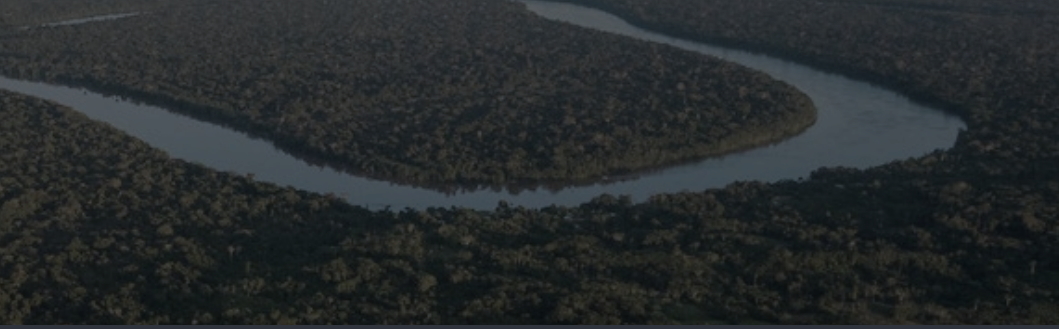
Machado Meyer ADVOGADOS

Green Hydrogen heats up

Regulation and market prospects

The hydrogen market has been heating up in recent years on the global stage. More recently, green hydrogen has been pointed to as an important tool for the global energy transition process, especially with a view to a low-carbon economy. It is essential for decarbonization of the economy – that is, for large-scale industrial application and in diverse sectors, as a carbon neutral alternative (CO_2). Produced sustainably, it stands in opposition to so-called gray hydrogen, more widely produced and more competitive today, and blue hydrogen.

As has been happening in Europe, we are living in a time when it has become essential to incorporate green hydrogen as a strategic component in the Brazilian energy matrix and design incentive and promotion mechanisms for its production chain.



Hydrogen is the most abundant chemical element in the universe, constituting approximately 75% of its elemental mass. It is known that stars, like the Sun, are formed mainly of this gas, which can also assume a liquid state. Hydrogen is also the most common element on our planet: its molecules are present in many of the chemicals used in our daily lives.

Hydrogen began to be used by humans as a gas for balloons and airships, since its mass is lighter than that of air. It has been replaced by helium, which is a less volatile and less flammable element.

HYDROGEN APPLICATION

Today, hydrogen is one of the main inputs of the industry, and is used in various productive sectors, with a range of functions:

Food industry: used, for example, in the production of hydrogenated foods such as margarine.

Agribusiness: used in obtaining ammonia (NH_3), the main raw material for fertilizer production.

Petrochemical industry: used in the process of improving fossil fuels, such as sulfur removal during fuel refining processes.

Mining: it has application in chemical reduction processes for metallic minerals, in addition to being important in welding metals. It is used in high temperature welding.

Technology: in its liquid form, it acts as a cooling agent and is used in the study of superconductivity, a process that requires very low temperatures.

Energy: it has great potential in the production of **nuclear energy** – hydrogen isotopes (deuterium and tritium) are used in thermonuclear power plants.

HYDROGEN APPLICATION

Hydrogen can be used as a **fuel**, especially in the space sector. Hydrogen batteries, also called fuel cells, are used to power the spacecraft's electrical system. The only product of this battery will be water (H_2O), which is then used for crew consumption.

Additionally, when hydrogen is used as a fuel, new technologies have been allowing it to be added to fossil fuels to reduce pollution from existing generation plants. When added to gasoline, for example, it increases energy performance and reduces carbon dioxide emissions. By adding approximately 5% hydrogen to gasoline, the reduction in gas emissions can reach up to 40%.

There are also hydrogen fuel cells for **generation of electricity**. These cells are extremely energy efficient, but still very expensive to produce. With the advance of new technologies, the prospect is that small cells may power electric cars, while larger ones can generate electricity.

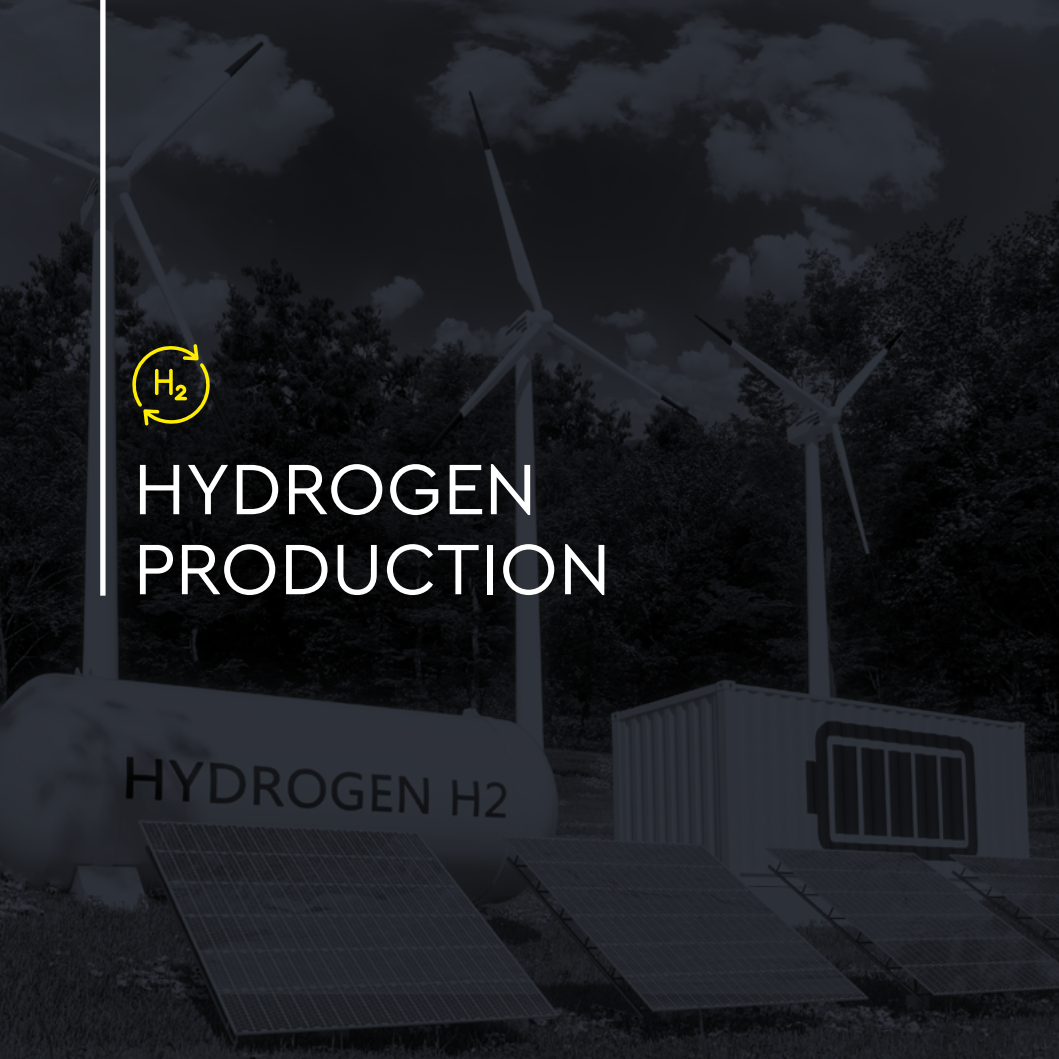
For the generation of electricity, hydrogen can be used for combustion in thermal power plants. This combustion is deemed clean, unlike with the burning of fossil fuels: in this process, hydrogen recombines with oxygen, generating basically only water and energy. Nitrogen oxide is also produced, but in small amounts, especially when compared to other fuels.

Hydrogen can be important for the generation of electricity mainly due to its great energy potential: its energy density is 38 kWh/kg, compared to 14 kWh/kg with gasoline.

In this sense, much has been said about hydrogen for **energy storage** in potential form. As occurs, for example, in hydroelectric plants, when there is no energy demand, water is maintained in elevated locations, generating potential energy.

Furthermore, the high energy density of hydrogen can lead to a more economical transport of this element. Natural gas pipelines could be used to transport hydrogen gas, but with lower pumping costs, as it would take only a third of the amount of hydrogen to generate the same amount of energy. Hydrogen pipelines appear to be a more efficient and cheaper alternative to transmission lines, used to send electricity over long distances.

Hydrogen can be stored in liquid form, with high energy potential, and is used for combustion in thermal power plants, according to demand for electricity.



HYDROGEN PRODUCTION

Although hydrogen is the most abundant element in our planet, it only exists in combination with other elements. It is in water, in association with oxygen, and combines with carbon to form hydrocarbons such as gas, coal, and oil. Accordingly, to be used in industry, it needs to be separated from other atomic components of molecules. The production of hydrogen in large quantities is one of the major challenges for the industry.

Hydrogen may be categroized in gray, blue, and green colors, according to its production form. Gray is used for hydrogen originating from fossil sources such as natural gas, oil, and coal; blue when generated by fossil sources, but whose emitted carbon is captured to neutralize the pollution generated.

To be considered green, hydrogen must be produced from renewable energy. It is obtained by an already well-known process, which consists of the use of electricity from renewable sources, such as wind, solar, and biofuels, to separate it from oxygen in the water molecule. This process is called electrolysis.

Currently, most of the hydrogen produced is generated from polluting sources such as carbonated coal gas, natural gas, and oil. According to the International Energy Agency, more than 90% of hydrogen used as fuel is produced from non-renewable sources. A very small portion is produced by electrolysis of water from renewable sources.

GREEN HYDROGEN

The Hydrogen Council, an initiative that brings together CEOs from 92 global companies, estimates that green hydrogen will account for about 20 percent of all energy demand in the world by 2050, creating a market valued at $2.5 trillion.

Green hydrogen will require 20% of the energy produced in the world by 2050

US$ 2,5 tri is the estimated size of the green hydrogen market by 2030

A few years ago hydrogen began to be produced from renewable energy sources, such as solar and wind, through electrolysis. This process consists of the use of electric current to separate water into hydrogen and oxygen, within a device called an electrolyzing device.

In addition to the industrial applications already addressed, green hydrogen can be used as an important source of clean energy. This is because its combustion basically releases water (H_2O), in the form of steam, and oxygen (O_2), i.e. does not produce carbon dioxide (CO_2).

The problem is that green hydrogen is currently still less competitive than gray hydrogen (produced from fossil energy). To make it more competitive, it will be necessary to install about 50 GW of water electrolysis over the next few years, according to calculations by the Hydrogen Council in partnership with the consulting firm McKinsey.This will require the development of new technologies. In this sense, the growing number of green hydrogen projects being developed in recent years should ensure that the volumes produced are large enough to provide scale to the fuel market. This is the conclusion reached in recent research by Wood Mackenzie, for which green hydrogen production costs are expected to fall 64% by 2040, equaling those of gray hydrogen and making it a competitive product. In some countries, such as Germany, which operates at the forefront of the sector, this will happen as early as 2030. The report states that green hydrogen projects jumped from 3.5 GW to more than 15 GW in 2020 alone. For Ben Gallagher, senior researcher at Wood Mackenzie and author of the report, the 2020s will be the decade of green hydrogen.

Green hydrogen projects jumped from 3.5 GW to more than 15 GW in 2020 alone.

Another factor that highlights green hydrogen is the rise in the price of fossil fuels, which should affect other forms of hydrogen. Although gray hydrogen is currently the most competitive, the report points out that its price is expected to skyrocket 82% by 2040, due to the increase in the price of natural gas – excluding China from the market. The cost of blue hydrogen is also expected to rise 59% by 2040.

The fall in energy costs from renewable sources per se and the improvement of electrolysis process technologies will also contribute to making green hydrogen competitive by 2030, according to the report *Green Hydrogen Cost Reduction*, of the International Renewable Energy Agency (Irena).

The same report by Irena points out some strategies to reduce production costs of green hydrogen, through a continuous process of innovation, capable of generating, for example, increased performance and expansion in the production scale. Among these strategies, the following stand out:

- increased capacity of electrolysis plants from 1 MW (typical potential in 2020) to 20 MW, which could reduce production costs by more than a third;
- increased production scale with automated processes;
- efficiency and flexibility in operations, observed that the supply of energy leads to large losses in efficiency at low load;
- diversification of industrial applications, so that the design and operation of electrolysis systems could be optimized for specific applications in different industrial sectors; and
- alignment of green hydrogen expansion with major international climate goals for reducing carbon emissions within a global energy transition program.

In addition to macroeconomic aspects and technological progress, government policies capable of generating national strategies to stimulate market growth in an orderly manner will also be needed. In this sense, the National Hydrogen Plan is being designed in Brazil.

POTENTIAL OF BRAZILIAN GREEN HYDROGEN

Brazil has been touted as the country with prospects of becoming the main power in the green hydrogen market. Considering, for example, the agribusiness sector, we can produce hydrogen from sugarcane and biodiesel alcohol, originating from soybean and sunflower, among other plants. Furthermore, the gasification of biomass and urban waste (biogas) can be used for the production of green hydrogen, especially in landfills and sewage stations.

Brazil has the potential to become one of the largest producers and exporters of green hydrogen in the world.

We are also one of the countries with the highest potential for renewable electricity generation in the world and with one of the lowest marginal production costs. Our energy matrix therefore makes Brazil a candidate to be one of the largest producers and exporters of green hydrogen in the world.

Brazilian industry also represents a significant domestic market and has the technology and a supply chain to sustain the new sector. In the domestic market, green hydrogen can be used, for example, by the oil and gas segment (transformation of oil into higher value-added products). It can also be used for the production of biodiesel from the hydrogenation of vegetable oils. Another potential sector is nitrogen fertilizers such as ammonia and urea. In this case, green hydrogen would contribute to reducing production costs of the agricultural sector, since 80% of the fertilizers used in Brazil are imported. There is also the possibility of using waste from pulp and paper production, from residual biomass of agriculture (such as sugarcane), and from biogas.

REGULATION OF GREEN HYDROGEN IN BRAZIL

It is not yet clear who will have the jurisdiction to regulate the hydrogen market. At the beginning of the year, the CNPE presented its Resolution No. 2 guiding the National Electric Energy Agency (ANEEL) and the National Agency of Petroleum, Natural Gas and Biofuels (ANP) to prioritize the allocation of research, development, and innovation funds to energy-related issues, including hydrogen. The various possible origins of hydrogen increase doubts regarding jurisdiction for regulation.

Hydrogen obtained from fossil fuels such as oil and natural gas would enter the scope of ANP regulation, under Law No. 9,478/97, according to which the ANP is the "regulatory body of the oil industry, natural gas, and its derivatives".

When obtained from water or even biofuels, hydrogen does not fit within this scope, as it does not originate from Federal mineral resources or the process of refining such mineral resources.

The Federal Government would still have legislative jurisdiction in the field of energy, but this does not automatically confer jurisdiction on existing regulatory agencies. Thus, regulatory jurisdiction must be based on an authorizing legal provision. This means that a law should be enacted to assign jurisdiction to a particular regulator.

The CNPE has general jurisdiction over energy as established in Law No. 9,478/97, as well does the MME, as set forth in Law No. 3.782/60.

With the national hydrogen plan being published by the end of 2021, the regulatory vacuum is expected to fill soon.

NATIONAL HYDROGEN PLAN

It has been often said that the development of the green hydrogen production chain must be done in parallel with the development of infrastructure and, more importantly, demand. This is mainly during the early stages of the sector, when the market is still in formation, a phase in which projects need to be developed at the same pace as demand, to ensure that that part of the production is absorbed.

There is already widespread interest from power utilities, steel mills, chemical companies, port authorities, car and aircraft manufacturers, shipowners and airlines, among others, but industry experts warn that the technology will not increase scale without the support of various stakeholders.

In government terms, actions to promote production would have an impact only on the preliminary stages of development of the sector. It is also necessary to adopt initiatives such as regulation and market financing, both to form it and for its expansion process. For Irena, governments should also take a flexible approach, with frequent review of strategies and targets to consider market development.

The Brazilian government has already mobilized to this effect, as shown in the timeline below:

TIMELINE

February 2021

CNPE Resolution No. 2

Establishes guidelines regarding research, development, and innovation in the energy sector in Brazil.

Article 1. Guide Aneel and the ANP on prioritizing the allocation of funds to R&D for (...) I – hydrogen; IV – energy storage;

April 2021

CNPE Resolution No. 6

Provides for the performance of a study to propose guidelines for the **National Hydrogen Program**

MME, in partnership with the MCTI and MDR, and, further, with the technical support of the EPE, presents the guidelines for the program

The guidelines should provide for security norms, regulatory designs, and a structure that allow for competitiveness for the large-scale use of hydrogen

June 2021

Presentation of the National Hydrogen Program

December 2021

NATIONAL HYDROGEN PLAN

By the end of June, we will have the first outlines of what the National Hydrogen Plan will be, which should regulate the development of the hydrogen production chain in Brazil.

A Resolução nº 6/21 do Conselho Resolution No. 6/21 of the National Energy Policy Council (CNPE) provides for a study to propose guidelines for the National Hydrogen Plan. The Ministry of Mines and Energy (MME), in partnership with the Ministry of Science, Technology and Innovations (MCTI) and the Ministry of Regional Development (MDR), and also with the technical support of the Energy Research Company (EPE), will have two months to present the guidelines, which should provide for safety standards, regulatory designs, and a structure capable of promoting the competitive use of hydrogen on a large scale.

The CNPE, through Resolution No. 6/21, provides that the National Hydrogen Program must take into account:

1. The national interest in developing and consolidating the hydrogen market in Brazil and the national placement of Brazil on competitive economic bases;
2. The inclusion of hydrogen as one of the priority topics for investment and research, development, and innovation;
3. The importance of hydrogen as an energy vector, contributing globally to the low-carbon energy matrix;
4. The interest in international cooperation for technological development of the market for production and energy use of hydrogen;
5. The diversity of energy sources available in Brazil for production of hydrogen;
6. The technologies associated with this energy vector already developed and under development in Brazil;
7. The diversity of applications for hydrogen in the economy;
8. The potential for internal demand and for exportation of hydrogen in the context of energy transition;
9. Brazil's leadership in the topic "Energy Transition" in the United Nations High Level Dialogue on Energy

GREEN HYDROGEN PROMOTION INITIATIVES

In addition to the guidelines being defined for the National Hydrogen Plan, there are already various mechanisms to stimulate the renewable energy market that could be replicated for the green hydrogen market.

Based on this, we have developed some initiatives to promote the sector to be proposed to the CNPE. They will be the subject of the weekly articles of our **Green Hydrogen Series**.

Our Infrastructure and Energy team has been seeking dialogue with development players in the sector and outlining initiatives that can contribute to the National Hydrogen Plan.

The following stand out:

- regulations pricing environmental benefits from renewable sources;
- market reserve mechanisms for special energy in order to ensure part of the demand;
- regulated energy auctions to ensure the future purchase of green hydrogen – similar to the current model for energy auctions in Brazil;
- policies for the introduction of green hydrogen as a means of storing electric energy;
- inclusion of green hydrogen in RenovaBio, allowing the bookkeeping of CBios to reward the positive externalities of reducing carbon emissions;
- encouraging the financing of green hydrogen projects, designing, for example, mechanisms for access to incentivized debentures; and
- definition of policies to stimulate the creation of hubs for production of green hydrogen.

Follow our **Green Hydrogen Series** to learn more details about each initiative.


THE VANGUARD
IN THE GREEN
HYDROGEN MARKET
IN THE WORLD

The main players already envision potential for the application of green hydrogen in four main areas:

- hydrorefining oil to transform the heaviest oil into higher value-added products (such as gasoline and diesel), as well as removal of sulfur from petroleum products;
- production of hydrogenated fertilizers (ammonia and urea); and
- production of green diesel from the hydrogenation of vegetable oils.

For energy storage, not only are there workarounds, but they also take advantage of seasonal moments of renewable energy sources, such as wind and water (which can face prolonged periods of drought). Any surplus energy can be used locally to produce green hydrogen, later usable in energy production in times of scarcity.

Thyssenkrupp, a German conglomerate in more than 60 countries, boasts about 600 projects worldwide with a total installed power of 10 GW. It participates, for example, in the development of the world's largest green hydrogen plant, which is expected to go into operation in Saudi Arabia by 2025.

Siemens Energy is also already negotiating with Brazilian industries interested in pioneering the use of green hydrogen and is expected to announce its first pilot projects soon. The company's chief operating officer for Brazil foresees the use of green hydrogen, especially in the segments of thermal generation, steel, pulp and paper, and transportation.

THE VANGUARD IN THE GREEN HYDROGEN MARKET IN THE WORLD

The magazine Forbes called green hydrogen "the energy of the future". Initiatives to stimulate the market for this product can be seen around the world. Germany has already taken its first steps in this direction. The country last year established its National Hydrogen Strategy, which aims to invest 9 billion euros in projects on German soil and in other countries in order to ensure supply to the domestic market.

Meanwhile, the European Union has committed to investing $430 billion in green hydrogen by 2030, installing 40 GW electrolyzers over the next decade. The goal is to achieve a carbon-neutral economy by 2050. Already in the United States, President Joe Biden has promised an energy plan to ensure that the market has access to green hydrogen at the same cost as conventional hydrogen within a decade.

We highlight below some countries that have been exercising leadership in this market.

Australia

The country's production plans include construction of five megaprojects based especially on wind and solar energy. The largest project in the world today is the Asian Renewable Energy Hub in Pilbara, which is expected to build electrolyzers with a total capacity of 14 GW. The project is expected to receive $36 billion in investments and be operating by 2028.

Holland

The Anglo-Dutch oil company Shell leads with other developers the NortH2 project in The Port of Ems, involving 10 GW of electrolyzers, which use offshore wind power.

Germany

The largest project in the country is AquaVentus, with a planned capacity of 10 GW by 2035. The project is led by a consortium of 27 companies, research institutions, and organizations, and will be based on wind energy.

China

Today the world's largest producer of gray hydrogen, China has taken its first steps into the green hydrogen market with the construction of a megaproject in Inner Mongolia. The initiative is led by state-owned concessionaire Beijing Jingneng, with investments expected at $3 billion to generate 5 GW from wind and solar power. The project is expected to go into commercial operation in 2021.

Saudi Arabia

The Helios Green Fuels project will be based on the futuristic "smart city" of Neom, on the shores of the Red Sea. The project is expected to receive investments of US$ 5 billion and install 4 GW of electrolysis capacity by 2025.

GREEN HYDROGEN MARKET IN BRAZIL

Brazil is also developing projects and partnerships for the expansion of the green hydrogen market. The newly constituted Brazil-Germany Alliance for Green Hydrogen, created by the private sector to mediate the purchase and sale of the product between the two countries, reinforces Brazil's role as a global supplier of green hydrogen.

In the national green hydrogen race, the state of Ceará comes out ahead. The state government, in partnership with the Federation of Industries of Ceará (Fiec), the Federal University of Ceará (UFC) and the Pecém Complex, recently launched the Green Hydrogen Hub. It is an industrial complex, to be built in the Port of Pecém, which can produce 900,000 tons of the product per year, in a potential area of 200 hectares and with an electrolysis capacity of 5 GW.

Source: Northeast Diary

The project will not have public investment, but the State of Ceará promises to promote public policies for renewable energies for sustainable development in the region.

The Pecém Complex signed memoranda of understanding with three major companies in the sector to ensure investments. The first was with the Australian company Enegix, which will invest US$ 5.4 billion. White Martins is the second company to make a partnership official for the project. Australia's Fortescue Metals Group, in the mining business, is also negotiating with the Government of Ceará to deploy another green hydrogen plant in the Pecém Complex, with a potential investment of US$ 5 billion.

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