Energy transition in the Netherlands

Hydrogen factories the new power plants? From natural gas to hydrogen?

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Over a year ago a press release was issued that Shell, the Gasunie and Seaports Groningen were to host the largest 'green' hydrogen factory in Europe in the Eemshaven in the Netherlands.

But what role could hydrogen play in Europe's energy transition and the reduction of CO_2 emissions?

During my research and search for more information, I came across a 'sea' of enthusiastic, but also critical information about all kinds of issues surrounding hydrogen, such as production, storage, transport, onshore wind parks, offshore wind parks, large solar parks and information about the many consortiums of companies involved with hydrogen. Ultimately, it became four separate articles in which all aspects of the energy transition and green energy are discussed in detail. This article is a summary of the main points in the four articles on hydrogen in the Smeeroliekroniek (Lubricating Oil Chronicle), magazine of the Dutch Lubricants Assosiation.

The 'old' Amercentrale,(started in 1952) coal and bio-mass power plant in Geertruidenberg

The Eemscentrale, modern gas-fired power plant near the Eemshaven Delfzijl (Groningen)

It will come as no surprise that these consortiums of companies involved with hydrogen are the current energy companies and the major oil companies. But just as naturally perhaps are the governments both provincial and local authorities, the port companies of Rotterdam, Amsterdam and of course the Groningen Seaports with Delfzijl and Eemshaven, as well as industry as future purchasers of this type of energy. The investment costs needed to produce hydrogen on an industrial scale run into many billions and without large and reliable customers, all plans have little chance of succeeding.

OFF THE (NATURAL) GAS?

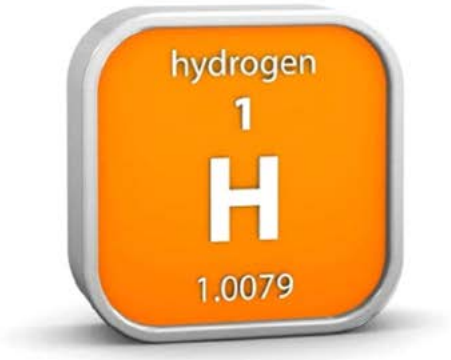
Yes, it will happen and it looks like we will have several (clean/green) alternatives at our disposal around 2040-2050. One of those alternatives is green hydrogen. Slowly but surely, hydrogen is receiving more attention as an alternative to traditional (fossil) fuels such as coal and natural gas, as well as petrol, diesel and even kerosene.

Attention for hydrogen not only as a fuel for cars or airplanes, but even more importantly as an energy source for industry and as a future replacement for natural gas. Whereas until recently all the cards were put on (green) electricity from wind and solar energy, biomass and heat pumps, there is now more and more attention given to (green) hydrogen. And in politics, nuclear energy has recently even been discussed again.

Green energy

We are confronted with the move to greener energy sources every day: It has to be cleaner, less polluting, producing less waste, with lower consumption and lower (CO_2) emissions. The coal-fired power stations must be closed, we must move away from gas. Politicians need to provide solutions. And it is not just a Dutch problem. The environment has many borders, but it does not stop at the border of the Netherlands.

Green energy from wind, sun and water is one of the solutions to halt climate change and air pollution. Hydroelectric power stations, wind and solar parks can provide green energy to generate electricity and to make hydrogen with this electricity to keep our households, transport and industry moving.



Hydrogen

Is hydrogen a panacea? You can use it to drive cars or heat the house. And all without emissions. The only residual product is water. The disadvantage is until now that it has mainly been produced by 'converting' natural gas at high temperatures to extract hydrogen. And then this source of energy is again partly fossil-based. However it can be produced differently, through means of 'electrolysis' in water (H_2O) by splitting the molecules into hydrogen (H) and oxygen (O). If you use green energy for that electrolysis, such as wind or solar energy, then hydrogen can be CO_2 neutral.

Hydrogen electrolysis

Hydrogen, the Dutchman and the industry

Many Dutch people currently think of hydrogen as an alternative to natural gas, such as an electric car run by a fuel cell or even the nuclear bomb. But hydrogen has also been widely been used for many years in all kinds of processes in refineries and the chemical industry. After Germany, the Netherlands is one of the largest hydrogen producers in Europe.

Gray and blue hydrogen

The largest part of Dutch hydrogen production comes from natural gas. Another part is produced as a by-product of naphtha cracking and in the production of chlorine, coke and methanol. This releases CO_2 that ends up in the air which we call 'gray' hydrogen. If the CO_2 is captured and stored in, for example, empty oil/gas fields under the North Sea, this is referred to as 'blue' hydrogen.

Green hydrogen

Around 2010, demand rose in connection with the increasingly strict environmental requirements for 'renewable' hydrogen for industry and mobility in the transport sector. One way of generating energy such as hydropower or wind energy could be through a process of electrolysis, although the energy required in this process is higher than the value of the hydrogen produced. But it is perhaps the best process for people and the environment as it does not release any CO_2 at all by the use of green electricity produced from wind and solar parks, whereby water could be split into hydrogen and oxygen.

Note: The reference to the color of hydrogen, gray, blue or green, only refers to the production method as hydrogen itself is colourless and odourless.

Green energy

A different story is the province of Groningen, an area around Eemshaven, Delfzijl and Veendam. This area is mainly known for natural gas extraction. Near the town of Slochteren, about 20 km east of the capital Groningen, a gigantic gas field was discovered in 1959, which drastically and forever changed the area and the energy supply in the Netherlands.

Natural gas extraction in Groningen

The province of Groningen with Eemshaven and Delfzijl

The economy and industry received a huge boost when the field began production in 1963, and after a few years there was hardly a house in the Netherlands where the heating or cooking did not run on natural gas from Slochteren.

Eemshaven and Groningen's Seaports

In the same period, the government and the province of Groningen decided to construct a new seaport in the Northern Netherlands, the Eemshaven, 20 kilometers north of the existing seaport Delfzijl. Both the port of Delfzijl and Eemshaven are managed by Groningen Seaports. The Eemshaven plays a central role in the development of the chemical industry in this area, in the construction of power plants and of enormous solar parks and gigantic wind parks on land and offshore. And again with the construction of the hydrogen factories.

The Eemshaven opened in 1973 at the same time as an expansion of the port of Delfzijl. The latest development in Eemshaven came in 2018 with the connection to the national railway network and the building of its own station.

Groningen Seaports – in Eemshaven

Key players in the developments in Groningen are Gasunie and Gasunie New Energy, Groningen Seaports, Nouryon (formerly AkzoNobel Specialty Chemicals), Shell, NAM (Nederlandse Aardolie Maatschappij), a number of major energy companies, such as RWE, E.ON and Vattenval and the government. The shareholders and the relationships between the energy companies are constantly changing. For example, the activities of the Dutch companies Essent, Nuon and Innogy have been merged into the German energy giants E.ON and RWE and the Swedish Vattenval.

Green energy through wind and solar parks

The ports of Eemshaven and Delfzijl and also the town of Veendam, about 30 km to the south, will be the hart of the 'hydrogen-business'. In both Eemshaven and Delfzijl plans have been developped to build enormous hydrogen factories which will receive the needed electricity from equal enormous wind and solar parks nearby on land and sea.

Windpark in the North Sea

Solar park in Eemshaven

Developments

Since 2017, plans for hydrogen factories in the Netherlands have been gaining momentum. The Port of Rotterdam Authority together with BP and Nouryon (AkzoNobel Specialty Chemicals) have brought forward plans for the construction of a 'green' hydrogen plant, followed by Vlissingen with a consortium of the Danish energy company Ørsted including Dow, Yara, Shell, Gasunie, Nouryon , the Zeeland refinery, the University of Utrecht and Imperial College London. It is striking that universities are also showing their interest and participating. And in the Amsterdam region, the port company reseaches under the project name H2ermes, together with Nouryon and Tata Steel the establishment of a hydrogen factory in IJmuiden on the existing Tata Steel site.

In 2019, King Willem-Alexander opened an operational hydrogen factory in Veendam. This Hystock factory became a pilot plant for the production of green hydrogen with the factory generating 1.1 megawatts mainly generated through solar panels.

Representatives of the province of Groningen in Gasunie, along with Shell and Greenpeace were present at the opening of the factory to emphasise the importance of a hydrogen economy. "Green hydrogen is a building block to enable the energy transition."

The industry's interest in hydrogen is enormous, not only from the oil industry, but also from the chemical industry and from many major users of natural gas. And of course also from many Dutch people who wonder what if they have to get rid of natural gas and from the environmental movement that sees the benefit in a sharp fall in emissions.

Distrbution via the gas network

The advantage of hydrogen is that it can be easily transported and stored. Distribution therefore seems to be the smallest problem at the moment. The Gasunie has shown that its natural gas pipelines can be made suitable for the transport of hydrogen with minor modifications and that the gas network extends to the farthest corners of the country.

Storage in salt caverns

An almost ready-made natural solution is also available for storage. The salt caverns in Groningen, which are already being used for the storage of natural gas. Just like the gas network, the caverns can be made suitable for the storage of hydrogen with some modifications. If the caverns in the ground at Zuidwending in Veendam are filled with hydrogen, that is enough to heat all the houses in the Netherlands for three weeks.

Hydrogen storage in salt caverns near Zuidwending

HYDROGEN FACTORIES NOT ONLY ON LAND BUT ALSO AT SEA. ON OIL AND GAS PLATFORMS IN THE NORTH SEA.

Electrons (electricity) and molecules (hydrogen)

The Netherlands does not stop at the dunes. The North Sea is the place to generate a large share of Dutch energy. In 2021, there will be seven huge wind farms with 462 wind turbines with a capacity of more than 2.5 gigawatts and a large number are planned to be built until 2030. The North Sea is rapidly being built up with wind farms and the planned capacity will increase to 11.5 megawatts by 2030. The turbines will then produce so much power that TenneT, the operator of the high-voltage electricity transmission grid in the Netherlands and large parts of Germany, can barely handle it. If more wind turbines are added (and there will be), after 2030 there will be a traffic

jam on the way to the coast, not from bathers on their way to the sea, but from electrons (electricity) on their way to land. And then many wind turbines may have to be shut down.

You can also convert the wind energy from the wind farms in the North Sea into hydrogen and then bring it ashore together with the natural gas via the (large) pipelines. In addition to green energy based on electrons, this creates a second system based on molecules (hydrogen) and we are no longer dependent on electricity cables and intermediate stations or the capacity of the high-voltage grid on land.

Trial plant on production platform Q13a-A from Neptune Energy

A world first in energy innovation has already taken place in 2021 on the operational gas production platform approximately 13 kilometers off the coast of Scheveningen. Neptune Energy's gas platform Q13a-A has begun to produce offshore hydrogen for the first time.

The pilot project, called PosHYdon, integrates three energy systems in the North Sea: offshore wind, offshore gas and offshore hydrogen. In order to be able to make green hydrogen using a process whereby seawater is converted into demineralised water on the platform. This water is then converted into hydrogen by means of electrolysis using electricity from wind farms in the North Sea.

This test set-up is the first hydrogen factory at sea. The hydrolyzer, as a hydrogen factory is officially called, can fit into a sea container that can easily be placed on the oil or gas platform.

Neptune Energy platform Q13a in the North Sea, 13 kilometres off the coast of Scheveningen

The aim of the pilot is to gain experience in integrating working energy systems at sea and the production of hydrogen in an offshore environment. The intention is that the experience with PosHYdon helps in the move towards large-scale offshore production of green hydrogen. As noted earlier, hydrogen production at sea will prevent overloading of the high-voltage transmission grid and will breathe new life into superfluous oil and gas platforms in the future.

Collaboration

This project is being carried out by a consortium 3P2G - Pre-Pilot Power to Offshore Gas - led by TNO a Dutch Organisation for Applied Scientific Research, in collaboration with Energie Beheer Nederland EBN on behalf of the state shareholder of all oil and gas extraction locations, Nexstep the organisation of the offshore industry for the demolition of North Sea platforms, an initiative of EBN and NAM, in broad collaboration with the oil and gas industry (e.g. Neptune Energy), energy companies and the government.

An Island in the Noth Sea

It is expected that dozens of hydrolyzers with ultimately 100 megawatts of capacity each will be placed on the 'old' oil and gas platforms within a few years. But in order to generate a significant amount of energy through this process then a something completely different is needed: An island in the North Sea, which is an idea already in development.

Initiator and operator of the high-voltage transmission grid in the Netherlands, TenneT is already working on the development of this island, christened the North Sea Wind Power Hub, with its partners in Denmark and Germany and with Gasunie. But the idea will not be fully realised until 2040.

Demolition of oil and gas platforms will cost billions

If there is one industry that cannot wait for the hydrogen revolution in the North Sea to make all fossil energy superfluous, it is the oil and gas industry itself. That seems strange, because hydrogen is the biggest competitor to oil and natural gas. But for the operators/oil companies, something very different is at stake. Billions in demolition costs.

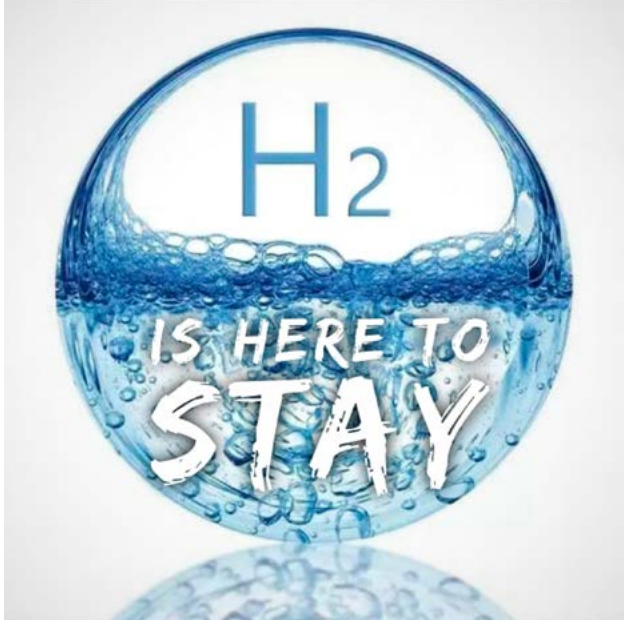
There are approximately 1,350 offshore oil and gas extraction installations in the entire North Sea that

will either become redundant or have reached the end of their economic life, 180 of which are located in the Dutch part of the North Sea. Calculations by the Dutch government show that the costs for the demolition and removal of these 180 installations in the Dutch part alone could amount to 7 billion euros.

A large part of the oil and gas platforms in the Dutch part of the North Sea will also become redundant in the coming years. If the operators cease production, they are obliged to remove the platform, including the redundant pipelines. Unless they can be used for other purposes!

A new life

The switch from oil and gas pumping to hydrogen transport production would give many oil and gas production platforms in the North Sea a new lease of life!



HYDROGEN AND LUBRICANTS

Hydrogen can be used to power a number of different types of transportation. It can be stored and transported at high energy density in liquid or gaseous form, and it can be used as a fuel for power or in transport and in industry as feedstock. Similar to synfuel or syngas hydrogen could be reformed in a chemical proces with CO_2 to a Group V base oil. As far as I could find reforming hydrogen into base oil is still under development in the field of resaerchers and chemists.

Synfuel base oil

Synthetic fuel or synfuel is obtained from either syngas, a mixture of carbon monoxide and hydrogen or carbon dioxide and hydrogen. The syngas can be derived from gasification of solid feedstocks such as coal, biomass or by reforming of natural gas. The result of the process, Fischer-Tropsch, is GTL (Gas to Liquids), CTL (Coalt o Liquids) or BTL (Biomass to Liquids) depending on the feedstock. Shell has a big plant in in Ras Laffan Quatar where they produce large quantities GTL base oil by converting natural gas of nearby sites.

GTL plant in Quatar

Base oils

Maybe base olis produced with hydrogen will be called HTL-Hydrogen to Liquid?. Furthermore it is expected that these base oils will be classlified, as an API Group III base oil. According the API clasification system it should be Group V. Group IV is not possible because of an API decision (blockade) in the past. The choice for Group III has the advantage of access to the traditional additive systems and the usual approvals.

Carbon dioxide from the atmosphere and green hydrogen

Alternatively a mixture of carbon dioxide from the atmosphere and green hydrogen could be used for an almost climate neutral production of synthetic fuels and feedstock.

Electrification and lubricants

Most electric cars and light vans have at the moment a semi hydrid, full hybrid or full battery-electric

powertrain. The number of fuel cell-electric cars is still minimal due to the price of the cars and minor availabilty of hydrogen at the network of fuel stations of the oil comapanies

The lubricant needs for all hybrid battery-electric vehicles are similar tot cars with petrol or diesel engine. Full battery-electric and fuel-cell electric cars have no internal combustion engine and need only a (special) transmission fluid and nearly always a special coolant for the cooling system of the batteries.

The future opportunities for fuel cell electric truck and buses are much better because of the problem with the weight of the batteries which goes at the expence of the load capacity. The lubricant need for trucks and buses with a fuel cell powertrain is similar as with battery-electric and fuel-cell electric cars, no engine oils needed anymore.

But a lot of engine builders and truck manufacturers have not given up the (Diesel) internal combustion engine (ICE) and are adapting the engine to run on Hydrogen similar to other gases as LPG or CNG. These engines do need a different engine oil and most additive suppliers and oil companies already have these oil available or are developing them.

Hydrogen station Automotive Campus, Helmond the Netherlands

DAF XF Fuel Cell Electrick truck

The developments at aviation, shipping and industries, e.g. power generation are still in its infancy and are concentrated on biofuels and synfluids. Wärtsilä a prominent Finnish diesel engine builder for big ships and power stations is to pursue a 100% renewable energy future with a groundbreaking technology in the process of synthetic fuel production. The so called Power-to-X this process shows synthetic fuels can be generated from excess CO_2 emissions. It will be no surprise that the big marine engines also need special engine oils.

LINK
www.smeerolievereniging.nl