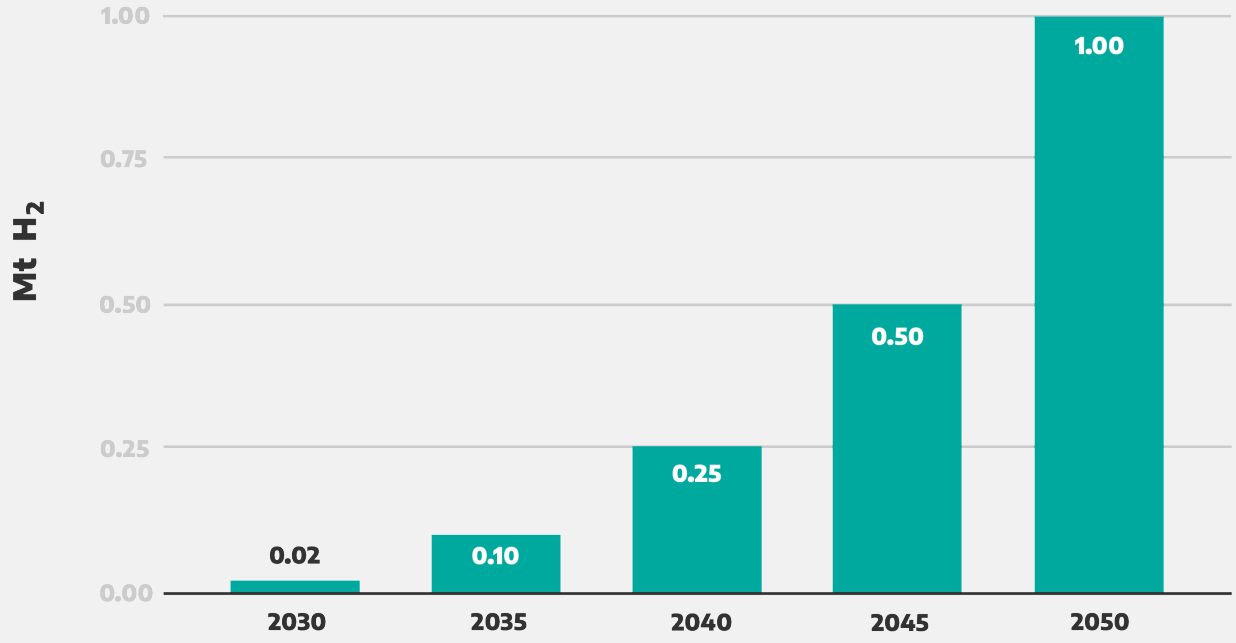
Gas blending

Gas blending is incorporating a percentage of hydrogen into the natural gas stream. This use of hydrogen is seen by some countries as a way to generate a steady domestic demand that promotes supply. In addition, it makes it possible to take advantage of the surplus of renewable energy that cannot be dispatched and contributes to reducing emissions associated with the combustion of natural gas. Its implementation requires a technical assessment of existing gas pipelines, involving additional costs, which must be weighed against the potential benefits.

Internal Market Targets 2030-2050

Domestic demand for low-emissions hydrogen will show steady growth as from 2030 onwards, reaching 100,000 tonnes per year by 2035. Demand is expected to reach 500,000 tonnes per year by 2045, rising to 1 million tonnes by 2050. A portion of the demand will be covered by domestic production of blue hydrogen, which will contribute to improving the conditions for larger scale developments that can participate in export markets.

Argentina's domestic low-emissions hydrogen market 2030-2050



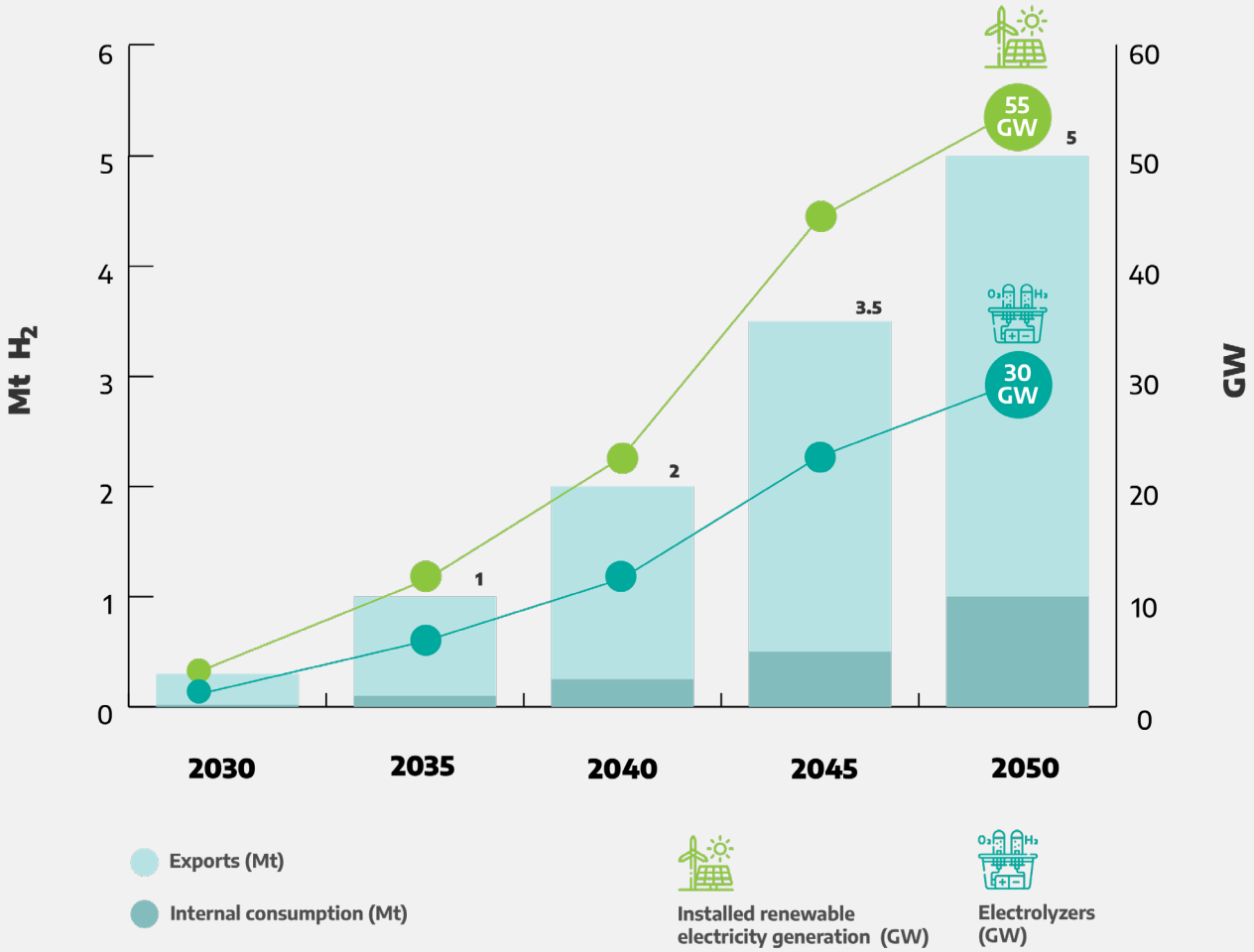
Actions to Create and Strengthen the Domestic Market

- **Generating demonstration projects on the use of low-emissions hydrogen in domestic industrial processes and transport.**
- **Enabling regulatory sandboxes to make hydrogen demonstration projects viable.**
- **Conducting studies and operational tests for the implementation of gas blending in isolated natural gas networks.**
- **Creating mechanisms to harmonise cost differentials between low-emissions hydrogen and fossil fuels.**
- **Applying sectoral analysis tools to assess the potential growth of new carbon markets.**
- **Enhancing the role of public utilities in the production and adoption of low-emissions hydrogen.**
- **Creating, adapting and implementing safety regulations for the entire hydrogen value chain.**

Industrial Development in the Hydrogen Value Chain

Argentina's hydrogen production will grow from the current 0.4 Mt per year to 5 Mt in 2050, which implies that the sector will increase in size by 12 times. The adaptation of this industry will make it possible to progressively abandon traditional methods and incorporate clean technologies. **International demand will drive to scale up production by increasing efficiency and productivity. This outlook of strong growth creates a window of opportunity for industrial development throughout the value chain.**

Projection of Hydrogen Supply and Capital Goods Demand



Given the competitive conditions of natural gas and the extraordinary potential of renewable energy, particularly wind and solar photovoltaic energy, **it is expected that green and blue hydrogen will be produced in the short term.** In the long term, technological learning regarding the CAREM project, one of the first small modular reactors under construction in the world, could enable the country to become a world leader in the production of **pink hydrogen** and in its value chain.

For illustrative purposes, considering a scenario in which all of Argentina's projected hydrogen production (5 Mt) is obtained from water electrolysis and renewable energy, **30 GW of electrolyzers and 55 GW of renewable energy capacity would be needed by 2050.** Based on current technologies, **this would mean installing between 6,000 and 8,000 wind turbines, occupying an area of 11,000 km2, which is equivalent to 55 times the area of the Autonomous City of Buenos Aires or half the area of Argentine provinces such as Tucumán and Tierra del Fuego. As for the required power of electrolyzers, it is equivalent to 30,000 units of 1 MW, 10 times the installed power of the Yacyretá hydroelectric power plant.**

> The expected soaring growth in global low-emissions hydrogen production will create additional pressures on the manufacture of crucial technologies, providing an opportunity for the establishment and development of specialised suppliers in Argentina.

The expansion of hydrogen production will require a set of complementary capital goods and technological services. Crucial equipment and infrastructure includes electrolyzers for hydrogen production; the production of capital goods for renewable energy generation; natural gas steam reforming plants; parks for renewable electricity generation; and the infrastructure needed for the application of CCUS technologies. Knowledge-intensive services are also important, such as engineering services, which are key in conducting feasibility and pre-feasibility studies; services for project management and operation (including construction and assembly of renewable energy parks); and software and IT services.

The expected soaring growth in global low-emissions hydrogen production will create additional pressures on the manufacture of crucial capital equipment. Global projections show that installed electrolysis capacity requirements will be 232 GW in 2030 and 3200 GW in 2050. This represents 3.2 million 1 MW electrolyzers and more than 6,000 GW of renewable energy, equivalent to about 600,000 10 MW wind turbines.

Global investment announcements for electrolyzers production up to 2023 will only cover half of the needs, provided that every project is completed on time. These conditions make it possible to foresee bottlenecks in the supply of these crucial capital goods.

Wind turbines and photovoltaic technology manufacturers have recently started to rethink their production capacities to meet the additional demands. The IEA and the IRENA published reports in 2022 and 2023, respectively, identifying the need to expand the production capacity of electrolyzers and wind turbines.

In addition, **there is a wide range of electromechanical components and equipment associated with this industry, which will be key for transportation and storage**, ranging from pressure vessels and compressors to valves and piping. The whole chain will also require technological services and software for plant operation, maintenance, logistics and traceability, especially for certification of origin.

This shows a growing **demand for capital goods worldwide and opens up an opportunity for the establishment and development of specialised suppliers in Argentina,** in order to efficiently meet the needs of the domestic and regional markets. According to the national strategies developed by different countries in the region and various international reports, 15% of the world's hydrogen production will be generated in the Southern Cone.

Low- Emissions Hydrogen Production Prospects in Latin America

Argentina's industrial, scientific and technological capacities make it possible to foresee that part of the supply of technology, electrolyzers and other capital goods and services will be generated in the country, which is a strategic target to expand and improve the productive matrix with higher value-added activities.

Industrial Development Targets 2030 - 2050

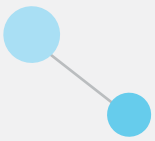
Argentina aims to achieve domestic hydrogen production of at least 1 Mt by 2030 and 5 Mt by 2050. This will require the development of local suppliers based in the country to meet the needs of capital goods and related services in the value chain to achieve 50% domestic content by 2050, and to export to the regional market.

We expect to strengthen industrial capacities and create new ones, for example, in the renewable energy sector for the production of capital goods, their parts and components, nacelles, towers and potentially wind turbine blades. We also propose to adapt existing capacities to manufacture equipment for the storage and transportation of hydrogen and hydrogen derivatives, as well as new suppliers of electrolyzer parts, components and equipment.

Capabilities	Renewable energy equipment	Electrolyzers	Vessels and compressors	Technological services
Existing	Casting and machining of parts. Transformers and components Storage systems, tower construction.	Two projects for the development of prototypes of alkaline electrolyzers. Companies with technological proximity to the production of electrolyzers.	Suppliers for compressed gas. Suppliers for high pressure hydrogen.	Technology services for the oil and gas, petrochemical and other industries.
Strengthen and generate	Nacelles and Panels. Construction of towers and blades. Equipment for energy conversion, transformation and control.	Parts of electrolyzers and complementary processes in electrolysis plant. Power electronics equipment.	Adaptation of current hydrogen storage and transport equipment	Plant operation. Predictive and preventive maintenance. Logistics. Traceability.

Actions to Promote the Industry and Added Value

- **Developing hydrogen value chain suppliers (goods and services).**
- **Promoting the construction of prototype electrolyzers and other crucial capital goods.**
- **Fostering partnerships between technologists, local industrial companies and capital goods prospective buyers.**
- **Promoting the contracting of national suppliers and services in public procurement.**
- **Accelerating the adoption of safety regulations for the production, handling, transportation and use of hydrogen along the value chain.**
- **Strengthening certification capacities and increasing the total number of supplier companies certified according to international quality and industrial safety standards.**
- **Creating and adapting specific regulations for geological storage and transport of CO2.**



Science, Technology and Innovation

The contribution of scientific and technological research to increase the efficiency of technological assets is essential to improve the competitiveness of domestic low-emissions hydrogen production. Over the next few years, a number of technology sectors will become more dynamic, mainly electrolyzers and CCUS technologies. **Boosting the country's research and development, together with industrial capacities in the field of electrolyzers, mainly alkaline electrolyzers, is a strategic aspect for Argentina to position itself in the hydrogen technology race.** This boost to technological development will make it possible to offer local technology to projects established in the country.

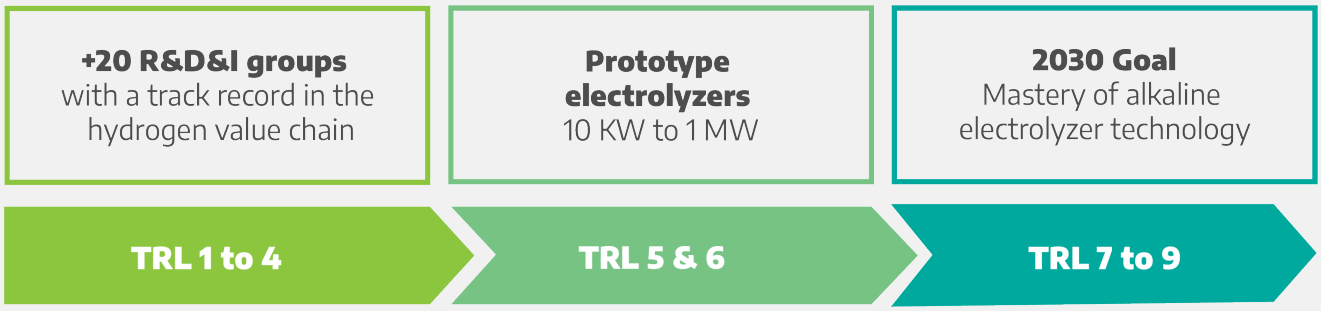
Argentina has a wide network of national and provincial universities, as well as a set of scientific and technological organisations that make up a robust science and technology system distributed throughout the country. More than 50,000 researchers work in the National Science and Technology System (SNCT). A large part of these human resources are concentrated in I&D (Innovation and Development) groups in national universities and in the National Scientific and Technical Research Council (CONICET). Other decentralised institutions, such as the National Atomic Energy Commission (CNEA) and National Institute of Industrial Technology (INTI), are also working on issues related to the hydrogen economy with greater proximity to its applications.

> A wide network of national and provincial universities, as well as a set of scientific and technological organisations, will enhance hydrogen research and development in Argentina.

The country has scientific and technological hubs that stand out for having groups with extensive experience in hydrogen-related topics, such as La Plata and Bahía Blanca, in the province of Buenos Aires, Bariloche in Río Negro, and those in the cities of Córdoba and Santa Fe, in the respective provinces of the same name.

The SNCT cooperates and links closely with a network of state-owned companies such as YPF Tecnología (Y-TEC), a partly state-owned company owned by YPF and CONICET; INVAP, a state-owned company of the province of Río Negro that conducts complex technological projects; the solar photovoltaic technology-oriented provincial energy company of the province of San Juan (EPSE); and the Planta Industrial de Agua Pesada (PIAP, industrial heavy water plant in its Spanish acronym), managed by CNEA and the government of Neuquén, with potential for ammonia production. In the case of Santa Cruz, the experimental hydrogen plant in Pico Truncado is both a pilot test in low-emissions hydrogen production and a training and research facility. The association of these capacities with the private sector generates consortia and projects linked to a wide range of industrial applications.

R&D projects by degree of technological maturity in Argentina



This strong federal public-private network gives the country a broad basic scientific expertise, especially in energy materials and other technological know-how, covering a portfolio of projects at different stages of technological maturity. The last five years have seen an increase in alkaline electrolyzer technology development projects at intermediate stages.

Technological Readiness

The Technology Readiness Level (TRL) emerged in the 1970s at NASA, with the aim of measuring the state of development of a technology. Currently, the TRL is used internationally as a reference to identify the degree of progress and maturity of technologies, to determine and specify the viability of the project and the proximity of the product to the market from the beginning of the research.

The scale of TRLs ranges from 1 to 9, where the initial stages comprise TRL 1 to TRL 4 (assessment of the basic principles or conceptual model in a laboratory environment), the intermediate stages TRL 5 and 6 (testing in a controlled environment) and the advanced stages TRL 7 to TRL 9 (validation and adjustments of the technology in a real environment).

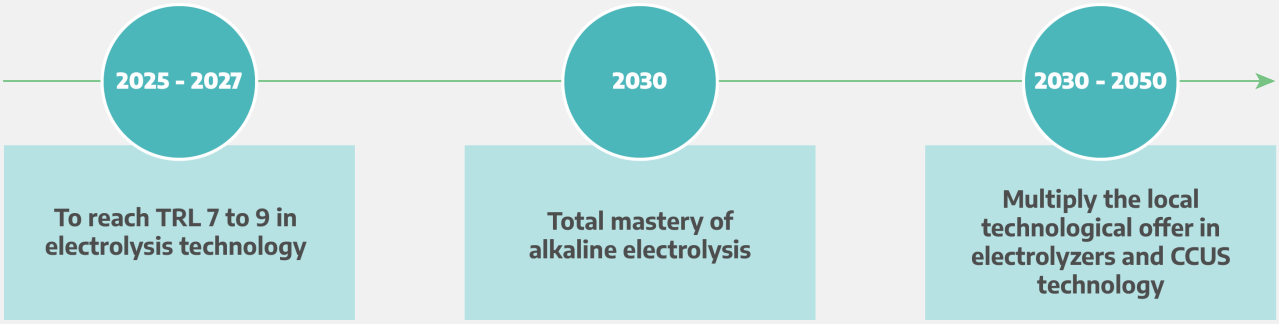
Pilot plants are a key capacity to test technologies in real-world environments and obtain prototypes that demonstrate their operation on a small commercial scale, boosting the domestic market. They also help to identify operational problems as well as resolve issues related to regulations, safe implementation methodologies, infrastructure, and supply chains. Two pilot plants, pioneers in the region, are currently operating in the country. **Being able to replicate these capacities in other locations, where there is potential to produce hydrogen, favours and accelerates the implementation of large-scale projects, allowing technologies to be tested and adapted to the operational context.**

A concrete example where a pilot plant can be very useful is blue hydrogen. In this case, there is the possibility of adding value to the gas resource by incorporating CCUS into the traditional process, which implies resolving technological issues linked to the capture and safe storage of CO2 that must be tested in real environments.

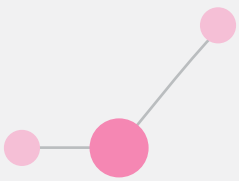
Science, Technology and Innovation Targets

Argentina aims, in the short term, to reach advanced technological maturity level (TRL 7 to 9) in alkaline electrolyzers and their auxiliary equipment. Y-TEC has a prototype alkaline electrolyzer in the testing stage and aims to build the first high-power (1 MW) alkaline electrolyzer with its own technology. This project was generated in coordination with research groups and with the support of the Argentine Sectoral Fund (FONARSEC) of the National Agency for the Promotion of Research, Technological Development and Innovation, in collaboration with the Ministry of Science, Technology and Productive Innovation (MINCyT) and the Federal Council for Science and Technology (COFECyT). There are other examples like this one, which are being developed with the aim of reaching a greater number of projects in intermediate and advanced stages in the coming years.

R&D Projects accord of technological readiness in Argentina



By 2030, Argentina aims to master alkaline electrolysis technology, which will enable the transfer to the industry of the knowledge necessary to start the serial production of these critical technological goods and supply the early stages of the large-scale production projects. Within this time horizon, there will also be a secure and sustainable CO2 storage capacity atlas for blue hydrogen projects. Between 2030 and 2050, the goal is to consolidate the local supply of technology, including CCUS, in order to produce low-emissions hydrogen on a large scale.



Actions for a Hydrogen Economy with National Scientific and Technological Development

- **Promoting alkaline electrolysis technology in prototypes for giga-scale applications and PEM technology for research and mega-scale applications.**
- **Fostering I&D in CCUS, new materials, and CO2 storage technology, as well as studies on geological hydrogen storage.**
- **Promoting public-private pilot projects for synthetic fuels and decarbonisation of industrial processes.**
- **Encouraging the creation of hydrogen-related technology startups.**
- **Promoting research on new technologies for hydrogen production.**
- **Establishing centres and boosting research, development, and innovation teams linked to the hydrogen value chain.**
- **Strengthening laboratory infrastructure.**
- **Encouraging the creation of public-private consortia for technology development and innovation.**
- **Fostering promotional strategies and tools aimed at building capacities in emerging new technologies that may eventually alter hydrogen generation, storage and usage scenarios.**

Employment and Training

The deployment of the hydrogen economy will bring significant changes and opportunities in employment prospects. **A just transition towards decarbonisation and a shift in the production matrix entail both a positive impact in terms of the number of jobs and an improvement in working conditions and the creation of quality employment.** The adaptation of current occupations will require new job profiles and, consequently, new skills from workers. This poses a dual challenge in the Argentine federal map: boosting the development of hydrogen production while simultaneously seizing the opportunity to promote social inclusion by fostering local labour markets.

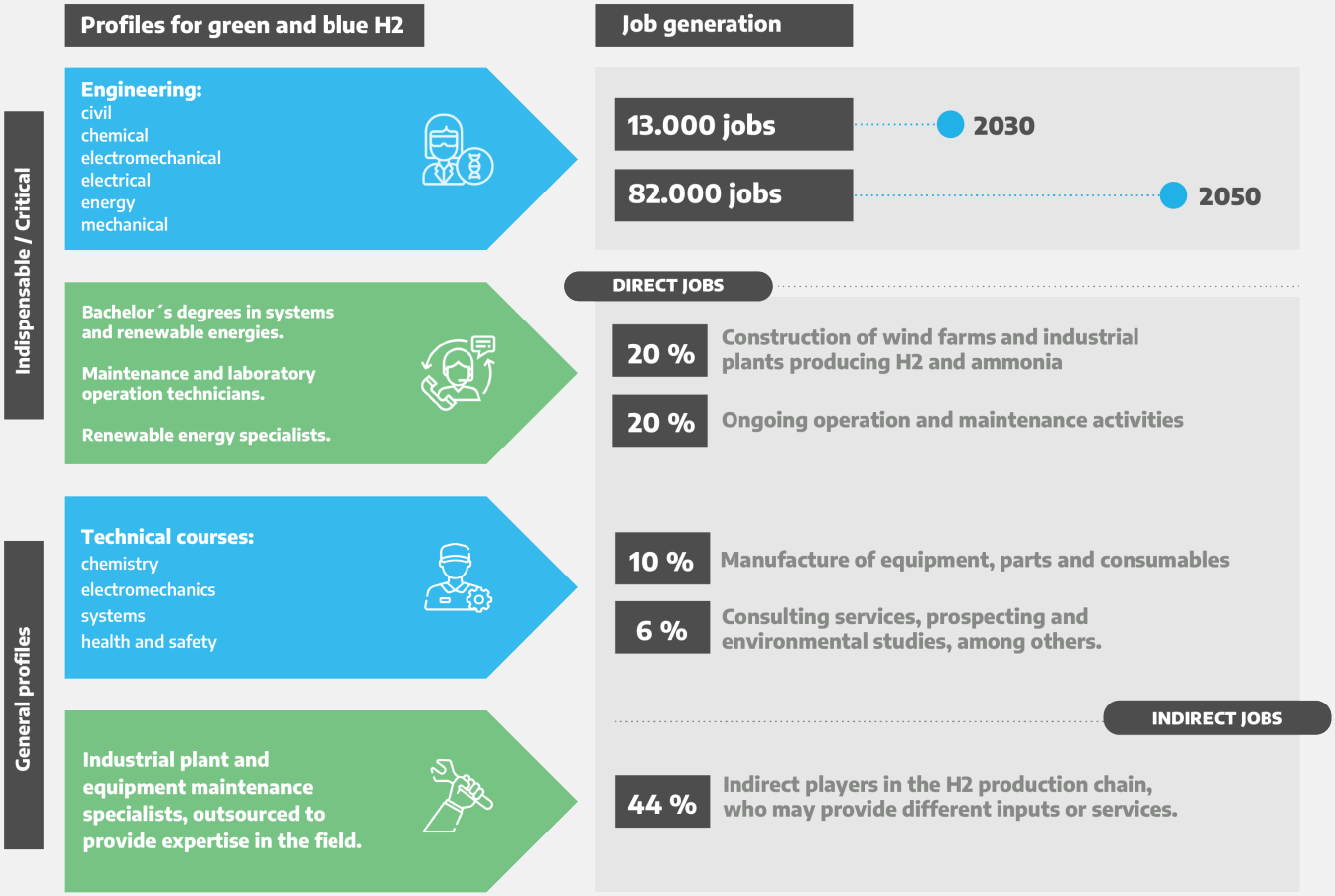
A just transition towards decarbonisation and a shift in the production matrix entail both a positive impact in terms of the number of jobs and an improvement in working conditions and the creation of quality employment.

The expansion of domestic and international demand for this energy vector, along with other activities that will do so in the future, will encourage a positive balance between the jobs to be created and those that may be affected as a result of the transition to clean energies. This includes new jobs in the construction, operation and maintenance of infrastructure, not only for low-emissions hydrogen production, but also for transportation and refuelling. Some of this demand for jobs will be met through the conversion of occupations linked to the fossil fuel extraction and production chain.

Employment Targets 2030 – 2050

In Argentina, the hydrogen economy will generate more than 13,000 quality jobs by 2030, and over 82,000 by 2050. Out of the total number of jobs, 56% will be directly related to the activity and 44% will be indirect positions.

In the short term, this new activity will not only require a large number of workers but also new job profiles, which will be especially in demand where hydrogen production hubs are established. Among the profiles considered essential and critical are university graduates (engineers and/or other graduates), and/or technicians in fields related to renewable energies, chemistry, energy, mechanics, electricity, electromechanics, civil engineering, electrical network maintenance, systems and laboratories.



The technical and higher education system of Argentina has the capabilities to address these challenges. In turn, labour institutions in the country can contribute to this transition by guiding the training of workers through their technical and vocational training centres. Collaboration with unions and business chambers facilitates the process of identifying job profiles, developing curricula and defining training pathways throughout the working life.

Having pilot-scale plants that promote the training of human resources and the identification of needs in the fields of hydrogen technology, critical professions and trades, communication tools, and workplace safety and hygiene is essential for the creation of green jobs.

Actions to Enhance Labour Skills and Promote Employment

- **Strengthening vocational training programs in areas near hydrogen production hubs.**
- **Enhancing scholarship programs in fields and skills identified as critical.**
- **Improving coordination among secondary, technical, and higher education, as well as with the vocational training system, for the development of training pathways required by the industry.**
- **Coordinating actions among government areas for technical and vocational training and for training in topics related to the hydrogen economy.**
- **Boost labour skills and promote green employment.**

Certifications

At the global level, hydrogen type and origin certification systems are currently under development. **These systems will enable the hydrogen industry to guarantee to consumers their carbon content, creating a competitive advantage in meeting minimum requirements for accessing international markets** and, in addition, promoting the entry of local producers into the carbon credit market.

Discussions are currently focused on technical definitions regarding emissions criteria and governance of the scheme. The initial proposals have been made public in recent years. The European Union has promoted, through the creation of a public-private consortium called CertifHy, a voluntary scheme that uses colour-coded labels to characterise hydrogen production in accordance with the European Directive on renewable energy. Adopting a different approach, the United States proposes categorising hydrogen based on lifecycle emissions without using colour-coded labels. **Other proposals suggest adding aspects related to the sustainability framework** in a broad sense to the certification criteria, incorporating issues such as biodiversity loss, community displacement, or growing inequalities. The PtX-Hub platform in Europe proposes providing a conceptual basis for the subsequent translation of these aspects into certification criteria.

Latin America is taking the first steps to define its guarantee of origin scheme. Even though a specific scheme has not yet been established, the general consensus is that the implementation of such a scheme is key for the deployment and consolidation of the regional market. The Inter-American Development Bank (IDB) is leading efforts to contribute to this task. This organisation is promoting a scheme whose governance is under the supervision of a supranational institution with regional recognition. It also proposes a broad sustainability framework that considers the region's specific characteristics, with particular respect for the decisions of native communities and the preservation of water sources, and that relies on the capabilities of each country for the execution of the necessary actions for its operation. Argentina can enter into agreements and collaborate with MERCOSUR partners to establish regional certification schemes.

In Argentina, the National Institute of Industrial Technology (INTI) is working within the framework of an Inter-Institutional Project on Strategic Issues (PITES), coordinated by Y-TEC, on developing a roadmap for the certification of origin of green and low-emissions hydrogen.

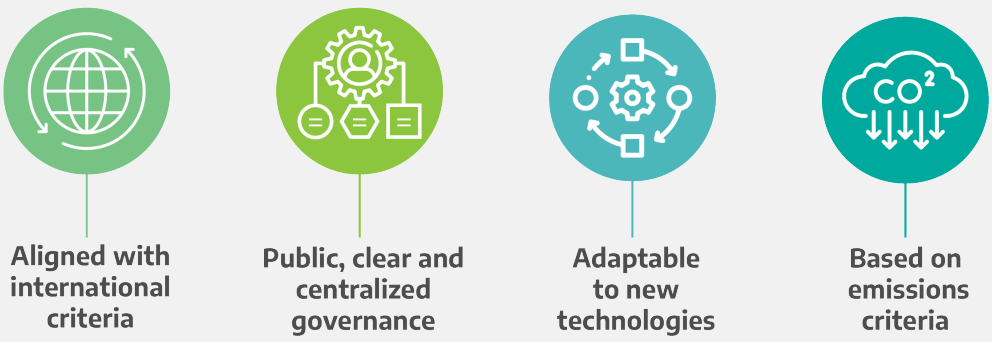
> Certification of origin and the incorporation of new technologies for hydrogen production, require regulations to ensure safety throughout the value chain. Argentina commits to deploying a system assessing emissions criteria with no technical preference.

Certification of origin and the incorporation of new technologies for hydrogen production, transportation, and use require regulations to ensure safety throughout the value chain and in the new emerging markets. In this regard, the international landscape is well-defined, as reference standards are established by the Technical Committee 197 of the International Organization for Standardization (ISO). Each country then adopts and adapts these standards through its ISO member standardisation bodies. In Argentina, this work is carried out by the Argentine Institute of Standardization and Certification (IRAM), which convenes experts from public and private organisations.

Certification Targets 2030 – 2050

Argentina will implement a certification of origin scheme based on emissions criteria with no technological preference before 2030. This system will rely on existing public capacities and will have clear mechanisms for determining emissions, adaptable to technological changes and aligned with the requirements of adopting markets. An important aspect for its organised operation is governance, which will be centralised by the national public sector and coordinated at the regional level through supranational organisations that will make it possible to enhance its scope.

Scheme main characteristics



Actions to Guarantee Safe and Sustainable Hydrogen Production

- **Developing the low-emissions hydrogen certification scheme in coordination with countries in the region.**
- **Acquiring the tools and building capacities for emissions measurement in activities related to the hydrogen value chain.**
- **Strengthening public access capabilities for conducting life cycle analysis of the various projects.**
- **Deepening the process of adopting and adapting ISO TC-197 technical standards to ensure safe conditions throughout the value chain.**
- **Building capacities of the National Quality System and its associated infrastructure to provide access to the technological offerings throughout the country.**
- **Accelerating the issuance or adoption of safety regulations across the entire value chain, including specific regulations for geological storage and CO2 transport.**
- **Promoting the incorporation of economic, social, environmental, and governance criteria into certifications.**

Support Infrastructure for the Hydrogen Economy

The development of the hydrogen economy will require the deployment of new infrastructure and the adaptation of existing infrastructure. **Work planning and execution must be combined with commercial-scale production projects, which will be geographically located close to natural resource availability, geological conditions for CO2 storage, and local demand centres.**

Key points in this field include: (i) creating facilities around production hubs: (ii) adapting corridors to connect production sites and adopters; (iii) adapting port infrastructure for exports; (iv) constructing sites for hydrogen and derivatives storage and dispatch; (v) defining geological storage spaces and building infrastructure for CO2 transport; and (vi) planning energy transport networks.

> Infrastructure projects must involve creating facilities around production hubs, adapting corridors to connect production sites and demand side, adapting port infrastructure for exports, constructing sites for hydrogen and derivatives storage and dispatch, defining geological storage spaces, building infrastructure for CO2, planning energy transport networks, and achieving other important objectives.

Infrastructure needs depend on the type of project, distinguishing between export projects and those focused on domestic demand. During the assessment and planning stages, other potential uses for this infrastructure will be considered.

Export projects are expected to be primarily located in the Southeastern region of the country (from the south of the province of Buenos Aires to Tierra del Fuego) in order to take advantage of the availability of world-class wind resources and access to the Atlantic Ocean. In this region, it will be necessary to strengthen road infrastructure, which will be required during the erection of wind farms and for the provision of industrial inputs. It will also be necessary to evaluate existing capabilities and the technical and socio-environmental feasibility of new ports, especially deepwater ports.

There are currently 17 ports in the Patagonia region, 7 of which are deepwater ports. Among these, the port of Bahía Blanca stands out, as it has services for dispatching hydrogen derivatives such as ammonia, and its capacity can be expanded. Currently, this region is being evaluated by developers of low-emissions hydrogen projects. Large-scale projects planning off-grid self-generation will build their own electrical infrastructure.

On-Grid and Off-Grid Generation

An on-grid renewable generation system remains connected to the electrical distribution network, allowing it to draw energy from the grid for hydrogen production when renewable resource availability is insufficient. Off-grid installations do not have this backup, and consequently, hydrogen production depends entirely on dedicated renewable energy generation.

A survey conducted by the Ministry of the Interior, in cooperation with provincial governments and other production and labour sectors, **reveals that there are strategic needs for renewing and improving at least 9 ports in 5 provinces. The tasks to be undertaken include the deployment of new capabilities, dredging, and expansions, among other works.** Additionally, over 30 electrical infrastructure projects are planned to improve transportation and interconnection between cities in Patagonia, where economic activity could increase due to the establishment of hydrogen production hubs.

Projects focused on **domestic demand** will be located near consumption centres. Production methods will be defined based on resource availability and production costs (access to renewable energy, natural gas infrastructure, and geological conditions for CO2 storage). These projects may be on-grid projects because they are of a smaller scale, and infrastructure needs will be of lesser magnitude.

Infrastructure Targets 2030 – 2050

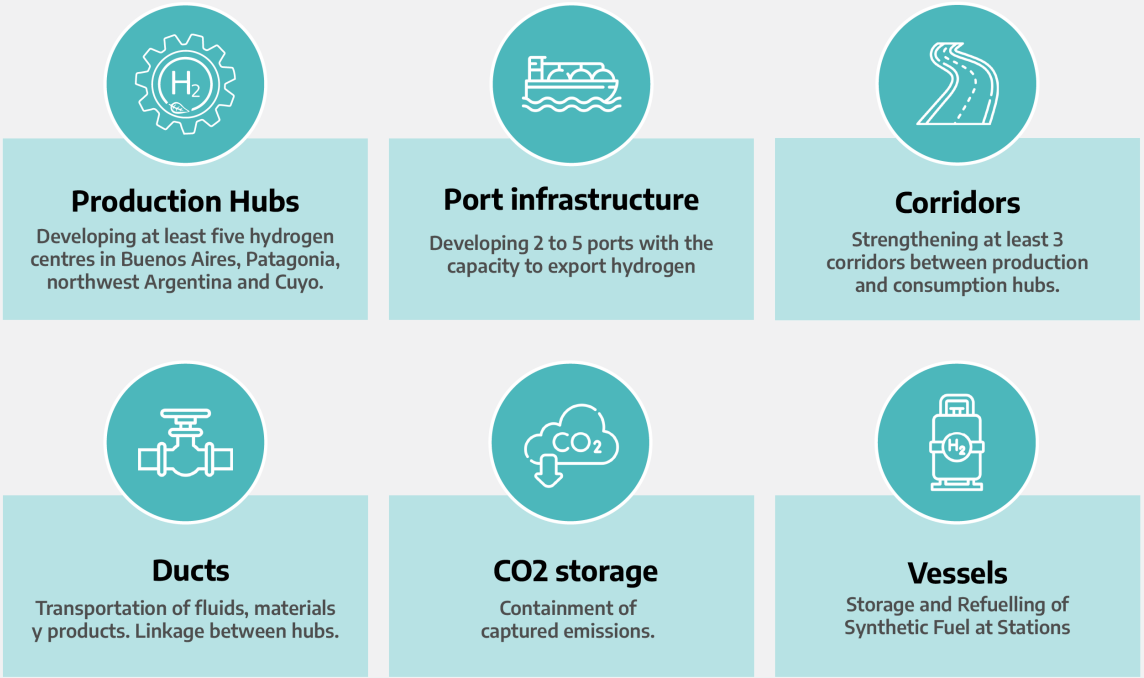
The characteristics of production projects for export and domestic demand suggest that at least 5 production hubs will be established in Argentina. Responses to inquiries made within the framework of the Hydrogen Intersectoral Roundtable with various stakeholders indicate that potential locations for these hubs would be in the area between southern Buenos Aires and Tierra del Fuego region, as well as in Northwest Argentina, Cuyo, and northern Buenos Aires.

Hydrogen production from natural gas using CCUS technologies requires infrastructure related to the transport of CO2 from capture sites to locations with potential for reuse and/or large-scale storage. Defining these points will enable the design of a pipeline network for the interconnection of these areas.

Road corridors will require, in some cases, adjustments depending on the type of hydrogen production for the connections associated with its consumption, transport and storage. It can also be supplemented with the adaptation of specific existing railway networks of short routes, for example between production and port centres. **In accordance with the contributions made by the Hydrogen Intersectoral Roundtable, at least three corridors will be strategic: one in the southern region connecting Buenos Aires and Tierra del Fuego, a second one in the western corridor between Bahía Blanca - Río Negro - Neuquén and the third one in the centre, enhancing the Buenos Aires - Rosario - Córdoba connection.**

Among the new uses of hydrogen, we can highlight its application for the production of synthetic fuels which will be demanded for maritime and air transport. This use requires planning the adaptation of storage places and new refuelling stations.

infrastructure targets



In Argentina, the region between southern Buenos Aires, Patagonia and current or future export ports are the gravitation centres for the development of hydrogen projects. It will be strategic to adapt between 2 and 5 ports to support the Argentine hydrogen exports in the international market and the exchange of goods and supplies shipped by sea.

Actions to Address Infrastructure Needs

- **Planning the territorial deployment of the hydrogen economy.**
- **Conducting port feasibility studies for productive export centres.**
- **Analysing the capacity of current road infrastructure to address the growth of hydrogen production centres.**
- **Planning refuelling stations for clean fuel services at ports and airports.**
- **Running demonstrative hydrogen-based synthetic fuel refuelling station projects.**
- **Developing hydrogen transport associated with production centres (short distances).**
- **Identifying and defining places for CO2 storage.**

Investments

The high-scale hydrogen production is a capital-intensive activity that has great uncertainty because it is **a market under construction, in which there are great expectations in the initial phases of these new businesses.** The access to financing to close capital and technology investments is an important factor for competitiveness. Therefore, the definition of the ENH together with a legal framework of incentives and foreseeability to attract productive investments and transfer technology will accelerate and increase the number of the projects needed to consolidate the hydrogen economy.

> It is a key aspect to have an active policy on the search of investments and the promotion of opportunities offered by the country which enables positioning Argentina on global markets as a safe and reliable supplier of low-emission hydrogen, ammonia and synthetic fuels.

At the international level, our country's promotion by the Ministry of Foreign Affairs and Worship in coordination with embassies located in countries with the greatest potentiality of demand and/or possibilities to establish investment agreements is essential, as well as having an information system on the financing of the green economy.

Investments Targets

The expected amount of investments compatible with the expected production is around USD 90 billion.

In that regard, **an active policy on the search of investments and the promotion of opportunities offered by the country which enables positioning Argentina on world markets as a safe and reliable supplier of low-emission hydrogen, ammonia and synthetic fuels is fundamental.**

As there is no consolidated demand, **the first stage must be focused on highlighting strategic partners to finance test plants that allow testing technology in real surroundings and demonstrating the technical and economic competence. The second stage will enhance the initiatives of positioning, presence and participation in bidding processes for future supply contracts,** as well as the promotion of partnership and cooperation with companies and institutions that supply demanding markets.

It is important to continue training the diplomatic body and other areas to represent the country in investment rounds and/or related commercial fora in order to strengthen strategic partnerships with external partners for the production and/or the development of technology linked to the value chain. In addition, to optimise this promotional work, **it is essential to have a detailed and updated map of the technological and industrial requirements prioritised by various stakeholders involved in the hydrogen economy** (like producers or users).

Moreover, the amount of financing for energetic transition projects is greater and greater. **Multilateral development banks are working hard to adequate their portfolios in that regard.** Among them, the IDB adopted a policy in order not to finance projects associated with an increase of emissions; the goal of the Development Bank of Latin America and the Caribbean (CAF) is that 40% of its portfolio goes green by 2026; the World Bank is revising its goals; and main global investment funds are also in the process of decarbonizing their portfolios.

> The National Strategy for the Development of the Hydrogen Economy will provide medium- and long-term signs to reduce the risk of private investments in this market under construction.

Likewise, even though it is incipient, **there is a volunteer market of green bonds in the country that can be attractive so that companies in the hydrogen sector, as well as small and medium savers, can acquire debt securities in projects of this kind;** also providing an active role for bank entities to promote credit lines in productions that aim at decarbonisation.

The National Strategy for the Development of the Hydrogen Economy will provide medium- and long-term signs to reduce the risk of private investments in this market under construction. **The goal is to create an investment multiplying effect with the support of the public sector to accelerate the production and exports of low-emissions hydrogen.**

Actions to Promote Investments

- **Training the Argentine diplomatic body with information for the international dissemination of neutral carbon projects.**

- **Identifying technological and industrial needs and requirements in order to design roadmaps that guide the actions of Argentine representations across the world to contribute to the development of the Argentine technological and industrial ecosystem of the low-emissions hydrogen economy.**

- **Identifying markets issuing Foreign Direct Investment (FDI) aimed at neutral carbon projects, together with the design of plans and strategies to attract such investment flows.**

- **Promoting investments and cooperation agreements for the manufacture of electrolyzers and/or their parts and pieces as well as the capital goods for the systems and infrastructure to store and transport hydrogen and its derivatives.**

- **Promoting the transfer of technology as well as infrastructure.**

- **Promoting national and/or international investments for the construction of infrastructure and projects of low-emissions hydrogen.**

- **Consolidating the role of the Ministry of Foreign Affairs, International Trade and Worship as a public contact entity with potential investors of low-emissions hydrogen. Expanding and strengthening a communication strategy to convey reliability and stability for investment projects.**

- **Promoting the signing of long-term supply contracts that contribute to the stability and foreseeability of the low-emissions hydrogen economy in our country.**

- **Promoting bilateral agreements with low-emissions hydrogen demanding countries for the development of infrastructure to export it.**

- **Promoting the access to carbon markets of hydrogen projects.**

Environmental Policy

The high-scale low-emissions hydrogen production follows environmental mitigation goals as it aims at a reduction in GHG emission, but it can have adverse effects on the environment and the communities, such as a change in the use of soil and land, biodiversity loss, water stress, habitat fragmentation, increase in pollution and other socio-cultural impacts. And blue hydrogen includes the possibility of generating fugitive emissions of CO2 in storage sites.

> Building agreements that incorporate the voices of local communities early in decision-making is a key action to enhance opportunities and mitigate risks associated with the implementation of low-emission hydrogen production projects.

These possible effects must be critically assessed to ensure a sustainable development of the activity. The conclusion of agreements, including the views of the local community at the very beginning of the decision-making process, is a key action to enhance opportunities and mitigate risks associated with the implementation of projects.

Environmental Policy Targets 2030 - 2050

Argentina intends to deploy a consistent low-emissions hydrogen economy with a sustainable development that takes into account the protection of the environment and the national climate policy. The hydrogen production targets established under this national strategy will contribute to address the local and international market demands, making the country an ally for global decarbonisation.

low-emissions hydrogen certification will strengthen the achievement of these goals and will provide relevant information to expand and enhance the data of the National Inventory of Greenhouse Gases (INGEI). In addition, it will allow the hydrogen project to participate in carbon markets and access new financing sources and other incentives aimed at the mitigation of climate change.

> Argentina intends to deploy a consistent low-emissions hydrogen economy with a sustainable development that takes into account the protection of the environment and the national climate policy. low-emissions hydrogen certification will strengthen the achievement of these goals.

In order to establish a sustainable market of the The National Strategy for the Development of the Hydrogen Economy, a Strategic Environmental Assessment (SEA) has been implemented to: (i) provide greater consistency among productive goals and environmental targets, within the context of the compliance with current environmental legislation; (ii) generate more certain conditions for potential investments, establishing the bases for the Strategic Environmental Assessments that must be faced by the projects individually; and (iii) draft potential zoning proposals to establish productive hubs.

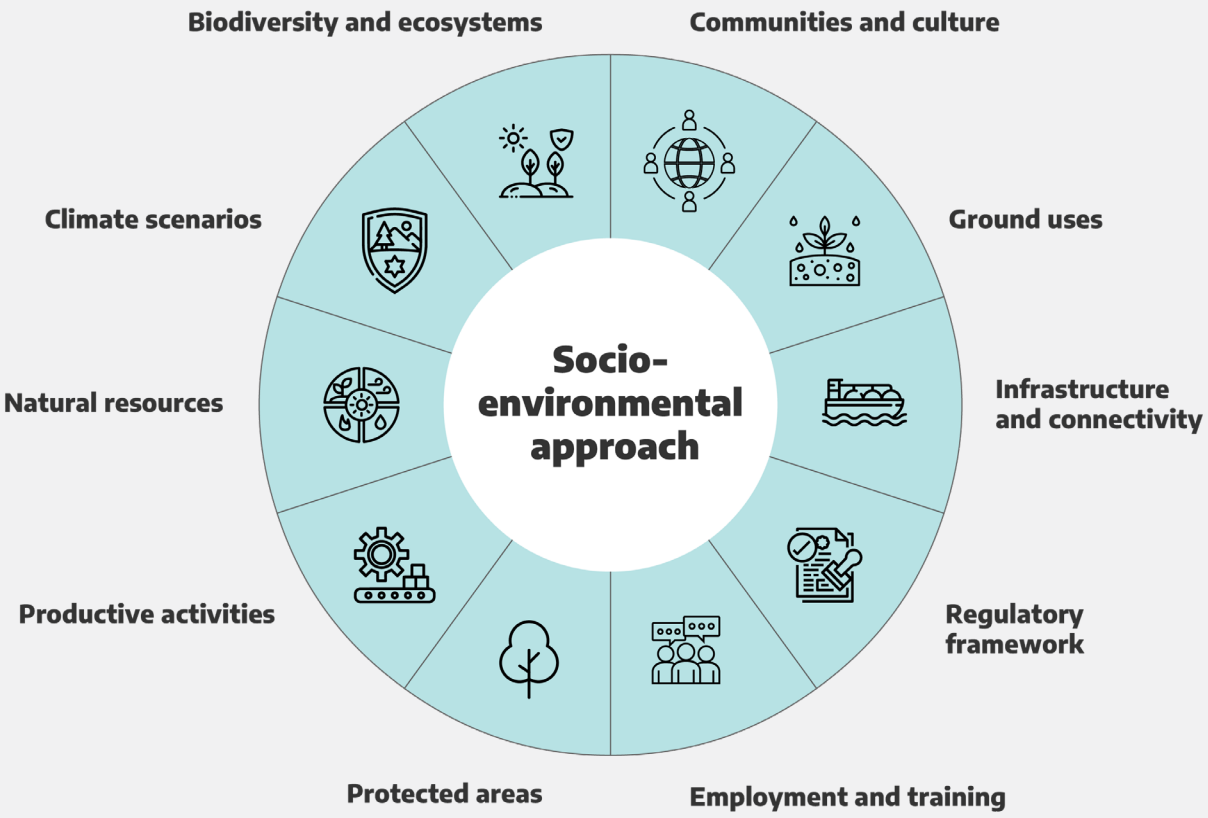
Strategic Environmental Assessment

In line with the technical guidelines developed by the Secretariat for Climate Change of the Argentine Ministry of Environment and Sustainable Development, the Secretariat for Strategic Affairs is in charge of the Strategic Environmental Assessment (SEA). This mechanism is essential in order to provide for a sustainable framework to the territorial deployment of the hydrogen economy.

Its implementation means developing a participatory and federal planning which provides for: (i) the collection and systematisation of information on socio-environmental variables potentially affected by the low-emissions hydrogen production; (ii) the implementation of a methodology of communication and consultation with the territory's stakeholders; (iii) the assessment of the results obtained in a multicriteria analysis that weighs the opportunities and the risks of the territorial deployment of the activity; and (iv) the elaboration of a follow up plan for future iteration of the SEA which provides for the enhancement of the available information and accounts for the progress of projects and/or implementation policies with regard to the hydrogen economy.

The implementation of this mechanism is consistent with the Argentine Republic's adherence to the Regional Agreement on Access to Information, Public Participation and Justice in Environmental Matters in Latin America and the Caribbean (better known as the "Escazú Agreement").

Socio-environmental approach



In 2030, Argentina will have revised and, if necessary, expanded the scope of the SEA to other territories and technologies with the goal of generating better conditions and practices in terms of communication and public participation.

Actions to Build a Sustainable Framework

- **Implementing the SEA and a follow up plan for future revisions.**
- **Promoting participation, communication and awareness associated with the production of low-emissions hydrogen in the national territory.**
- **Incorporating the participation of hydrogen projects into the implementation of the National Strategy of Carbon Market Use.**
- **Adding tools to the certification of origin scheme that enable estimating the low-emissions hydrogen contribution to the mitigation of climate change and to the sustainable development challenges.**
- **Identifying loopholes and promoting the creation of necessary regulations for an environmentally safe and efficient management of hydrogen and its derivatives, as well as storage places.**

International and Regional Cooperation Agenda

Latin America is a hydrogen exporting power. It is expected that the region can respond to more than 30% of Europe and Asia's demand. In this context, **the coordination and cooperation of Argentina with other countries in the region and its Mercosur partners will be a key element.** Some examples of regional coordination opportunities are the hydrogen harmonised certifications and the development of compatible technical, environmental and safety standards, the joint infrastructure and complementary supplier networks.

In addition, the fact that our country is far from the main global conflict points, has been in a peace zone with democratic governments for 40 years and has a friendly and collaborative coexistence as well as cooperative relations with the main economies in the world enhances Argentina and the region as a reliable option as energy supplier through hydrogen.

The country has a long history of cooperation in the region and with other partners such as Germany, Japan, among others. Within the context of Mercosur, cooperation with Brazil is of great significance because of its bonds as trade partners, the similarities in their industrial matrixes and their technical and scientific development.

Advancing cooperation projects to maximise the potential of the various available renewable energy sources in the region will be a strategic pillar in the cooperation field. There are various exploitation opportunities based on the interconnection capacity of the region, such as the joint hydropower plants located between Argentina, Brazil, Paraguay and Uruguay that could support pilot projects that require small volumes of hydrogen. Another strategic opportunity is the possibility of adapting the current gas pipelines between Chile and Argentina to transport pure hydrogen as part of a network that permits regional exports through the Pacific and Atlantic ports to the current gas pipeline networks that are in the process of expansion.

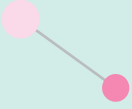
The coordination and complementarity dynamics will strengthen value proposals for the manufacture of parts, components or the assembling of equipment in a regional space, seeking to reach higher levels of vertical integration, creating value chains through scale economies that are attractive to investors and generate added value to the region.

> Articulating and collaborating with the region in regards to certifications, environmental standards, complementing of supplier networks, and infrastructure development are crucial for Latin America to establish itself as an export leader.

In addition, **regional coordination will be important to increase the influence capacity on the exchange process and the definition of standards, requirements and conditions that will be established to enter international markets,** to the extent that these countries, as potential exporters, can establish criteria that promote their future competitiveness.

Actions to Enhance International and Regional Cooperation

- **Consolidating Argentina's participation in international fora and other cooperation groups related to hydrogen and/or the energetic transition.**
- **Using the trade agreement network of Argentina, its participation in international platforms and its diplomatic relations to mobilise human and material resources that promote the deployment of the low-emissions hydrogen economy in the country.**
- **Promoting agreements for the regional supplier complementarity and development.**
- **Coordinating with regional countries productive, normative and trade strategies aimed at attracting FDI, making the most of institutional and political frameworks of regional integration.**
- **Working jointly with Mercosur partners in the technical definition processes related to technical certifications and rules on hydrogen, its transport and use.**



Expected Outcomes 2050

Costs **1,4 USD/kg** Green H2	**5 Mt annual** Total Production
4 Mt annual Exports	**82.000** quallity jobs
Certification of origen to access markets	**Strategic Environmental Assessment**
USD 90.000 millions Investment for H2 production	**Suppliers** and **1 MW National Electrolyzers**
30 GW Electrolyzers and **55 GW** renewables	**5 productive hubs** **2 to 5 ports** for H2 exports

Translated from Spanish. Buenos Aires, 12 September 2023.

Argentina
Presidency

Secretariat for
Strategic Affairs