

From wind power to **GREEN HYDROGEN**



The HyBalance project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking under grant agreement No 671384. The Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation program and France, Germany, Denmark and Belgium. www.fch.europa.eu. The HyBalance project has furthermore received funding from the Danish ForskEL program, which is administered by Energinet.dk. www.forskel.dk

HyBalance

WHAT IS HYBALANCE?

HyBalance is a project that demonstrates the use of renewable hydrogen in energy systems. The HyBalance project is one of several initiatives to help transform energy systems from fossil dependency to relying on renewable and local energy sources by utilising the potential of hydrogen.

The hydrogen is produced from water electrolysis, enabling the storage of cheap renewable electricity from wind turbines.

It helps balance the grid, and the renewable hydrogen is used for clean transportation and in the industrial sector.

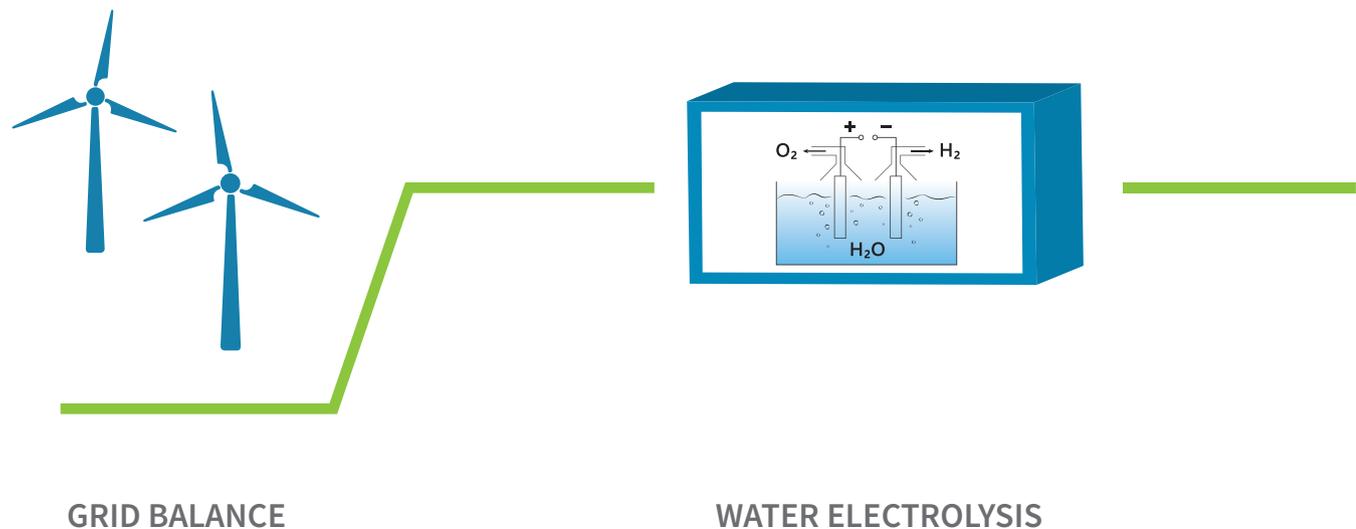
The project is a technology showcase for sustainable development pathways in Europe. For this reason, it receives both European and Danish support, through the Fuel Cells and Hydrogen 2 Joint Undertaking and the Danish ForskEL program.

Air Liquide, which is actively involved in setting up hydrogen energy and allowing the widespread use of hydrogen as a clean energy worldwide, is the main investor and project leader of the HyBalance project.

Denmark has been chosen as the location for the project as it is a leading country within integration of renewables into the energy systems.

In the following, the elements of the HyBalance value chain will be described:

1. Grid balance
2. Water electrolysis
3. Storage
4. Clean mobility, logistics and industry



GRID BALANCE

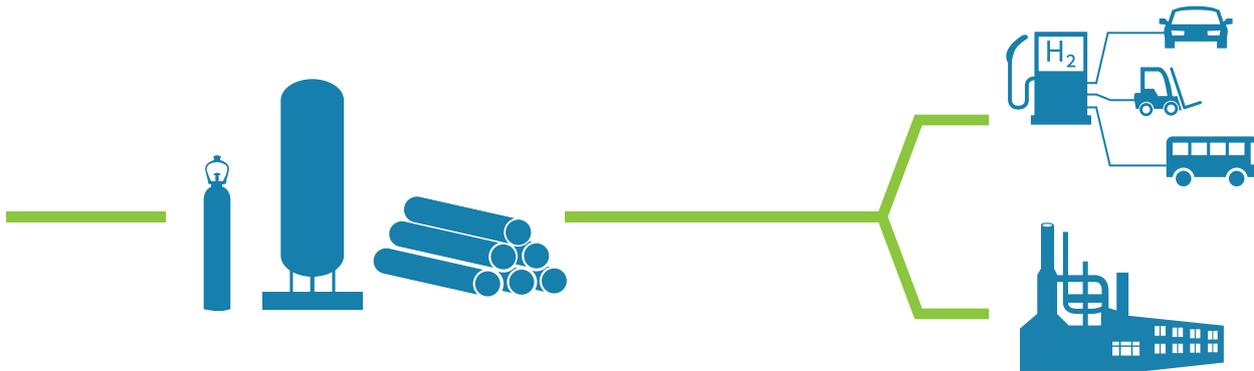
There has to be a perfect balance in the electricity grid at all times. The balance is maintained by operating flexible production and consumption units and by importing and exporting electricity. Balance responsible parties such as Neas Energy are responsible for assisting The Transition System Operator by maintaining the electricity balance.

Wind power is fluctuating and requires adequate flexibility options to ensure balance in the electricity grid. Dynamic water electrolysis offers such flexibility using electricity when the pri-

ces are low or there is a need for balancing and transforming it into hydrogen.

The **HyBalance** project will develop a model in which the operation of the hydrogen plant is simulated on hourly basis in relation to hourly power prices, the need for balancing the electricity grid and hydrogen demand.

The expected results of the project include determining the electricity threshold price for hydrogen production.



STORAGE

CLEAN MOBILITY, LOGISTICS
AND INDUSTRY

WATER ELECTROLYSIS

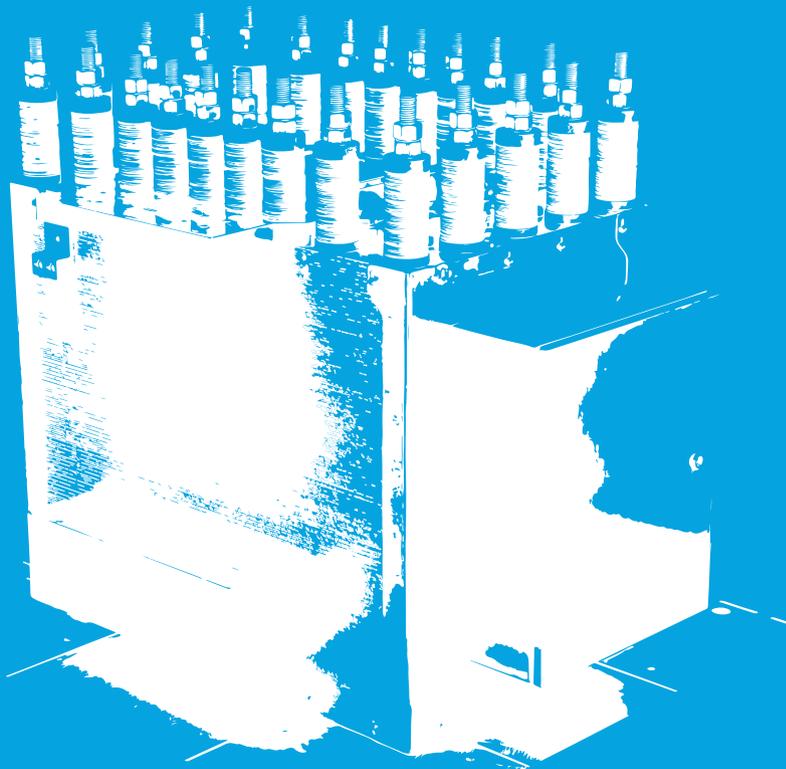
Electrolysis is the process of splitting water (H_2O) through a membrane into hydrogen (H_2) and oxygen (O_2) by applying an electrical current.

There are currently two main commercial technologies today: alkaline and PEM (Proton Exchange Membrane) electrolysis. Alkaline technology has been used for decades in the industry to generate hydrogen in large quantities and can be considered a mature technology. PEM technology is more recent. It is characterised by a higher efficiency (more hydrogen produced per kWh of electricity), a smaller footprint (more kg of hydrogen produced per m^3 of cell stack) and better capability to operate under flexible operations. These characteristics make PEM techno-

logy an excellent candidate to balance renewable power, and the PEM technology presents a high cost reduction potential through mass production.

In the **HyBalance** project, the PEM electrolyser – delivered by Hydrogenics – will be able to generate $230 Nm^3/h$ of hydrogen. The general aim of the HyBalance project is to demonstrate the highly dynamic operation of the PEM electrolyser to provide grid balancing services, a high efficiency over longer duration and a high level of availability.

At the conclusion of this project, the expectation is for PEM technology to be fully validated for commercial applications.



STORAGE

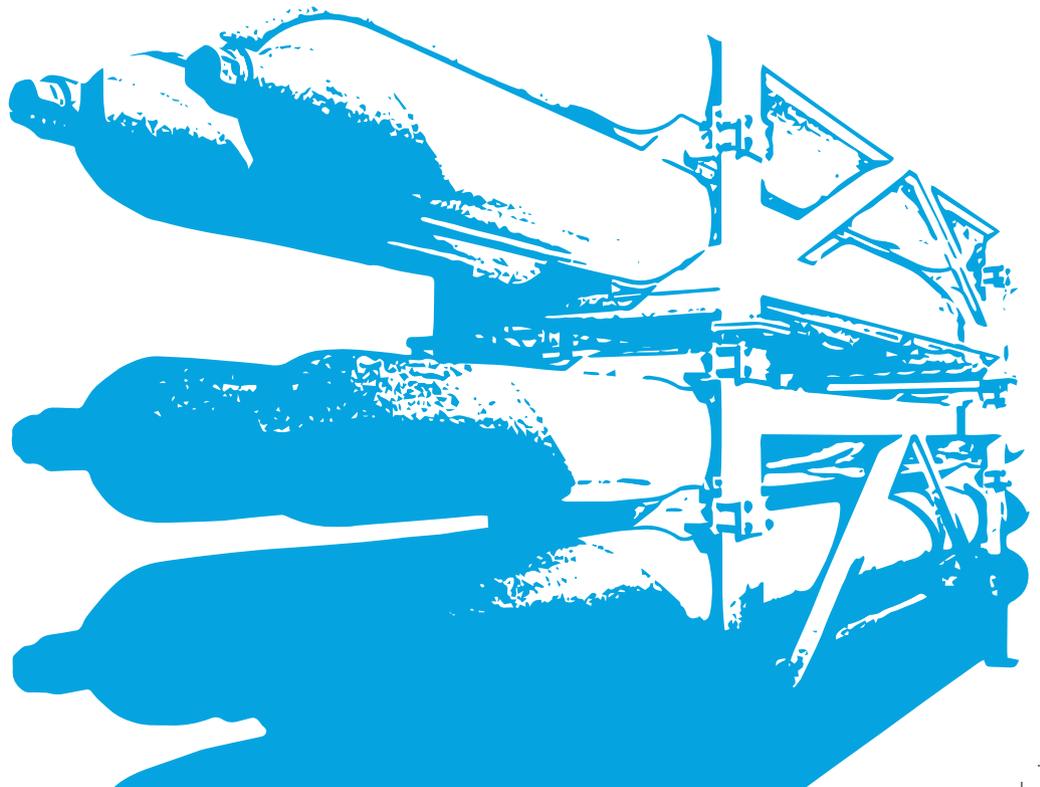
The EU is committed to a forward-looking climate policy with energy security and independence and decarbonising of the economy as some of its prioritised dimensions.

With the share of renewable, fluctuating energy from wind and solar growing in the energy mix, the need to store and downstream use in fossil dependent sectors such as transportation has become a critical issue.

By converting electricity into hydrogen, it is possible to store the electricity in the form of hydrogen. For that reason hydrogen holds promising perspectives as a contributor to solving the storage issue.

The **HyBalance** project will demonstrate how hydrogen can act as an energy-storage medium and thus maximize the use of renewable energy resources.

For large scale storage of hydrogen, salt caverns are very efficient and cost effective. The location in Northern Denmark, where the HyBalance facility will operate, is situated close to underground salt caverns, which in a future scenario might be utilised for storage purposes.



CLEAN MOBILITY, LOGISTICS AND INDUSTRY

Transportation has become a critical issue in decarbonising the economy. Hydrogen is one of the key enablers in completing energy transition from renewable sources to the transportation sector.

Hydrogen in transportation typically replaces internal combustion engine vehicles running on fossil fuels, thus offering close to a 100 per cent greenhouse gas emission reduction.

The **HyBalance** project will be the first project to demonstrate the complete value chain from hydrogen renewable energy production to end users, including hydrogen stations and Fuel Cell Electric Vehicles (FCEVs) in circulation.

Air Liquide already operates a network of five hydrogen stations in Denmark through the Copenhagen Hydrogen Network.

Capable of supplying a fleet of more than 1000 FCEVs

The interest in FCEVs is growing due to the fact that hydrogen cars enable a reduction of greenhouse gas (GHG) emissions, do not produce any local pollutant emissions (fine particles etc.), can be quickly fuelled and have a long range autonomy compared to electric cars.

The HyBalance project will assess the market for hydrogen mobility in Denmark, including cars, fork-lift trucks and busses. The hydrogen produced in the HyBalance project will be capable of supplying a fleet of more than 1000 FCEVs and can contribute up to 0.5 per cent of the transport sector GHG reduction targets in Denmark.

Reducing investment costs of hydrogen stations

The project will be the first to implement a high pressure distribution truck to supply hydrogen stations, which will allow the capacity of the hydrogen stations to be increased three or four-fold. Carrying out the compression at the plant in Hobro and transporting the hydrogen under high pressure to the stations will allow stations to reduce investment requirements and thus ease the addition of new stations at lower costs. It will also improve the efficiency of the compression and make it possible to transport higher volumes of hydrogen in a single truck.

The HyBalance project will contribute to accelerating the development of clean mobility in Denmark and will also show the path to wider similar developments in Europe and beyond.

Hydrogen not used for transportation will be applied in the industrial sector.



PARTNERS

AIR LIQUIDE

World leader in gases, technologies and services for Industry and Health. Air Liquide is present in 80 countries with more than 50,000 employees and serves more than 2 million customers and patients. Oxygen, nitrogen and hydrogen have been at the core of the company's activities since its creation in 1902. Air Liquide masters the entire hydrogen supply chain, from production and storage to distribution and uses for the end user. www.airliquide.com

COPENHAGEN HYDROGEN NETWORK (CHN)

Refuelling station network operator and institution rolling out national hydrogen infrastructure in Denmark. CHN is a joint venture owned by Air Liquide and H2 Logic. www.airliquideadvancedbusiness.com/en/who-we-are/chn.html

HYDROGENICS

Electrolyser technology developer and global leader in advanced large scale electrolysis, having profound expertise in the design, provision and operation of hydrogen generation, fuel cell power modules and electrolysers. www.hydrogenics.com

NEAS ENERGY

Balance Responsible Party and Danish electricity and natural gas trading company. As an experienced energy company, Neas Energy will prepare for new electricity and natural gas markets from hydrogen technologies and their markets. Neas Energy has outstanding experience of current and future electricity markets and trading schemes, with Denmark being at the forefront of introducing renewable energies in Europe. www.neasenergy.com

HYDROGEN VALLEY (FORMER CEMTEC)

Danish business incubator acting as a driver in the hydrogen industry in Denmark and contributing to the project by drawing from the local energy market expertise. www.hydrogenvalley.dk

LUDWIG-BÖLKOW-SYSTEMTECHNIK (LBST)

Research institute and consultancy with more than 30 years of hydrogen and fuel cells expertise, contributing its knowledge on life-cycle analysis, performance reporting and business case analysis of PtG systems for industry and politics. www.lbst.de

ASSOCIATED PARTNERS

ENERGINET.DK

Denmark's electricity and gas grid operator with responsibility for maintaining the overall short-term and long-term security of electricity and gas supply. www.energinet.dk/EN

AKZO NOBEL

Leading global producer of paints, coatings and specialty chemicals. Akzo Nobel has rinsed several large salt caverns in the vicinity of Hobro to leach brine for application in chemical

industry. Akzo Nobel's interest in the project is to develop new markets for their caverns by providing the possibility of large-scale storage of gases. www.akzonobel.com

SINTEX

Developer and manufacturer of power-based solutions. Sintex is also an industrial hydrogen customer, supplied with hydrogen delivered by Air Liquide. www.sintex.com

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Copenhagen Hydrogen Network (CHN)



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