EBOOK — JUNE 2021

H2 Green Hydrogen

Green H_2 : myth or reality?

John Cockerill, leader in the energy transition

johncockerill.com

John Cockerill

H2
Green Hydrogen

Hydrogen has always existed!
Previously, it was grey
Today we talk of blue, yellow or even green hydrogen.

Hydrogen is the most widespread element in the Universe.

It is the principal component of the stars and the gaseous planets and the lightest element in the periodic table. The sun itself is even made up of 75% hydrogen and as a result, the energy which comes down to earth is already hydrogen-based. In general terms hydrogen is rarely found in a pure state, and this is true on earth. It is normally in combination with other atoms such as oxygen in water (H_2O) or carbon in hydrocarbon (CH4, C2H6 ...).

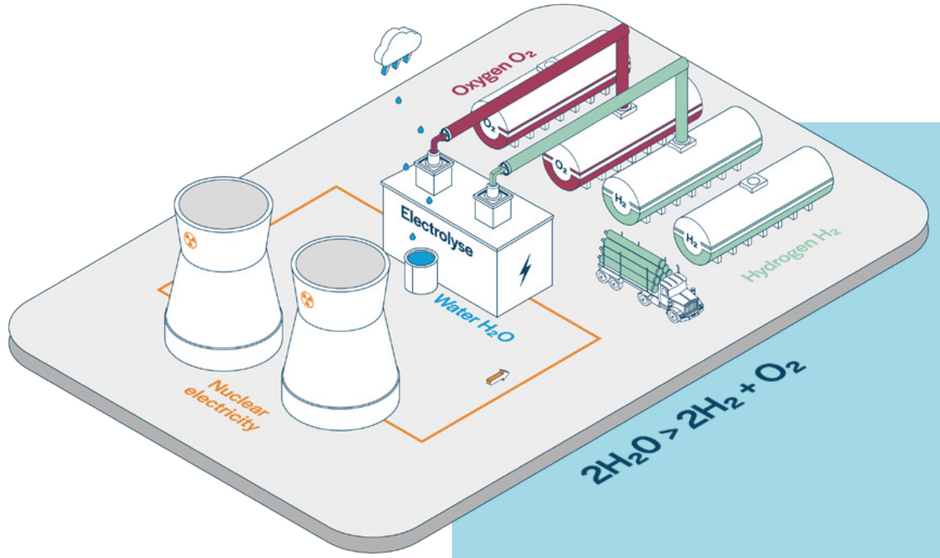
Hydrogen is found in various forms:

— 01.
Natural state :

- **White :** Gaseous in its natural state (rare), when two hydrogen atoms come together, we then speak of 'dihydrogen'.

— 02.
Transformation of carbon into gas:

- **Brown :** hydrogen created from lignite (brown coal).
- **Black :** hydrogen created from bituminous coal. These two processes are very old and extremely polluting.



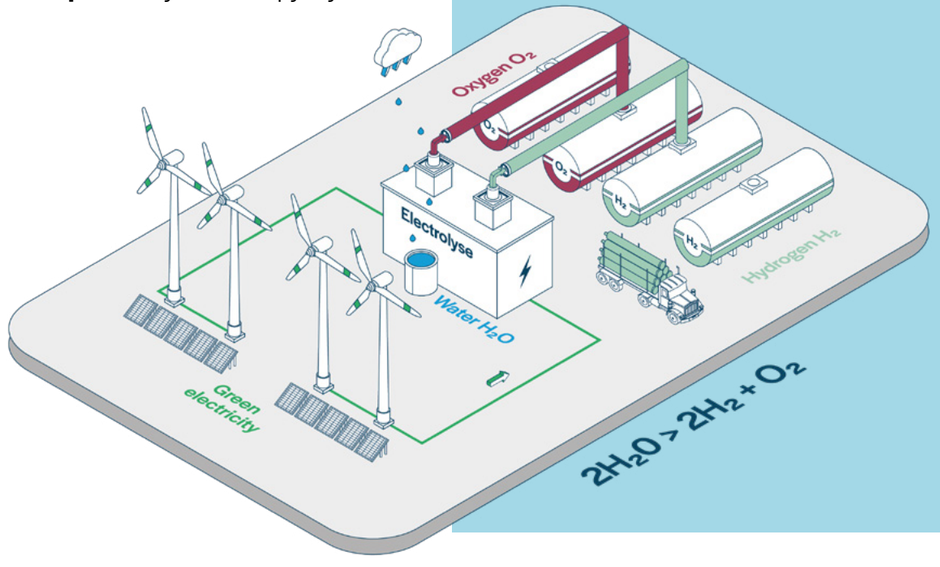
— 03.
Biomass transformed into hydrogen by gasification:

- **Grey :** production from natural gas (vapor-formation) or produced from fossil fuels.

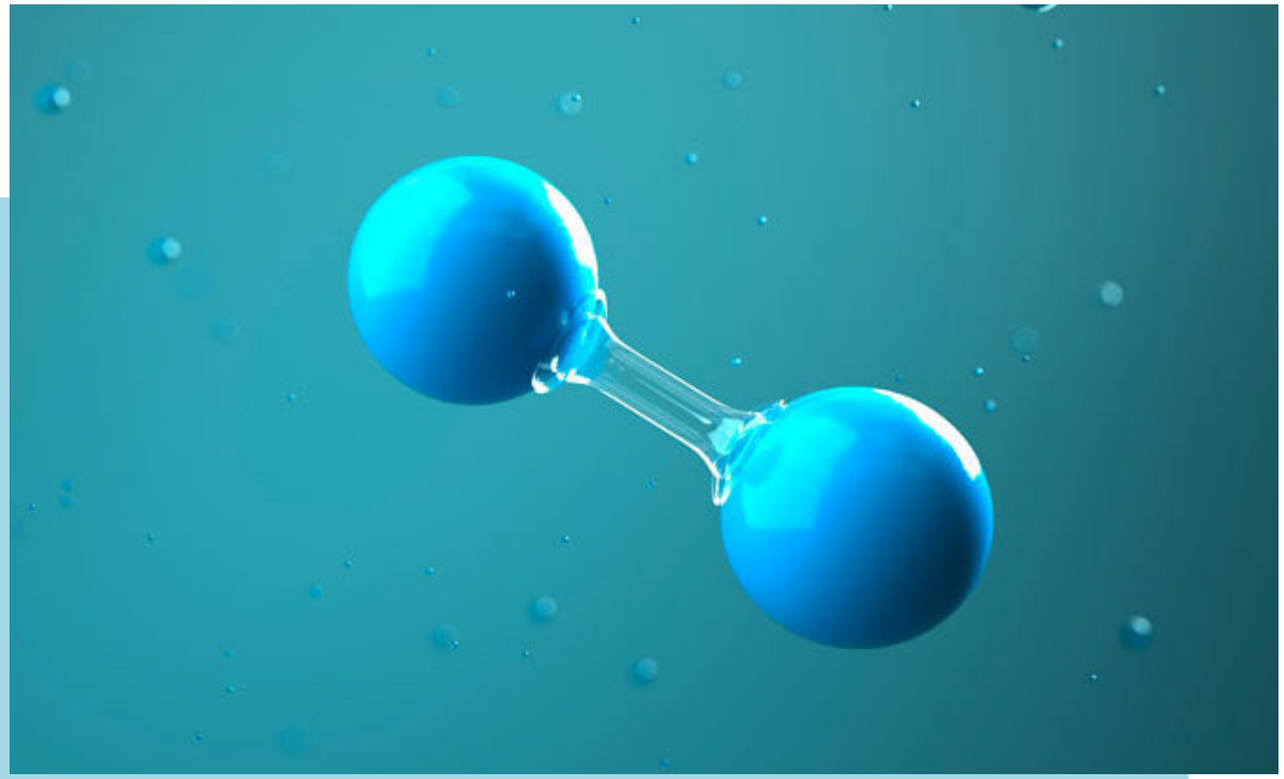
  Grey when the CO_2 emitted is not captured.
- **Blue :** also via vapor-formation but the CO_2 emissions are captured and stored in the ground (10% to 20% cannot be captured).
- **Turquoise :** by methane pyrolysis.

— 04.
By water electrolysis, two colors depending on the energy source used:

- **Yellow :** nuclear energy source.
- **Green : 'clean hydrogen' from renewable energy sources.**



Why are we so interested in **hydrogen today?**



Hydrogen was already used to inflate the Zeppelins of the 1920's. It is widely used today in the chemical and petrochemical industries. In the future, hydrogen will also be able to be used to store electricity even if this is not is primary vocation.

Hydrogen is the ultimate decarbonated gas : it contains no carbon at all, and burning it generates only water!

As a fuel, hydrogen thus has several virtues :

- **Mobile applications :** fuel for cars, trucks and buses, but also for ships, for which connecting to an energy network on the open seas is difficult.
- **As a replacement for natural gas :** although we still talk today of blending, the idea is to move to 100 % H_2 gas in the medium term.
- **Energy source :** hydrogen can be transformed into electricity when renewable energy sources do not produce sufficient electricity to meet market needs. Hydrogen is the ultimate decarbonated gas: it contains no carbon at all, and burning it generates only water!
- **Use within industry :**
  - Production of green steel, by replacing the coke with hydrogen, water is generated instead of CO_2.
  - In industrial processes which generate CO_2. A good example of a project in this domain is the Columbus project, undertaken by Engie, Carmeuse and John Cockerill.

  ➔ It is therefore easy to understand the importance of this element within the framework of the challenges facing our world.

In the future, hydrogen will also be able to be used to **store electricity even if this is not is primary vocation.**

Hydrogen is not a new technology, **what is new is that it is green.**

And indeed, in the past 100mWe projects had already been constructed as long ago as...1975! But at that time, we were not yet talking about green hydrogen.

The production of hydrogen from water – electrolysis – takes a great deal of energy. If hydrogen is back on centre stage, this is essentially for two reasons :

➔ **The cost of green electricity** has plummeted over the past two decades. It is thanks to the rapid growth and development of renewable energy production sites that we can now talk about green hydrogen. This is in fact the result of a process which exclusively uses, in the case of green hydrogen, renewable energy.

➔ **The necessity of arriving at a 'carbon-free' world by 2050.**

The race for green hydrogen starts today.

Is this really the Holy Grail? All of the recovery plans are putting their stakes on it. And where there's a race, there's business...

Most industrial groups have begun working on green hydrogen or are about to do so. The market is indeed enormous and demand is going to largely outstrip supply. The cake can therefore be divided into several slices and everyone wants to get hold of theirs.

Governments believe in it, enterprises are setting out on it, **car manufacturers are moving to it...**

➔ **Numerous support plans have recently been launched** and others, even more ambitious, are certain to see light of day. And in fact, in view of the beneficial impact of green hydrogen, it would b a pity not to take advantage of it.

➔ **Car manufacturers,** now focused on electrification, are gradually beginning to look at the question of hydrogen power, which would greatly reduce the pollution from current vehicles. The pollution would then be concentrated in the manufacture of the vehicle and no longer in its use.

➔ **The business** predicts that in a first stage hydrogen would be used in heavy vehicles within captive fleets such as waste collection trucks, buses etc. This would speed up the development of charging stations which would later be used to refuel lighter vehicles such as cars, motor-bikes etc.

➔ **The Tokyo 2022** project is already scheduling for the bus fleet used on the Olympic site to run on hydrogen. And among cars which are fuelled by hydrogen, the Toyota Mirai is already on our roads.

Hydrogen remains expensive at the current time.

It still needs subsidies in order to be competitive...

Processes such as water electrolysis in an alkaline environment have been in existence for a long time, but in all cases the cost of the equipment and of the process itself is currently preventing a profitable business plan to be achieved. It is therefore imperative that governments support this development in order to bring down costs and enable the market to be self-sufficient.

Several points : Today, the cost of green electricity represents around 70%of the cost of production of green hydrogen.

By 2030, a combination of the lowering of the cost of the electricity produced from renewable sources with a reduction of the cost of electrolysers and increased efficiency, should enable green H_2 to be competitive in the face of grey H_2.

In order to arrive at this profitability, enterprises need subsidies so that they can be competitive in the short term and arrive at sufficient volume to be able to mass produce.

Why is Australia a key candidate for the production of H_2?

Energy export

- Abundant renewable energies along with vast and cheap land resources.
- Very high level of direct sunlight.
- Prevailing winds.
- Geographical proximity to all of the major Asian H_2 importing countries: Japan, South Korea, China, Singapore and other countries in South-East Asia.
- An established production base in the domains of oil and gas with existing pipe-line and other infrastructures.
- A qualified labor force with a high level of expertise in the domains of oil and gas.

National economy

- The Paris Accord: by2030, a reduction of 26 to 27 % in CO_2 emissions compared to the 2005 level.
- Australia has very low levels of fuel reserves, just 21 days for diesel in 2018, and is looking for an Australian solution.
- The production of hydrogen can be coupled with existing gas infrastructures, with transport facilities and with other applications.

Stabilizing the network

- Due to the substantial increase in renewable electricity and to the decline in the use of coal as a basic fuel, Australia needs to stabilize the network.

Creation of green heavy industry

- Given that renewable energy is set to become an inexpensive commodity, iron and aluminum transformation, along with other high energy use industries, will doubtless come back to Australia, whereas they are currently principally active in China.
- The objective is to benefit from this cheap energy and to take full advantage of the emerging green markets in Europe, such as green aluminum, which is now quoted on the London stock exchange.

How **John Cockerill** is responding to this demand and **taking part in this dynamic**

John Cockerill is assisting in the energy transition by developing innovative technological solutions for different industries. By participating in the development of renewable energies- green hydrogen in particular – the Group is playing its part in the fight against climate change.

A key player in the ecological transition.

From its very foundation more than 200 years ago, **John Cockerill** positioned itself with steam as a key player in energy and mobility. Over recent years, the Group has been especially concentrating on renewable energies with the development of boilers for thermo-solar power plants and equipment for storing green electricity. Thanks to a co-enterprise with Chinese group Jingli, **John Cockerill** has also set out on the path of developing solutions for the production and storage of green hydrogen.

A pioneer in **green hydrogen**

Faced with ecological urgency and the necessity of reducing CO_2 emissions, hydrogen is a promising sector which could contribute to decarbonating transport and industry. As a pioneering enterprise, **John Cockerill** manufactures electrolysers and storage solutions which benefit more than 1,000 clients in different industries. The enterprise also offers the most powerful pressurized electrolysers on the market, capable of producing up to capable of producing up to 5 megaWatts (mW).

A European subsidiary for electrolyser production.

To respond to the needs of European companies and assist in the energy transition, **John Cockerill** is going to invest almost 100 million Euros to set up a 100% European subsidiary for electrolyser production. With this subsidiary, which is scheduled to be operational in 2023, the ambition of **John Cockerill** is to become the leading European volume producer of electrolysers.

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How does **John Cockerill stand out** in this domain?

John Cockerill is a pioneer in the manufacture of large size electrolysers (5mW) and has not finished in this domain. For indeed, numerous large scale projects of the future will require large scale units in order to optimize the size of the installations, their management and their maintenance.

John Cockerill is world leader in the production of alkaline electrolysers with a 20% market share in 2019 (according to BNEF).

John Cockerill has one of the largest electrolysers available on the market. Today, 14 of these large size electrolysers are installed and functioning across the world.

John Cockerill across the world

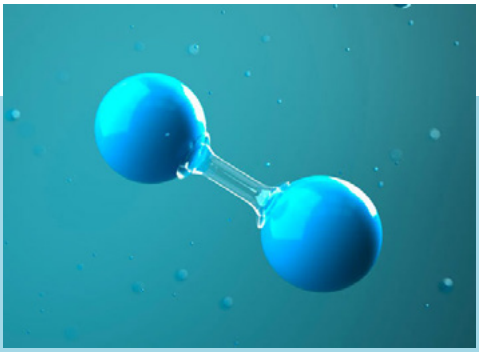
In what way is green hydrogen a reality for **John Cockerill?**

Leader in the energy transition

John Cockerill Hydrogen offers efficient and reliable solutions for the production of green hydrogen and responds to the whole of the needs of the major players in industry, mobility and energy. Staying true to its pioneering spirit, John Cockerill has already delivered electrolysers to more than 1,000 clients in different sectors of activity. Today, the enterprise supplies electrolysers among the most powerful on the market, capable of producing up to 1,000 Nm^3 per hour.

John Cockerill,

for solutions which are ever more reliable, higher peforming and more respectful of the environment.



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