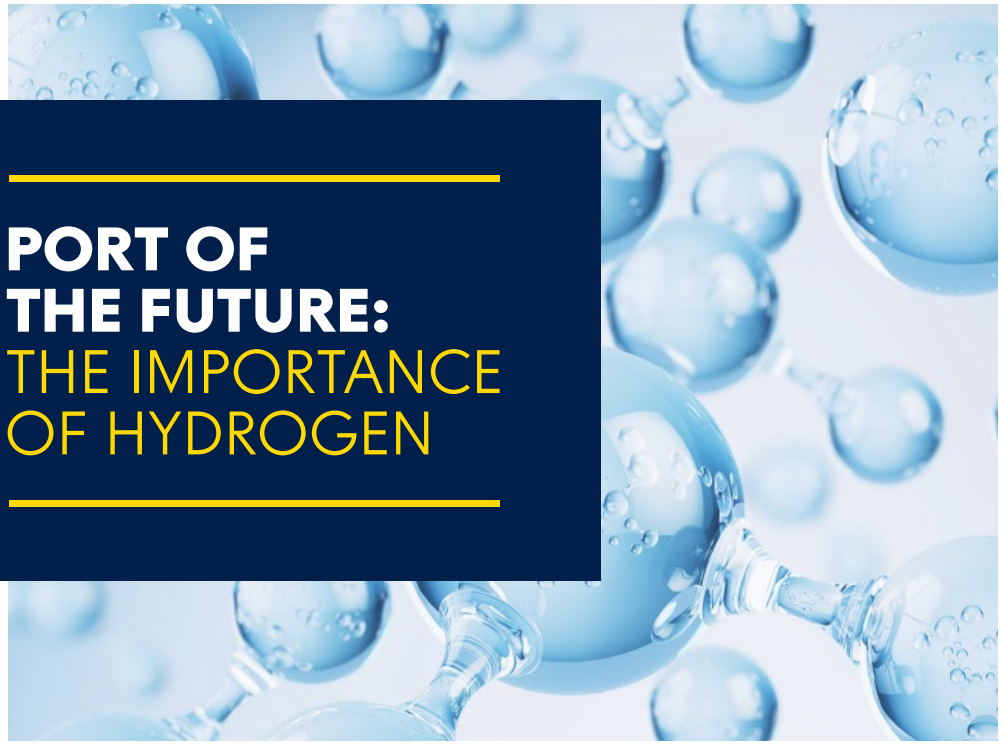


PORT OF THE FUTURE: THE IMPORTANCE OF HYDROGEN

Ports of the future will switch to sustainable energy carriers based on clean sources like wind, solar and hydro power. This handout zooms in on a very promising energy carrier: hydrogen. Why is hydrogen important? And what is the role that your port can play in the supply chain?

HYDROGEN IN SHORT

- Important alternative for the realization of a CO_2 neutral industry
- Complete supply chain can be fully sustainable
- Can be used to store large amounts of energy for a long period of time
- Suitable for industrial use by replacing natural gas for high heat production
- Feedstock for the chemical industry
- Fuel for heavy transport such as trucks, (inland) shipping and aviation

HYDROGEN IS EVERYWHERE

Hydrogen is the most common, lightest and simplest element that exists and it forms three quarters of the mass in the universe. On Earth, hydrogen is a molecule consisting of two hydrogen atoms (H_2), which prefers to bind itself with other molecules. The most "popular partners" are oxygen, with which it forms water (H_2O), and carbon, with which it forms hydrocarbons. Hydrocarbons are the main components of fossil energy sources such as natural gas, crude oil and coal, as well as biomass. Our societies currently mainly run on hydrocarbons, as fuel for heating and transport and as feedstock for chemical products which find their way in products that we buy and use every day.

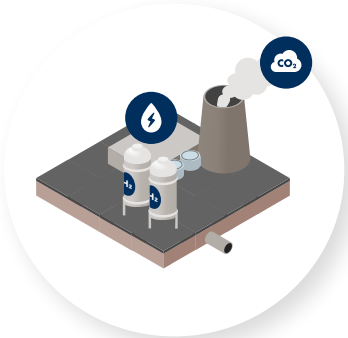
It is expected that in the next few decades the response to climate change will result in decrease of using fossil hydrocarbons. Therefore we must look for new energy sources and carriers, which are clean and sustainable, yet reliable and affordable. One of the most promising solutions: hydrogen.

THREE OPTIONS

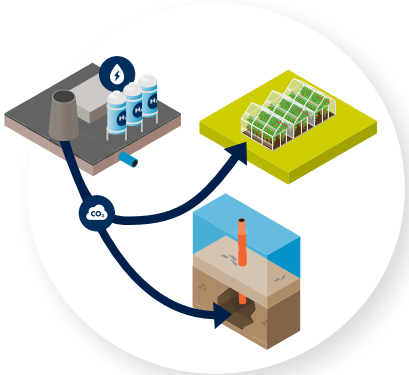
1. Hydrogen has to be produced as it is not readily available. This is already being done on the basis of natural gas. However, CO_2 is released during the production. This is called **grey hydrogen.**

2. Low-carbon production can be achieved by capturing and storing the CO_2, for example in depleted gas fields. This is known as **blue hydrogen.** Blue hydrogen is a viable possibility in the short term and it is seen as leading the way for green hydrogen.

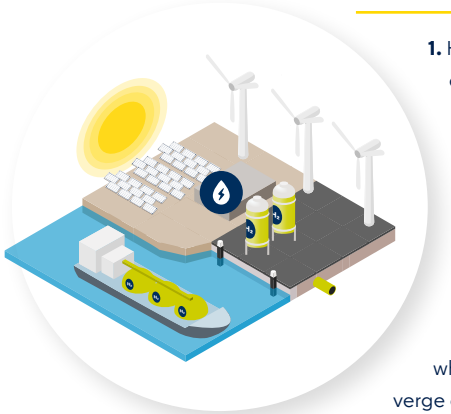
3. A third option is carbon-free **green hydrogen**, which is produced by electrolyzing water using green power, for example from (offshore) wind farms or solar parks. No CO_2 is released during production and of course also not when the hydrogen is being used. The production of green hydrogen is now on the verge of being expanded to a commercial/industrial scale.



GREY HYDROGEN



BLUE HYDROGEN



GREEN HYDROGEN

Port of Rotterdam

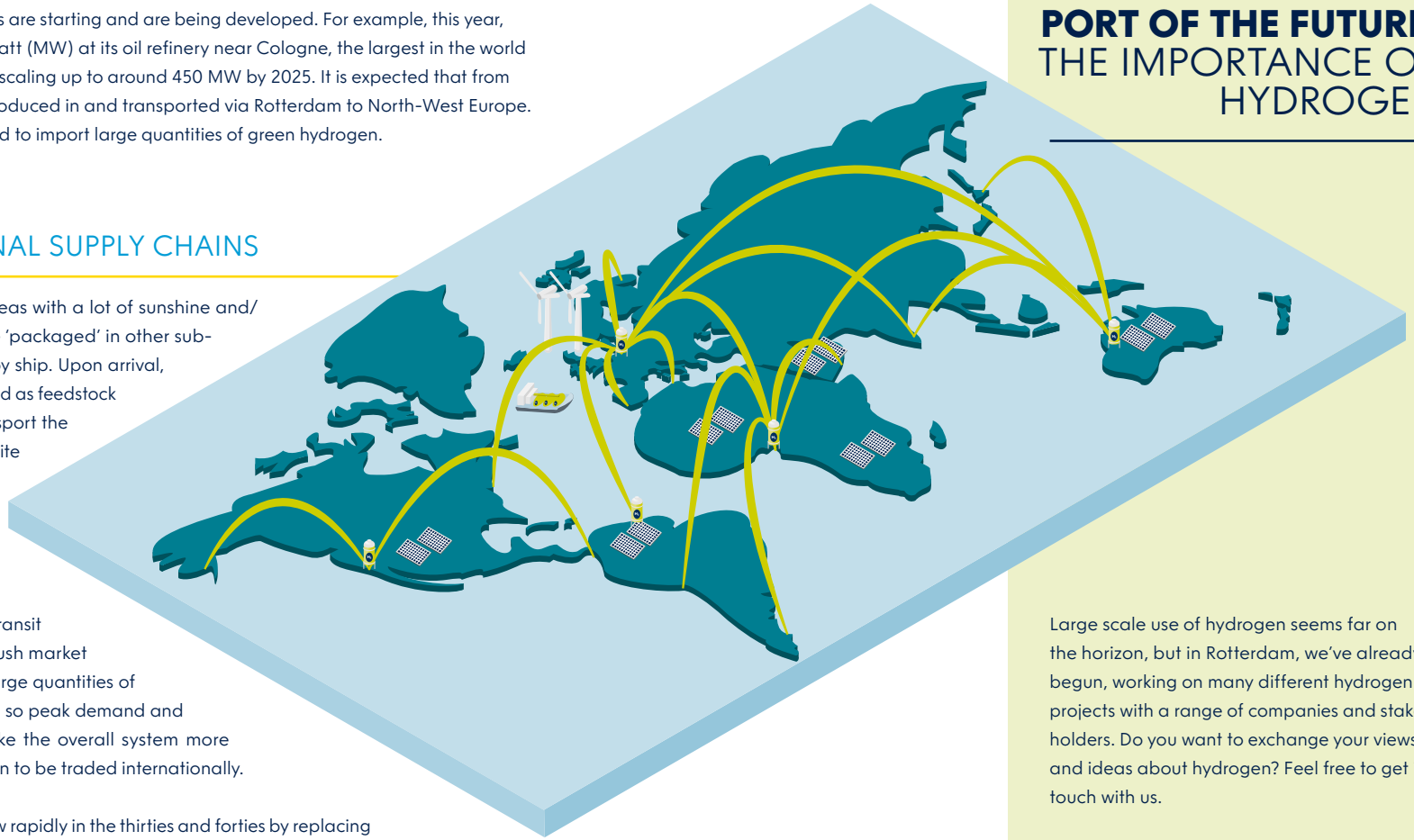
GREEN HYDROGEN PROJECTS

All over the world new green hydrogen projects are starting and are being developed. For example, this year, Shell will start up an electrolyser of 10 megawatt (MW) at its oil refinery near Cologne, the largest in the world so far. Announced plans in Rotterdam aim for scaling up to around 450 MW by 2025. It is expected that from 2050 there will be 20 MT/year of hydrogen produced in and transported via Rotterdam to North-West Europe. Besides local production, there will be the need to import large quantities of green hydrogen.

SUSTAINABLE INTERNATIONAL SUPPLY CHAINS

Hydrogen is generally produced on site in areas with a lot of sunshine and/or wind. The hydrogen molecule can then be 'packaged' in other substances and transported to a hydrogen hub by ship. Upon arrival, the hydrogen is 'unpacked' so that it can be used as feedstock or fuel. It is also possible to produce and transport the hydrogen in liquid form from the production site to the hydrogen hub.

Last year, the International Energy Agency called for ports with sizeable industrial areas to be developed into the new nerve centers for hydrogen. The robust supply and transit facilities of these nerve centers can further push market development. Also the possibility for storing large quantities of hydrogen is an important capability. By doing so peak demand and fluctuations can be taken care off and make the overall system more reliable. Storage will also enable the hydrogen to be traded internationally.



It is expected that the use of hydrogen will grow rapidly in the thirties and forties by replacing oil and gas and will become more and more commercially attractive. Several countries are taking steps to realize its long-term market potential. Development of import and export flows may already be a game changer in this decade.

At this moment a lot of research- and pilot projects still have to be executed, involving private companies, public organisations and knowledge institutes, before hydrogen is a mature business. By using an international approach, it will be possible to share knowledge and experience which will speed up the necessary developments and at the same time bring together different players in the supply chain.

New supply chains are being developed all over the world and it's more important than ever to seize the opportunity as a port. What will your future role be?

PORT OF THE FUTURE: THE IMPORTANCE OF HYDROGEN

Large scale use of hydrogen seems far on the horizon, but in Rotterdam, we've already begun, working on many different hydrogen projects with a range of companies and stakeholders. Do you want to exchange your views and ideas about hydrogen? Feel free to get in touch with us.

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Port of Rotterdam