Storing renewable energy as ammonia

It's currently impossible to store large quantities of energy produced by wind and solar power. In the Netherlands in times of over-supply the energy is sold off cheaply; in times of need gas-powered plants must make up the deficit. The Power To Ammonia project is now investigating whether renewable energy can be stored in the form of ammonia. This is later used as fuel for the gas plant… without emitting CO_2.

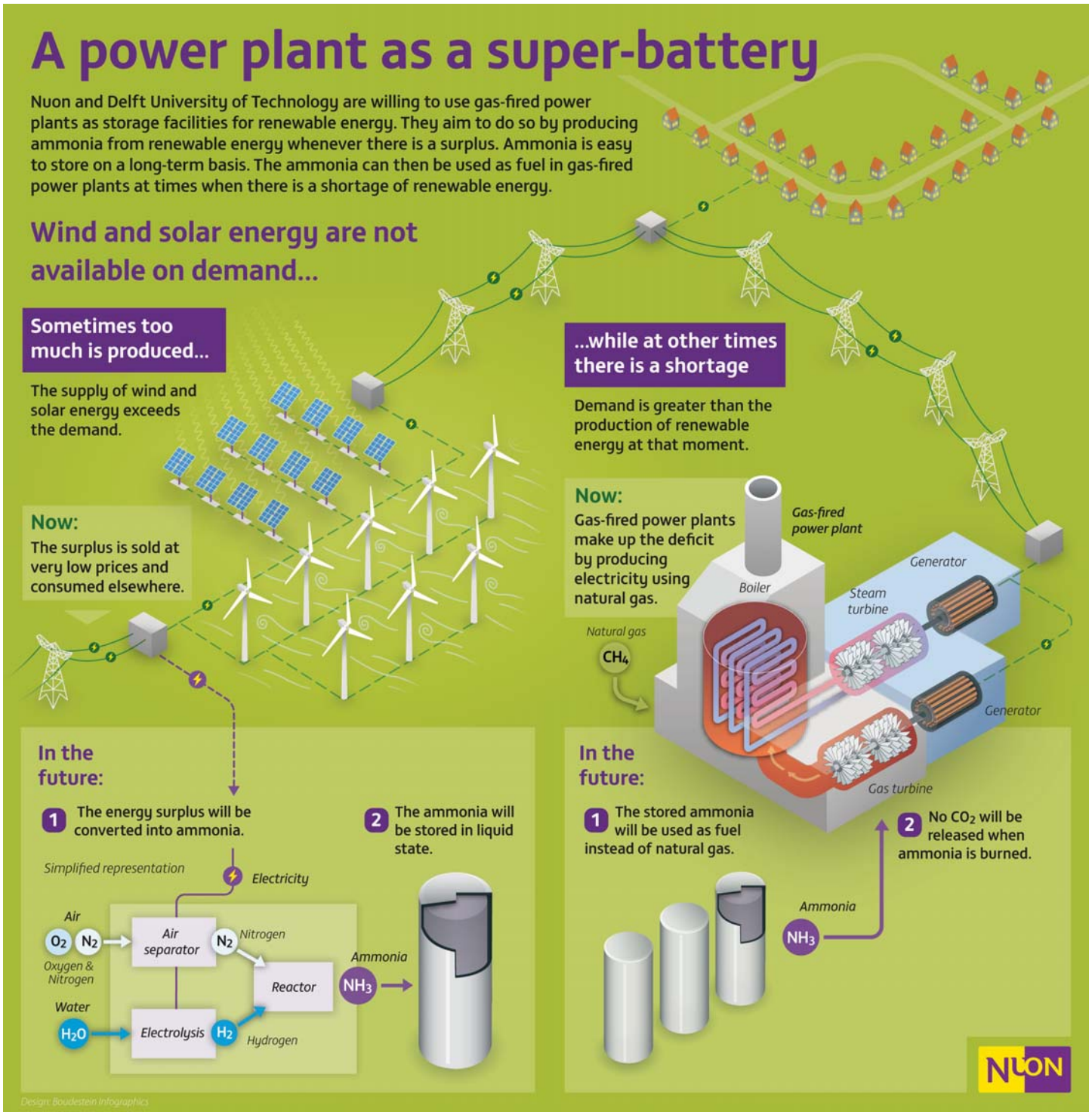
By Joanne McIntyre

The Nuon Magnum-plant in Eemshaven, the Netherlands, was officially opened in 2013. Photo ©Nuon

Thanks to the growing number of wind turbines and solar panels, the supply of renewable electricity will sharply increase in the coming years. At times when there is a surplus of renewable electricity, it can be converted to ammonia locally using small-scale plants. Just like natural gas, the produced and stored ammonia can be used by energy companies at any time as fuel for electricity generation. Ammonia can be stored as a liquid; a standard tank of 60,000 m^3 contains about 211 GWh of energy, equivalent to the annual production of roughly 30 wind turbines on land. Ammonia can be burned cleanly: water and nitrogen are released, but no CO_2 and little or no nitrogen oxides. What's more, the industry can use this ammonia as a renewable raw material for the production of fertilizer and other products. Last but not least, applications could include wind turbines that provide electricity solely for the sustainable production of ammonia and are not linked to the electrical grid, which would eliminate miles of expensive power cables.

Recycling the wind

Alexander van Ofwegen, Director of Nuon Heat, elaborates: "This idea consists of three steps. The first step is to convert the electricity garnered from wind power into liquid ammonia. This involves a chemical process wherein hydrogen and nitrogen are bound together to create ammonia. Ammonia is then stored in large tanks for as long as is needed. In this way there will always be a sizeable fuel-supply available to be used in times of low energy supply from sustainable energy sources. This is possible due



to the fact that ammonia can be used as a fuel that produces no CO_2. An additional strong advantage of this concept is the fact it can be used all over the world to convert sustainable energy to ammonia. This concept comes down to recycling the energy from the wind and the sun – wind and solar energy is used to produce ammonia and turn a gas-fired power plant into a super battery!"

Materials challenges

Ammonia – Condensed ammonia is a corrodent, and in anhydrous state it can cause stress-corrosion cracking of stressed carbon steels or high-strength, low-alloy steels.

Hydrogen – it itself it is not corrosive but it can lead to blistering and embrittlement of steel. Also, it readily combines with other elements to product corrosive compounds.

Oxygen – in high-temperature environments can cause oxidation scaling of metal surfaces of under-alloyed material.
Type 316 stainless steels and variants thereof – such as 316L, 316LN, 316LN (MO+) – are typically used in ammonia product.

Magnum-plant takes the lead

The Nuon Magnum-plant in Eemshaven, the Netherlands, was officially opened in 2013. The original concept revolved around setting up a power plant that would be able to run on different kinds of fuel, like biomass, gas and coal. In consultation with environmental organizations it was decided in 2011 that the Magnum-plant would remain a gas-fired power plant until 2020. Now, due to the research within Power to Ammonia, Nuon has decided to definitively renounce the option to use coal in the Magnum-plant in the future. Instead the focus will shift towards finding a CO_2-emission free future for Magnum.

Research TU Delft and Nuon

Although TU Delft and Nuon are still sitting at the drawing board and a lot of additional research is needed, both parties agree that storing energy in ammonia is a promising technique that after the necessary research and with additional funding can be made applicable on a large scale in about ten years. Of course both safety and environmental considerations are a major priority during this research.

Power to Ammonia

The research of Nuon and TU Delft is a part of the project 'Power to Ammonia', wherein the Institute for Sustainable Process Technology (ISPT) has brought together many different parties to perform research and share knowledge. Power to Ammonia is a partnership of ISPT, Stedin Infradiensten, Nuon, ECN, Technische Universiteit Delft, Universiteit Twente, Proton Ventures, OCI Nitrogen, CE Delft and AkzoNobel. For information contact Lisa Groothuis (Communications Manager, ISPT) at email: lisa.groothuis@ispt.eu.

Alexander van Ofwegen: "Ammonia has already been used in many different ways for over a century – it is the raw material for fertilizers, but it also sees extensive use in large scale cooling installations such as seen in ice-rinks for example. Additionally the Netherlands also has quite a lot of experience with the storage of ammonia. But of course, just as with storing any concentrated chemical product, taking the necessary safety precautions is essential. We hope to be able to do a demonstration on a relevant scale within five years."

Sources:
Nuon, ISTP, Nickel Institute