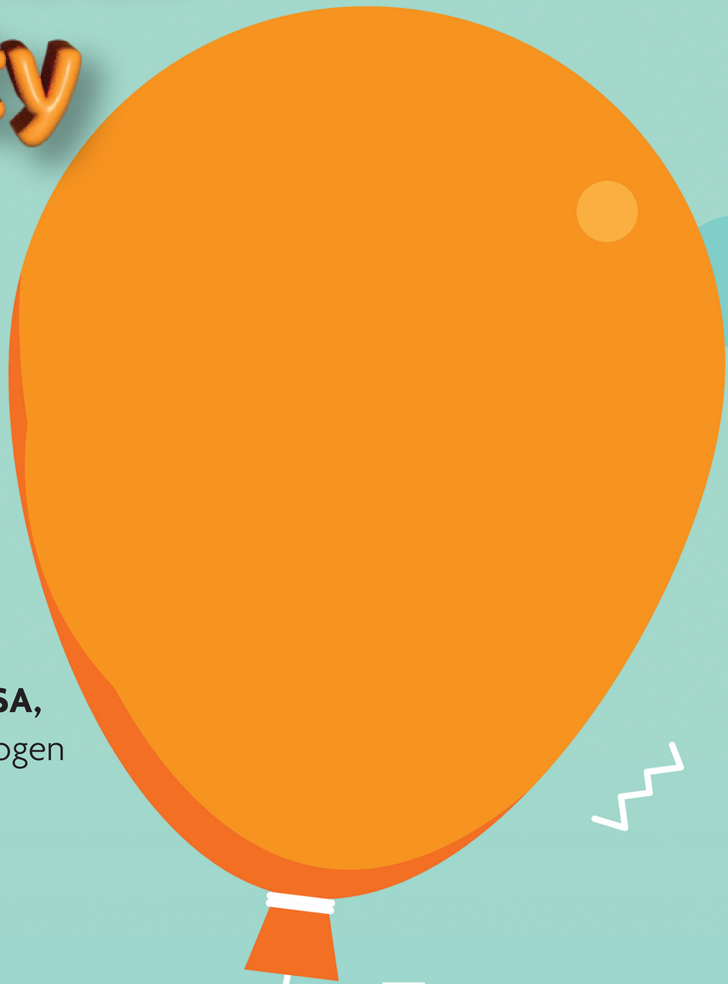
Maximising Hydrogen Electrolyser Capacity



Todd Cartwright, Nel Hydrogen, USA,
examines why the capacity for hydrogen electrolysers must be increased.

According to Statista, the global green ammonia market stood at around 5800 t in 2021, an increase of 3700 t from the previous year. Over the next decade, this figure is forecast to increase at a compound growth rate of 90%, reaching approximately 1.6 million t by 2030.[1] As roughly 80 – 85% of all the ammonia produced is used in the fertilizer industry, the pressure is on in virtually every market sector in the world to reduce fossil fuel usage and carbon emissions. To that end, different countries have different policies and incentives to promote the development and use of green ammonia.

Global development

In Europe, the EU Renewable Energy Directive will require 42% of ammonia to be green by 2030 – just six years from now. This regulation will also introduce a carbon border adjustment mechanism which will force ammonia and fertilizer importers to report emissions and pay a carbon tax at the border.

In India, the government has announced a new green hydrogen policy which offers a range of incentives to green hydrogen and green ammonia manufacturers, including allocation of land in renewable energy parks, waiving of interstate transmission charges for 25 years, and banking of renewable power for up to 30 days. The policy also aims to create bulk demand and scale up green hydrogen by specifying a minimum share of consumption by designated consumers as energy or feedstocks. In Canada, the government has launched a hydrogen strategy which includes investing in blue hydrogen projects that use natural gas with carbon capture and storage technology. The strategy also supports the development of green hydrogen projects that use renewable electricity to produce green ammonia.

These are just some examples of how governments around the world are trying to encourage the use of green ammonia.

Figure 1. Containerised PEM electrolysers are capable of producing 500 m^3/h or over 1 tpd of hydrogen.

Figure 2. The 20 MW PEM plant at the Iberdrola-Fertiberia facility in Puertollano, Spain, featuring Nel electrolysers, is the largest electrolysis plant currently in operation providing green hydrogen for green ammonia production.

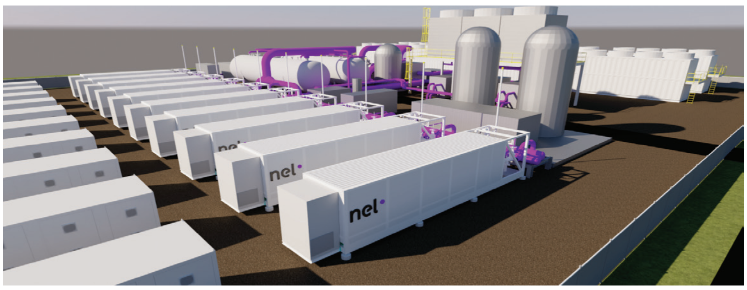


Figure 3. Nel's 10 MW PEM stack modules (PSMs) are containerised cell stack systems, and offer a plug and play subsystem for larger electrolyser plants, shown here in a 100 MW plant configuration.

Electrolysis

Green hydrogen is the feedstock that enables green ammonia. Hydrogen plays a vital role in ammonia production, as it is the main reactant for the Haber-Bosch process, which converts atmospheric nitrogen and hydrogen into ammonia. Hydrogen can be produced from various sources, including water electrolysis. This process uses electricity to split water into hydrogen and oxygen. The advantages of this method are that it produces pure hydrogen without any carbon emissions or by-products. When the electricity source for the electrolyser is carbon free, then the ammonia production process is carbon free.

There are two types of electrolysis systems that are generally considered commercially mature today. One is alkaline electrolysis, and the other is proton exchange membrane (PEM) electrolysis. There are other types in development which also show promise for the green ammonia industry, such as solid oxide, but for now alkaline and PEM are the field-proven methods. Alkaline technology has historically been used for large capacity hydrogen plants. Alkaline cell stacks costs less on a per kW basis because they do not use precious metal catalysts as PEM does, and alkaline equipment has been commercially deployed for almost a century. PEM electrolysers are compact and can ramp up quickly with variable energy sources. They can also achieve a similar range of hydrogen production, up to thousands of kilograms each day. Contrary to common belief, PEM electrolysis is a long-proven technology, and has been operating in the field commercially for about 50 years.

Electrolysis begins with the electrolyser's cell stack. That is the technology core of the electrolyser, akin to a computer chip or a car's engine. Each cell stack is made up of many electrolytic cells, each of which is an electrochemical reactor. Add water and a DC power source, and the cell stack creates hydrogen and byproduct oxygen.

There are several advantages of containerised PEM electrolysis. They include predictable availability and limited on site integration risk. The equipment is made in a factory; it is not assembled in the field. There are minimal technology and supply chain risks. There are also minimal infrastructure requirements in the field, in particular the cost of a building. Basically, the needs are deionised water, electricity, the ability to dispose of waste water, and the downstream gas and water processing. Highly skilled tradespeople are not necessary to do field fabrication and integration, and systems can be installed quickly and seamlessly.

Because the systems are highly standardised, companies receive an assured level of support from manufacturers who have made hundreds of such systems. It is believed that PEM electrolysers, at least initially, will play the larger role when coupling to renewable energy sources, because of their ability to respond instantly to electrical supply changes and downstream process needs.

Ramping up

To match the ramp-up of hydrogen needs for the green ammonia market and others, the electrolysis industry is investing to meet these growing needs.

Several projects are underway around the world to ramp up green hydrogen and green ammonia supply. It starts with the foundational infrastructure. As an example, Iberdrola, a multinational electric utility company based in Bilbao, Spain, selected Nel Hydrogen a few years ago to turn Spain into a technological and industrial benchmark in green hydrogen.

Iberdrola and Nel have developed and deployed large-scale electrolyser projects to promote the green hydrogen supply chain in Europe and the United States. Specifically for green ammonia for fertilizer, the Iberdrola-Fertiberia alliance is producing green hydrogen for the Puertollano ammonia plant in Spain. The electrolyser solution is a 20 MW PEM system, the largest electrolysis plant for green ammonia production currently in operation. According to the Ammonia Energy Association, Fertiberia's low-carbon fertilizer has been successfully used in pilot programmes by Heineken and PepsiCo.[2] This green fertilizer has been used on barley and potato crops in Spain, drastically reducing overall agricultural emissions and paving the way for future supply chains. Both Heineken and PepsiCo are aiming to reduce agricultural emissions from their product supply chains and intend to scale up the use of green fertilizer based on the success of their 2023 pilot programmes.

Another company making strides in green hydrogen/green ammonia production for fertilizer is Yara International ASA. They have also applied electrolyser technology to help achieve the company's mission to "responsibly feed the world and protect the planet". According to published press materials on its website, Yara has already removed half of its direct greenhouse gas emissions over the past 30 years and is striving towards carbon-neutrality by 2050.[3]

According to Recharge, the cost of green hydrogen is expected to fall to US$1.50/kg by 2030 as electrolyser capacity increases; more than 100 GW of electrolysers will be manufactured each year by 2030, up from 2 GW in 2020.[4] As one example, Nel is building a new electrolyser equipment manufacturing plant near Detroit, Michigan. When fully developed, the Michigan plant alone will have a production capacity of up to 4 GW/year of alkaline and PEM electrolyser stacks. WF

References

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