The future is green ammonia

Ammonia is a building block gas. It can be used as a neutraliser, stabiliser, refrigerant, and fertiliser, and in any number of industries and processes, as well as being a fuel in its own right. It is also tipped to become the most efficient carrier method for hydrogen. Several green hydrogen-ammonia projects have gained traction in recent months.

By Ellie Pritchard

Image source: Dreamstime

One such project is the Donaldsonville Complex in Louisiana, operated by CF Industries. Building on the company's flagship nitrogen complex in Donaldsonville, the company intends to install an electrolysis system which will generate carbon-free hydrogen. An estimated 20,000 tons of green ammonia will be produced per year after its completion, which is anticipated in 2023.

The company's commitment to the global green revolution is demonstrated by its re-branding in March of this year, as its website explains a refreshed logo: "[It represents] a stylized ammonia molecule, the base product we manufacture, firmly rooting us in our future as a company producing decarbonized ammonia for energy, fuel, fertilizer and emissions control."

The benefits of ammonia

- The molecule (NH_3) has a higher volumetric energy density than hydrogen
- Ammonia can be transported at -33 degrees Celsius, far more conducive than the minus 253 degrees Celsius required when transporting hydrogen
- The molecule does not contain any carbon
- It is possible to produce ammonia on a larger scale using renewable energy. This is not the case with other e-fuels

Road to sustainability

There are several challenges for CF Industries and other companies to venture into green or (more) sustainable ammonia. Most importantly, the current manufacturing process is not sustainable. The necessary hydrogen is produced through steam methane reforming (SMR) and accounts for 90 per cent of the carbon dioxide emissions from the entire process. The current process is energy-intensive, inefficient and produces roughly 1.8 per cent of global carbon dioxide emissions.

However, projects like the Donaldsonville plant aim to turn this around by scrapping the traditional SMR-method to produce the hydrogen via electrolysis. This is then fed into the Haber Bosch process, in which hydrogen and nitrogen (having been separated from air) react with each other at high temperatures and pressures to produce ammonia. This must all be powered by sustainable electricity to make this process to be considered "green".

As part of its sustainability goals, CF Industries will also produce blue ammonia, in which carbon dioxide sequestration and other carbon abatement methods will be used to offset the carbon emissions of the conventional SMR-process. The company intends to reduce its CO_2 emissions by 25 per cent by 2030 and reach net-zero carbon emissions by 2050.

Blue, turquoise and green hydrogen

If net-zero targets are to be achieved by 2050, the amount of carbon dioxide used in the production of ammonia must be reduced. The best way to do this is to look at low-carbon to carbon-free hydrogen, typically referred to on a range from grey to green.

Grey:
Although the gas itself is clean, the process for manufacturing hydrogen and transforming it into a usable product is not. 95 per cent of the world's production is grey hydrogen, which uses methane as a natural gas and produces carbon waste. It is the least sustainable form of hydrogen production but currently the cheapest.

Blue:
One step up from grey hydrogen, blue hydro- gen is produced by separating natural gas into hydrogen and CO2. The CO2 is captured and stored.

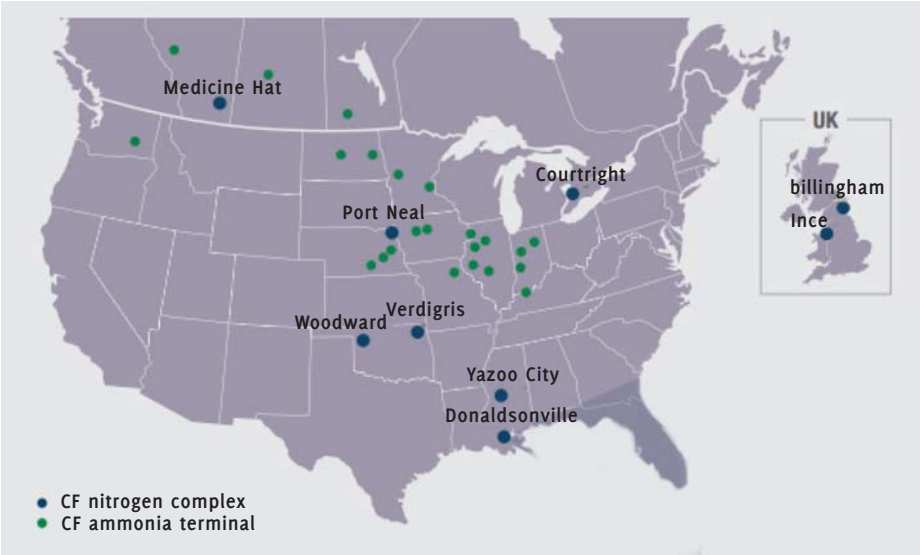
Turquoise:
Somewhere between green and blue hydro- gen sits 'methane pyrolysis'- or turquoise hydrogen. This method also uses methane as a feedstock, but is driven by heat in- stead of fossil fuel combustion. The carbon output of turquoise hydrogen is in solid form, and therefore doesn't require CCS. Instead, the by-product can be used in other applications such as the manufacturing of products such as tyres.

Green:
The most climate-neutral method of producing hydrogen is through electrolysis of water, breaking down water molecules into hydrogen and oxygen using renewable electricity. At the moment, green hydrogen production is expensive and uses a huge amount of electricity. According to Forbes, however, green hydrogen production costs have fallen by 40 per cent since 2015 and are expected to decline by a further 40 per cent through 2025.

Long-term investment

According to the American Chemical Society (ACS), CF Industries will spend over $100 million over the next three years on the Donaldsonville plant. Although an expensive investment (it costs two to four times as much to make green ammonia as it does to produce the standard version), CF Industries estimates that its sale price could eventually reach $2,200 per metric ton in the alternative energy marketplace, roughly eight times as much as conventional.

To accommodate the amount of electricity required for the electrolysis process, CF Industries will allocate renewable energy purchased across its network from available grid-connected sources to match 100 per cent of the electricity needed by the electrolyser to separate water into carbon-free hydrogen and oxygen. According to the company's website, "the electrolyser will be integrated into existing ammonia plants at Donaldsonville where atmospheric nitrogen will be fixed with the carbon-free hydrogen to produce green ammonia".



CF Industries' ammonia network. Source: cfindustries.com

Pivotal technology

In April this year, CF Industries signed an engineering and procurement contract with thyssenkrupp to supply the project with a 20 megawatt (MW) alkaline water electrolysis plant. According to thyssenkrupp's statement on hydrogen, the Donaldsonville project is one which aligns with the group's outlook on electrolysis.

"Water electrolysis is the pivotal technology for the decarbonization of the industrial sector. It is the only scaled technology for producing green hydrogen so far," says Head of Green Hydrogen at thyssenkrupp, Dr Christoph Noeres. "Green resources are only economically feasible if they are both produced and used on an industrial-scale, as upscaling improves cost structures. thyssenkrupp's water electrolysis offers the worldwide biggest standard modules, that can be combined easily up to multimegawatt and gigawatt installations."

Outlook for green ammonia

CF Industries' CEO, Tony Will, is reported by the ACS as saying: "Up to this point, we have made a business by selling the nitrogen value of the molecule. What's really exciting is now there is an opportunity and a market that values the hydrogen portion of the molecule".

Image source: Shutterstock

In 2020, Will shared his enthusiasm for ammonia in a conference call with stock analysts. He advised that CF Industries anticipates hydrogen to provide 20 per cent of the world's energy by 2050, a huge increase from the less than 1 per cent of today. Ammonia would be an ideal partner in this endeavour. "It is clear that the world needs clean energy," Will said. "Hydrogen has emerged as a leading clean energy source to help the world achieve net-zero carbon emissions, and ammonia is one of the most effective ways to transport and store hydrogen."

But the birth of an ammonia fuel industry won't be simple as there also remains the question of how to harness the molecule as a fuel. Technologies such as ammonia-burning engines are still in the experimental stages, although progress has been made. Certain projects include Finnish company Wartsila's ammonia-fuelled four-stroke engine which will be tested this year, and MAN Energy's two-stroke ammonia engine.

References:

- "Green Hydrogen, The Fuel Of The Future, Set For 50-Fold Expansion" - Mike Scott, Forbes 2021
- CF Industries