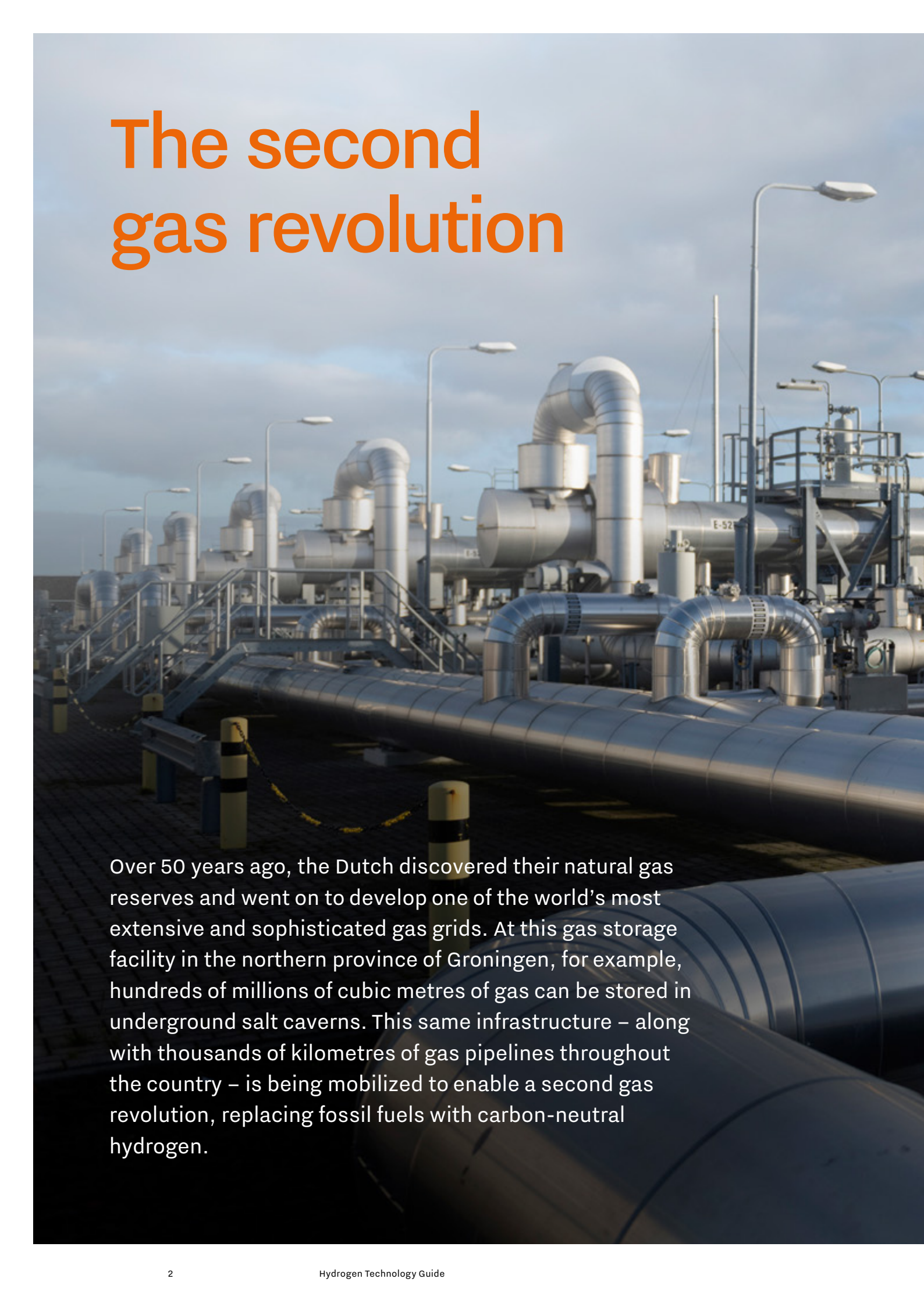




# Excelling in Hydrogen

Dutch technology for a climate-neutral world

# The second gas revolution

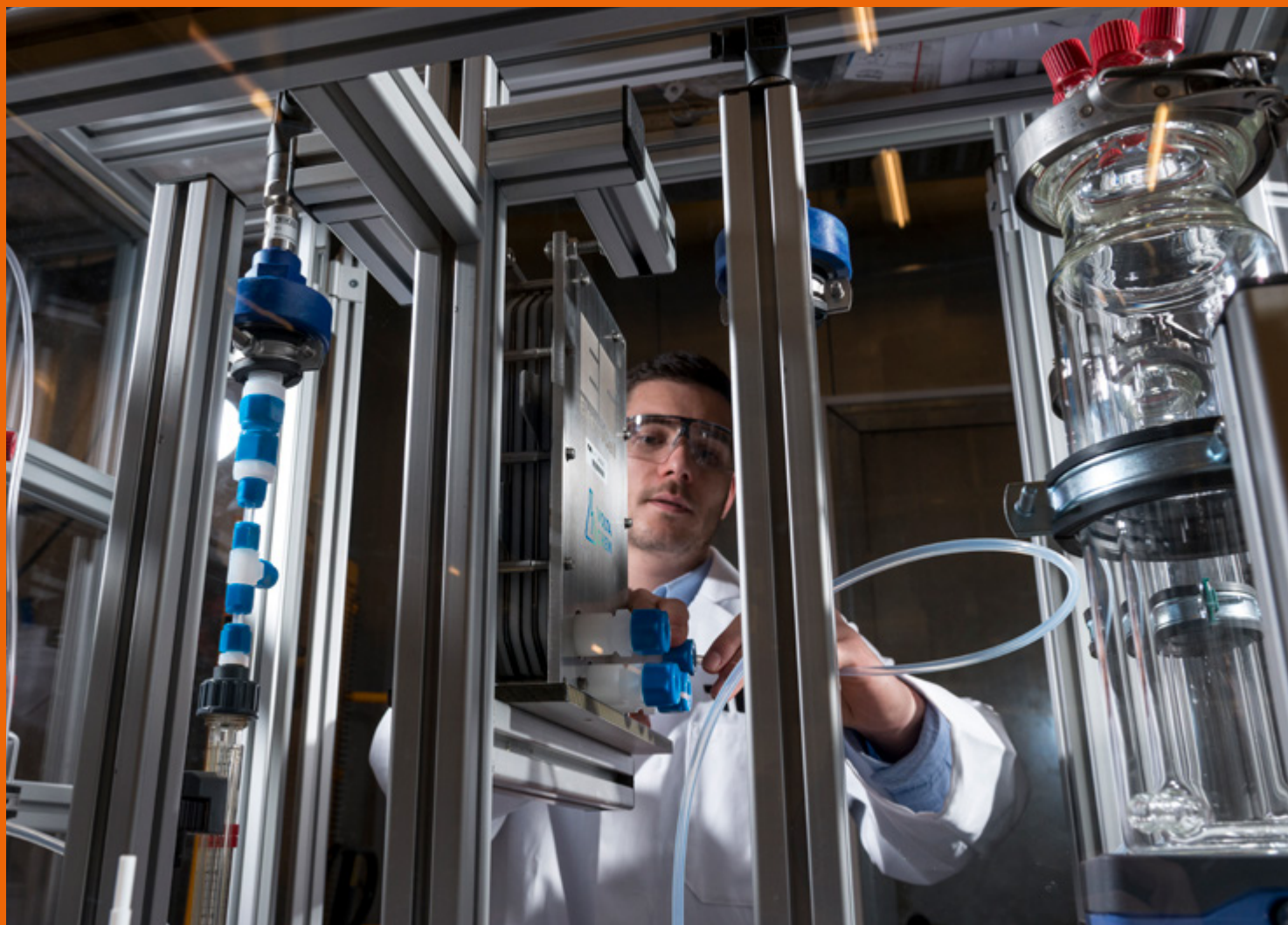


Over 50 years ago, the Dutch discovered their natural gas reserves and went on to develop one of the world's most extensive and sophisticated gas grids. At this gas storage facility in the northern province of Groningen, for example, hundreds of millions of cubic metres of gas can be stored in underground salt caverns. This same infrastructure – along with thousands of kilometres of gas pipelines throughout the country – is being mobilized to enable a second gas revolution, replacing fossil fuels with carbon-neutral hydrogen.





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# Building hydrogen-fuelled partnerships

Climate change is a global challenge of unique proportions, and no single country can hope to win the fight on its own. To successfully limit climate change the global community needs to work together. Not only by agreeing on international reduction targets, but also by pooling knowledge and resources to accelerate the development and implementation of clean technologies.

This is particularly true for the large-scale adoption of clean hydrogen. As one of the most flexible and versatile carbon-neutral fuels, it is often called the missing link in the global energy transition. Its potential is huge, yet unlocking it requires concerted efforts, from substantially scaling up production capacity to creating global demand and developing infrastructure and global logistics. Like the fossil fuels it looks set to replace over the next few decades, hydrogen will have to become a global commodity, in an international marketplace that connects individual countries and enables each to make the most of its natural resources.

The Netherlands is determined to play a substantial and constructive role in building a global hydrogen economy. And it has a lot to offer. As this brochure illustrates the Dutch are already at the forefront of European initiatives to kick-start a hydrogen revolution, building on various strengths including its strategic location as the gateway to North-Western Europe and a key hub in the global oil and gas trade. The country is also home to a rich ecosystem of research institutes and industrial partners who are remarkably effective at translating ideas and concepts into feasible, integrated solutions. This has resulted in a wide-ranging portfolio of technologies that covers every step in the hydrogen value chain, from electrolysis to transport and storage of hydrogen and a range of applications across sectors including industry, road and maritime transport and residential heating.

Yet perhaps even more important than the technology itself is the Dutch mind-set, which is open, pragmatic and outward-looking. The country has a rich heritage in building productive partnerships, both at home and around the world. Dutch hydrogen ambitions and initiatives are strongly embedded in European policies and innovation programmes. The country is home to Europe's first 'hydrogen valley', attracting foreign investors and technology companies who view the Netherlands as an excellent base for open innovation and business development. And the country's own technology sector has a long history of applying its knowledge and innovations to the specific needs and concerns of other countries and cultural settings.

Transforming hydrogen from a key technology with huge potential to the bedrock of a clean energy system will take years. Yet the technology to start the process in earnest is ready. And the Dutch hydrogen sector is keen to learn about your ideas, ambitions and objectives, and to help you achieve them.

**Jörg Gigler**  
TKI New Gas  
(Topsector Energy)

**Claire Hooft Graafland**  
Netherlands Enterprise  
Agency (RVO)

**Rogier Blokdijk**  
FME the Dutch employers'  
association in the  
technology sector



## Hydrogen

# The missing link in the global energy transition

The race is on to substantially reduce our global carbon footprint in time to halt the devastating consequences of climate change. Technological innovation is a key enabler of successful, large-scale decarbonisation of our societies. One technology in particular will be crucial to overcome some of the most persistent challenges: the production, distribution and use of clean hydrogen.







Scaling up clean hydrogen production requires huge amounts of renewable electricity. Wind power in particular is a crucial enabler. The Dutch have committed to installing 11 GW of offshore wind capacity by 2030, and to produce another 35 Terwatthour of renewable energy on land.

As a signatory of the Paris Climate Agreement, the Netherlands has enshrined in law its commitment to a decarbonised future, and has agreed ambitious targets in a national Climate Agreement (see the box). For one of the most densely populated and industrialised countries in the world, meeting these targets will present considerable challenges. Billions of Euros will be invested over the coming decade alone to speed up the energy transition. The Dutch are planning huge investments in renewable energy, especially offshore wind. Other key policies are aimed at putting all this carbon-neutral power to good use, through large-scale electrification of cars, residential heating and industrial processes.

Yet even with these ambitious policies, persistent challenges remain. For example, the country's large industrial sector requires huge amounts of high-temperature process heat, as well as feasible alternatives for fossil-based feedstock. As we become increasingly reliant on intermittent energy sources, such as wind and solar power, we urgently need solutions for storing large amounts of energy, both in the short term and across seasons. Yet another challenge is to decarbonise the marine shipping and road haulage sectors.

#### Hydrogen: the missing link

Hydrogen is widely seen as a crucial technology to overcome such fundamental obstacles to full decarbonisation. Many view it as the missing link

required for a successful energy transition. It can be used as an alternative to natural gas in industrial processes, as a feedstock for the production of chemicals, and as a carbon-neutral fuel in virtually all modes of transport, especially those for which electrification is not (yet) an option. Through electrolysis, hydrogen can be used to store and distribute large amounts of renewable energy, paving the way for further large-scale investment in wind and solar power and creating new opportunities for grid balancing, seasonal storage and even global exports of renewable energy.

#### The Dutch angle

The Dutch approach to building a hydrogen-based future has several distinctive characteristics. First of all, it is explicitly driven by the climate policies and commitments described above. Secondly, its scope takes in the entire value chain. Rather than viewing hydrogen production and various applications as separate issues, the Dutch have adopted an integrated approach to developing a 'hydrogen economy'. Dozens of pilot projects are underway in which companies and research institutes are building a complete hydrogen ecosystem, not only focusing on technology but also on creating demand, business models and on tackling regulatory and safety issues. This is often done in public-private partnerships and in a very pragmatic way: the Dutch have an open approach to innovation and this encourages experimentation.

Thirdly, the Dutch outlook on hydrogen is decidedly

## Facts and figures on the Dutch hydrogen ecosystem



**9 million m<sup>3</sup>**

The Netherlands is already Europe's second largest hydrogen producer, with an annual production of over 9 million m<sup>3</sup> of (fossil-based) hydrogen.



**4 GW / 2030**

To enable large-scale production of carbon-neutral hydrogen, the Dutch goal is to have installed 4 GW of electrolyser capacity by 2030 (10% of the total EU target for that year). The Northern Netherlands alone is aiming for annual production of 65 Petajoules (PJ) of clean hydrogen by 2030.



**11 GW / 2030**

Offshore wind power is a crucial enabler of scaling up the production of carbon-neutral hydrogen. Planned projects in the Dutch sector of the North Sea add up to 11 GW of offshore wind capacity by 2030, while there is enough space for a further scale-up to 20-40 GW.



**136,000 km**

The Netherlands already has over 1,000 km of dedicated hydrogen pipeline. The country's dense natural gas grid (136,000 km of high-quality pipeline) can be retrofitted to transport hydrogen at acceptable cost. This will accelerate the development of a 'national hydrogen backbone', which could be ready by 2026.



The Netherlands is strategically located at the heart of the European hydrogen infrastructure proposed by 11 European grid operators. Addressable regional demand in Northwestern Europe alone is estimated at 400 PJ by 2030.



global in nature. Living in a small country with an excellent strategic location, the Dutch have always been strongly aware of the need to look beyond their country's borders, and international trade has been the bedrock of the country's prosperity for centuries. Therefore, in addition to developing a Dutch hydrogen ecosystem and value chain, its businesses and research institutes also want to help accelerate the global, large-scale adoption of hydrogen as a carbon-neutral fuel and energy source. And building on its strategic location in global oil and gas logistics, the Dutch are aiming to become a European hub for the production and transport of low-carbon and especially carbon-neutral hydrogen.

### Strong foundations

These ambitions are underpinned by strong foundations. The Netherlands is already Europe's second largest producer of fossil -based hydrogen. It has a highly developed manufacturing industry, with hundreds of companies in all parts of the value chain, from producing crucial components for electrolyzers, to manufacturers of special vehicles and buses. It also has one of the world's most sophisticated natural gas infrastructures. Since discovering their natural gas reserves in 1959, the Dutch have developed a national gas grid reaching into nearly every home and business. And in doing so, they have built up extensive expertise in handling, monitoring and storing gas. The country is also a major European hub for cross-border trade in natural gas, both in its gaseous and liquefied forms. These are strong foundations as the Dutch seek to expand and adapt their existing infrastructure, transforming it into a flexible grid that enables large-scale rollout of hydrogen.

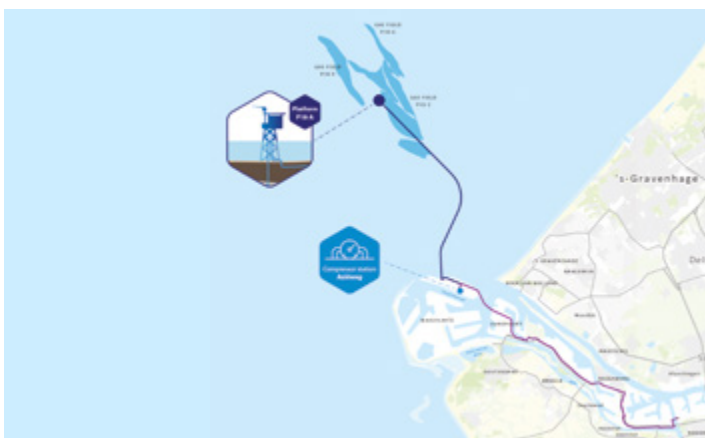
In short, the Netherlands has infrastructure, expertise

and technology to play a crucial role in the development of a hydrogen economy, both at home and abroad. And as the chapters below illustrate, companies in the Netherlands are already making a valuable contribution to developing smart and efficient solutions for the various challenges present throughout the value chain.

### The European perspective

Building a hydrogen economy is a major undertaking, that no single country can achieve by itself. The Dutch are keenly aware of the need for close international cooperation in research, development, demonstration projects and implementation of new technology. Dutch initiatives are therefore closely aligned with European partners and EU-wide innovation programmes. Examples include:

- Horizon Europe, an ambitious programme and 100 billion Euro investment fund, with which the European Commission and member states seek to boost Europe's global competitiveness. Hydrogen is a prominent topic in this programme, which includes the Fuel Cells and Hydrogen Joint Undertaking (FCH JU), a public-private collaboration aimed at boosting research, technological development and demonstration projects.
- The largest project to receive funding from the EU's Connecting Europe Facility (EU-CEF) programme is a Dutch initiative: TSO 2020. This project is aimed at developing a cross-border energy network in which surplus renewable energy from Germany and North Sea wind farms is converted into hydrogen in the Netherlands, which is then distributed to Dutch and German consumers.



Large-scale production of carbon-neutral (green) hydrogen will take time, although the required technology is being developed at a rapid pace (see the next chapter). To boost the transition to hydrogen as a clean fuel, the Dutch see 'blue' hydrogen as an essential intermediate step. In this case, hydrogen is produced from natural gas but the CO<sub>2</sub> released in the process is captured and stored. In the Porthos project, infrastructure is being developed which will allow CO<sub>2</sub> from 'grey' hydrogen plants in Rotterdam to be transported and stored in empty gas fields off the Dutch coast.



The North of the Netherlands was the first region to receive European funding as a 'Hydrogen Valley'. Its potential is widely recognized: the initiative was backed by dozens of companies from 6 different countries. In 2020 regional authorities, companies and knowledge partners published an ambitious investment plan totaling 9 billion euros over the next 10 years. It encompasses over 50 projects covering the entire hydrogen value chain, including large-scale production, the development of distribution and storage infrastructure and a range of applications.



Hydrogen production

# Making clean hydrogen competitive

Hydrogen is only as clean as the energy carrier it's made from. For hydrogen to have a meaningful impact on the global energy transition, the production of clean hydrogen has to be scaled up substantially. And this, in turn, requires innovations that make its production process – electrolysis – more robust and cost-competitive.





TNO's Faraday lab in Petten is an innovation lab that focuses on optimising existing electrolysis technologies such as PEM, alkaline, SOEC and AEM. It enables manufacturers of electrolyser and their suppliers to develop and test new materials, components and applications under different conditions.

Currently, 95% of hydrogen produced around the world is 'grey hydrogen', produced from fossil materials such as natural gas and coal. For hydrogen to play its pivotal role in the energy transition, the first challenge is to scale up the production of clean hydrogen, produced from renewable energy sources. Electrolysis, in which electricity is used to split water into oxygen and hydrogen, is a well-established principle for carbon-neutral production of hydrogen. Yet it has struggled to make a breakthrough: its cost price is still several times that of fossil-based hydrogen, and limited demand has, so far, hampered efforts to scale up electrolysis installations and reduce cost price.

#### Next-generation electrolyzers

Many Dutch initiatives focus on this key challenge of making clean hydrogen more affordable. Much of the work is centred around TNO's Faraday laboratory in Petten, one of Europe's largest hydrogen research facilities. In this open innovation lab, researchers and a wide range of industry partners are working to optimise existing electrolysis technologies such as PEM, alkaline, SOEC and AEM. The innovations developed here focus on improving efficiency, boosting production capacity and finding robust, cheaper alternatives to the rare materials used in current electrolyzers. Other examples of cross-fertilisation between research institutes and industry partners include Voltache, aimed at electrification of industry, and Hydrohub's Gigawatt-scale electrolyser test centre.

### *Work has started on the Netherlands' first Gigawatt electrolyser to be operational by 2030.*

In addition to state-of-the-art facilities and research groups, the Dutch hydrogen ecosystem includes a wide range of technology providers. A recent survey found that, even though electrolysis is yet to become a mainstream technology for hydrogen production, nearly a hundred companies in the Netherlands are already active in the field or are planning to enter this market. These include manufacturers of electrolyser components such as membranes, as well as stack integrators, suppliers of supporting technology and system integrators with the expertise and scale to build

complete electrolyser installations. Many of these companies have extensive and valuable experience in other industrial markets, which can help to make the production process of electrolyzers more robust and efficient. For example, by standardising and automating production processes, or by developing efficient water purification technologies.

#### Scaling up production capacity

In addition to optimising electrolyser technology, the Dutch are tackling the question of what is needed for larger scale use. Current electrolysis installations typically have a capacity of a few megawatts, but to facilitate the huge growth of renewable energy (as well as to compete with much larger 'grey' hydrogen plants), this capacity will have to be a 100 to 1,000 times larger. This requires the development of hydrogen plants incorporating hundreds or thousands of electrolyzers. In the Hydrohub project, a large consortium of research and industry partners has taken up the challenge and is working on plans for a 'Gigawatt Electrolyser' to be installed in the Netherlands between 2025 and 2030.

#### Moving offshore

Finally, an increasing number of researchers and companies are focusing not so much on the question of how electrolysis can be implemented, but where. This question arises from the fact that hydrogen is widely seen as an ideal storage and transport medium for electricity. This has encouraged efforts to install electrolyzers closer to wind or solar installations, in order to minimise the cost (and inevitable energy losses) of transmission infrastructure. Recent innovations in this area include a wind turbine with an integrated 4 MW electrolyser, and the world's first offshore electrolysis platform in the North Sea, where offshore wind energy is converted into hydrogen.

The latter presents an interesting perspective for the longer-term. It raises the possibility of converting disused oil and gas platforms into offshore electrolysis installations. Although sea water currently has to be desalinated before it can be used for electrolysis, Dutch researchers are looking at ways to use sea water directly, which would open up new opportunities for electrolysis in areas where freshwater is scarce. And perhaps even for large-scale electrolysis further offshore. The Dutch are also exploring the possibilities of creating artificial islands in the North Sea, to be used as hydrogen production hubs for the many offshore wind farms to be built over the coming years.





In the northern coastal town of Delfzijl, gas grid operator Gasunie and Nouryon Chemicals are planning to build the world's largest electrolyser (20MW), which would produce 3,000 tonnes of clean hydrogen each year. They are also studying options to expand its capacity to 60 MW in order to produce sustainable jet fuel.



In the Hydrohub Gigawatt Electrolysis Factory project, a consortium of companies, universities and knowledge institutes is paving the way for the design of an electrolysis plant on an industrially relevant scale by 2030. It is part of the Institute for Sustainable Process Technology's Hydrohub programme, which also includes a state-of-the-art open test centre based at the Hanze University of Applied Sciences in Groningen.



HYGRO specialises in the production, delivery and distribution of hydrogen produced directly from wind. It is building a 4 MW wind turbine with an integrated electrolyser in the province of North Holland. The aim is to maximise synergy between wind power, hydrogen and pipeline & storage technology. The concept optimises conversion of wind power to hydrogen, which can be transported at much lower cost than electricity and with a significantly lower impact on spatial planning.



An existing oil and gas platform off the Dutch coast is being converted to the world's first offshore hydrogen platform. Electricity generated by offshore wind turbines will be used to convert seawater into demineralized water and to power a 1 MW electrolyser producing clean hydrogen.



In the E-thor pilot project, a 5 MW electrolyser is at the heart of a promising business model. It is powered by electricity from AVR's waste processing plant, and the oxygen produced alongside hydrogen is used by chemical company Tronox to manufacture pigments. The hydrogen can be used as fuel or feedstock, or can be combined with CO or CO2 to produce methanol or other chemical products.

A large orange hydrogen carrier ship, the Arctic Prince, is shown at night, sailing on the water. The ship's hull is a vibrant orange, and its superstructure is illuminated by bright lights. In the background, an industrial city with various buildings and cranes is visible under a dark sky. The water reflects the lights from the ship and the city.

Transport, storage and distribution

# Towards a global hydrogen economy

Large-scale production of clean hydrogen is one crucial step towards a carbon-neutral future. Equally important is the challenge of distributing vast amounts of hydrogen safely and cost-effectively. Dutch innovations are contributing to the development of a hydrogen economy – both at home and abroad.





The most straightforward way of transporting hydrogen is through pipelines, and few countries are as well equipped to build a nationwide hydrogen network as the Netherlands. That's because the foundation is already present. First of all, the country already has a dedicated hydrogen pipeline network of more than 1,000 km, connecting it to industrial sites in Belgium and France. But perhaps even more significantly, it has one of the world's densest and most sophisticated natural gas grids. This network includes 136,000 km of pipelines and over 7 million connections, reaching into almost every Dutch home and business.

This infrastructure can already be used for hydrogen transport. Not just by mixing hydrogen into the natural gas flow, but by replacing one with the other. Various projects have demonstrated that, with modest alterations, existing infrastructure can be used for hydrogen. In the province of Zeeland, a 12-km-long industrial gas pipeline transports around 400,000 tonnes of hydrogen per year, and nearly a dozen pilot projects are underway in residential areas to replace natural gas with hydrogen, using the existing infrastructure. Over the coming years, this trend is set to gather pace. One of the key policies on the Dutch climate agenda is that over 2 million homes must have switched to natural gas alternatives by 2030. And as the demand for natural gas falls, much of the network's capacity becomes available for hydrogen transport, especially since the grid includes many 'parallel' pipelines. It is estimated that, by 2026, the Dutch could already have developed a national 'hydrogen backbone' connecting the country's five main industrial clusters.

In addition to transporting hydrogen, the existing natural gas infrastructure also offers opportunities for storage, in order to help bridge seasonal variations in the availability of renewable power, or to balance the power grid. For example, in the north of the country the Dutch have been storing natural gas in huge salt caverns, with a capacity of hundreds of millions of cubic metres. Pilot projects have demonstrated that hydrogen can be safely stored here as well. In addition to this, Dutch researchers and industry specialists are already examining the technical and economic feasibility of storing hydrogen in empty gas fields, both on land and in the North Sea. The potential storage and transport capacity there is huge and could easily accommodate the approx. 11 GW of offshore wind power planned in the Dutch North Sea over the next 10 years.

Building a hydrogen economy requires other and more flexible modes of transport besides pipelines and, in this respect too, the Dutch are working on a range of innovations. For example, researchers at TNO and industry partners are developing special hydrogen tanks. This includes the development of new materials that enable hydrogen to be stored at very high pressure or extremely low temperatures, paving the way for safe and cost-effective transport by road, rail or ship. Other Dutch companies focus on binding hydrogen with other materials, such as nitrogen, carbon dioxide or toluene, to create a carrier liquid that is much easier to transport, sometimes even in existing oil tankers.

## *The country's 136,000 km of gas pipelines offer unique opportunities to develop a hydrogen backbone.*

### **A hydrogen hub**

While such innovations open up new opportunities for distributing hydrogen in the last few steps of the value chain, they can also be applied to large-scale transport over (very) long distances. And there is an urgent need for such solutions, since the potential for a global hydrogen market is huge. Studies indicate that in areas with abundant sunshine and/or favourable wind conditions, the cost of renewable electricity could fall to less than 1-dollar cent per kWh within 10 years. This will boost the business case for large-scale electrolysis, producing carbon-neutral hydrogen for other markets. Over the next few decades, Europe is expected to become a net importer of clean hydrogen, and the Dutch are anticipating this by positioning their country as a major hydrogen hub.

Here, too, they benefit from an excellent starting position. Some of Europe's busiest transport corridors converge on the Netherlands, thanks to excellent road, rail and inland shipping infrastructure, as well as pipeline connections with much of Europe. The port of Rotterdam is the largest port for oil and (liquefied) natural gas in Europe, and is working with industrial partners to build up a similar position for hydrogen. Several multinationals are already building electrolyzers in Rotterdam, and work has started on a dedicated hydrogen pipeline infrastructure. Other companies are focusing on the technology needed for large hydrogen tankers, and for storage infrastructure not just in the Netherlands, but also in the countries that are looking to capitalise on their potential as hydrogen exporters.

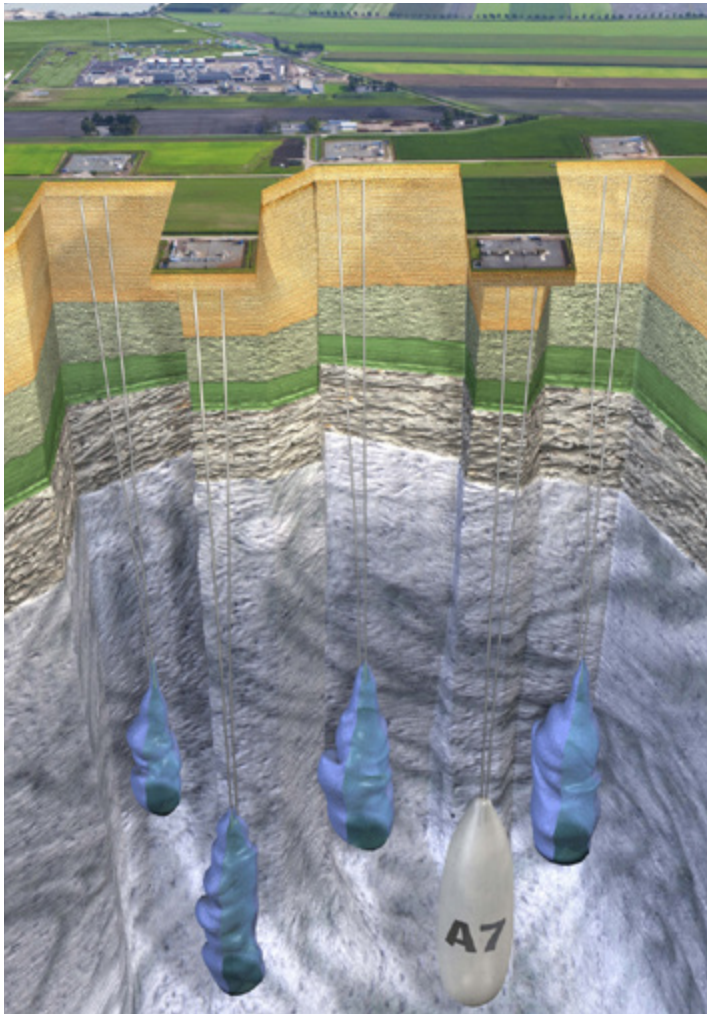




Various initiatives are underway to develop international hydrogen value chains. For example, the Port of Rotterdam has joined forces with Iceland's national energy company to explore the possibilities for importing clean hydrogen. The Dutch and Portuguese governments have announced plans for clean hydrogen from Portugal to be shipped to Rotterdam.



Stad aan 't Haringvliet is home to an active community of residents who are making a collective effort to phase out natural gas. Grid operator Stedin has already confirmed that existing gas infrastructure can be used to transport hydrogen to the village's 600 homes. Elsewhere, in Hoogeveen, similar plans have been developed which will allow hydrogen to be transported to over 500 new and existing houses over the next 5 years.



Dutch gas grid operator Gasunie is planning to develop its first large-scale hydrogen storage site at Zuidwending. Here its subsidiary Energystock operates a storage facility with six underground salt caverns, which are currently used for storing natural gas. Four new caverns will be developed for hydrogen, with a total storage capacity of 20,000 tonnes.



A national hydrogen backbone is being developed in the Netherlands, which will consist of 1,400 km of pipeline by 2030. The network will connect regional backbones with each other, with large clusters of industrial consumers and port facilities, as well as with storage facilities and grids outside the Netherlands. 85% of the backbone is expected to consist of reused gas infrastructure.



In the province of Zeeland an existing, 12-kilometre natural gas pipeline has been adapted to transport (residual) hydrogen from Dow Chemical's production site in Terneuzen to Yara's fertilizer plant in nearby Sluiskil. The initiative has allowed the two chemical companies to achieve CO<sub>2</sub> savings of 10,000 tonnes per year.





# Hydrogen applications Creating demand

Kickstarting the hydrogen economy requires investments in supply and infrastructure, but obviously also a large and stable demand. Dutch researchers and companies are working on a wide range of potential hydrogen applications, focusing on those with the highest impact on carbon emissions.





Holthausen is a fast-growing family business which specialises in converting lorries and special vehicles to run on hydrogen. It recently announced a joint venture with Hyzon Motors to produce up to 2,000 hydrogen lorries a year for the European market.

### Industrial applications

One of the areas in which hydrogen is expected to have the largest impact on overall CO<sub>2</sub> emissions, are industrial processes which require high-temperature heat. These are typically large installations which consume huge amounts of fossil fuel, mainly natural gas. The goal is to adapt industrial burner systems and ensure they can deal with hydrogen's radically different combustion characteristics. In combination with CO or CO<sub>2</sub>, hydrogen also has vast potential to replace petroleum and natural gas as a basis for the production of synthetic fuels and sustainable bulk chemicals, such as methanol, alkenes and aromatics.

### Mobility

Many Dutch innovations focus on modes of transport for which electrification is not (yet) an option, such as ships and long-distance road haulage. For example, the country has a large inland shipping sector, whose goal is to introduce 150 hydrogen-powered barges over the next 10 years, and as part of a pan-European project initiated by the province of Zuid-Holland, hydrogen fuelling stations will be built along the shipping corridor between Rotterdam and Genoa. Dutch solutions for road transport include hydrogen-fuelled buses and trucks, range extenders for electric vehicles and the technology needed for hydrogen refuelling stations.

### Residential heating

Gas-fired heating has been the standard for nearly every Dutch home for decades, yet this is about to change.

Newly built homes are no longer connected to the gas grid and, over the next ten years, millions of existing homes are expected to switch to sustainable alternatives. While for many newer homes this can be accomplished using solar energy, heat pumps and/or geothermal heating, for many older homes, hydrogen may be a more feasible solution. The existing gas infrastructure could be adapted to distribute hydrogen (see also p. 16). The Netherlands has a strong ecosystem of CV boiler manufacturers, who are investing heavily in transitioning from natural gas to hydrogen. Several have marketed models suitable for gas mixtures with up to 30% of hydrogen, and have showcased 100% hydrogen boilers. Others are working on technology that would allow existing gas-fueled CV boilers to be retrofitted for use with hydrogen.

### Flexible power infrastructure

Since our electricity supply is becoming more and more dependent on renewable – and intermittent – energy sources, it is important to ensure adequate buffers of carbon-neutral power. Currently, gas and coal-fired power plants provide the necessary back-up to offset a sudden drop in wind or solar power. The Dutch are working on the technology to convert these power plants to run on (carbon-neutral) hydrogen, as well as on the storage solutions needed to create large hydrogen buffers (see p. 16). Other innovations include flexible electrolyzers that can be used for grid balancing, frequency containment or as emergency power systems.



Near a crucial hub in the cross-border energy network connecting the Netherlands to Germany and Norway, Nuon/Vattenfall is preparing to convert an existing power plant to hydrogen. The first of the plant's three 440 MW units will run on (low-carbon) hydrogen by 2023. By converting the remaining units and switching to clean hydrogen by 2030, this is likely to become the world's first carbon-neutral hydrogen-fuelled power plant.





Dutch researchers at Nefit Bosch are working on a hybrid CH boiler, suitable for both natural gas and for 100% hydrogen. This concept would contribute to the affordability of a large-scale transition to hydrogen. The technology is already being tested in a large pilot project in the UK, in which 1,000 homes will be fitted with hydrogen boilers.



A consortium of more than 30 public and private partners, headed by DNV GL and glass manufacturer Celsian, has set up a two-year programme aimed at developing new industrial burners for high-temperature production processes. Its goal is to facilitate a fast and cost-efficient transition from natural gas to hydrogen.



Large-scale adoption of hydrogen as a transport fuel requires new technology for filling stations. Several Dutch companies, including Hyet and Resato, have developed proven solutions for some of the related challenges, such as the need for affordable and reliable high-pressure compressors.



Nedstack is Europe's largest producer of PEM fuel cell stacks. Its technology is used by customers around the world and was key to developing the world's first Megawatt-size power plant. The company is currently closely involved with various projects to develop hydrogen-powered ships. For example, it is working with the shipping sector to develop a hydrogen-electric drivetrain for marine applications. A 100% hydrogen-powered, 135 m long inland barge is being built, which will transport salt from Delfzijl to Rotterdam. Project partners are the NPRC, Lenten Shipping and engine supplier Koedood Marine Group.





# Five benefits of doing business with the Dutch







### **1. Quality and reliability**

The Dutch combine first-class technical expertise and innovative strength with a commitment to delivering high-quality, reliable products and solutions. Working with Dutch technology means you can be certain of compliance with the highest (European and international) standards.

### **2. An international outlook**

The Dutch have been doing business abroad for centuries. They understand what it takes to work successfully across borders and cultures, and are regularly ranked as having the world's most proficient non-native English skills.

### **3. High-tech excellence**

The Netherlands has a long history in high-tech innovation. In terms of the number of patents per capita, it ranks second in the world. It is home to world-class research institutes in clean energy technology, global players in semiconductor technology and excellent machine manufacturers.

### **4. Joint innovation**

The Dutch excel in creating flexible, fast-moving networks of specialist companies and research institutes. The Netherlands is home to dozens of 'field labs' in which such networks translate fundamental research into innovative solutions and test them in real-life pilot environments.

### **5. Easy access to specialist expertise**

The Netherlands has organised its clean energy expertise into national consortia. These networks offer fast and easy access to the right technology providers, researchers or combination of specialists. They pursue a common goal: solving global challenges together.

# Dutch hydrogen expertise in brief

Looking for specific expertise or technological solutions? In this section nearly a hundred Dutch technology providers with international track records introduce themselves and their portfolios. Consult the table on p. 26/27 to identify possible partners in your next step towards hydrogen successes.



# Enabling hydrogen successes

Energy is a necessity of life for people all over the world and global demand for energy is increasing rapidly. One of the greatest challenges of our time is to provide reliable, affordable and renewable solutions for all. Besides increasing demand for energy, we also have to prepare for global climate change. Climate change requires a different kind of energy supply and calls on us to develop new solutions and systems for a durable supply of clean energy.

The Netherlands has made substantial strides in the areas of renewable energy and energy efficiency, attaining a leading position in breakthrough hydrogen innovations. The energy sector contributes substantially to Dutch national revenue, exports and employment.

## Approaching complex energy issues

The Dutch energy sector enjoys a strong global position. This success is founded on a typically Dutch quality: the willingness to share knowledge within tight-knit alliances between industry, research, NGOs and government. This has made us a frontrunner in public-private research and open innovation partnerships and is how we prefer to approach complex energy issues.

## Effective and clean solutions

This cooperative approach is manifest in our hydrogen energy solutions, which offer complete, effective and coherent products and services geared to what people and companies truly need. The Netherlands regularly paves the way from knowledge to skills to new products and services, leading to integrated, sustainable and effective hydrogen solutions to meet energy demand.

## Win-win solutions

The Dutch energy sector is an ideal partner with experience, knowledge, products and services in the field of clean hydrogen energy. The Dutch offer solutions to deal with complex energy supply and demand, both in developed and developing countries. Cooperating and doing business with the Netherlands means all parties invest in a win-win solution. Citizens, companies, research institutions, investors and governments can all work together to achieve results that make a difference.

The Hydrogen Energy Guide showcases innovative Dutch organisations operating in the hydrogen energy sector. It is with great pride that we present these organisations to you.

**Manon Janssen**  
Chair Top Sector Energy



# Company profiles

	ELECTRICITY	H <sub>2</sub> PRODUCTION	ENGINEERING / INSTALLATION	INFRASTRUCTURE	FLOW SOLUTIONS	STORAGE	MOBILITY	MARITIME	INDUSTRY	BUILT ENVIRONMENT	INFRASTRUCTURE AND STORAGE	RESEARCH / ADVISORY	ASSOCIATION	PAGENUMBER
ABB	•	•	•	•	•	•	•	•	•	•	•	•		28
ABC-Techniek B.V.			•	•	•			•	•		•			28
Alles over waterstof												•		29
AMF Bakery Systems – AMF Den Boer									•					29
Ansaldo Thomassen BV									•					30
Antonius				•		•		•	•		•			30
AquaBattery B.V.		•				•		•	•	•	•	•		31
Berenschot												•		31
Bosch Rexroth B.V.				•	•	•	•	•	•	•	•			32
Bredenoord	•						•		•	•	•			32
BrigH2		•					•		•			•		33
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ABB is a leading global technology company that energizes the transformation of society and industry to achieve a more productive, sustainable future. By connecting software to its electrification, robotics, automation and motion portfolio, ABB pushes the boundaries of technology to drive performance to new levels. With a history of excellence stretching back more than 130 years, ABB's success is driven by about 110,000 talented employees in over 100 countries.

ABB's broad portfolio encompasses the full hydrogen value chain from production, transportation, storage to consumption. We are working closely with partners and our customers to create the new hydrogen ecosystem.

### Reference projects:

- ABB to install control solution for the automation of Lhyfe's first green hydrogen clean energy production project: [new.abb.com/news/detail/62419/abb-to-install-control-solution-for-the-automation-of-lhyfes-first-green-hydrogen-clean-energy-production-project](https://new.abb.com/news/detail/62419/abb-to-install-control-solution-for-the-automation-of-lhyfes-first-green-hydrogen-clean-energy-production-project)
- ABB will deliver automation, electrification and instrumentation solutions for the Hydrogen Energy Supply Chain (HESC) pilot project: [new.abb.com/news/detail/39225/abb-to-support-asia-pacific-clean-energy-project](https://new.abb.com/news/detail/39225/abb-to-support-asia-pacific-clean-energy-project)
- ABB will provide a power and propulsion solution for a newbuild vessel operating along the Rhône river in France to run entirely on hydrogen fuel cells: [new.abb.com/news/detail/24058/abb-to-enable-worlds-first-hydrogen-powered-river-vessel](https://new.abb.com/news/detail/24058/abb-to-enable-worlds-first-hydrogen-powered-river-vessel)

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ABC-Techniek started their activities in 1990 and over a period of three decades became a well-known and established system integrator.

ABC-Techniek is at your service in the following disciplines:

- Engineering
- Panel building
- Electrical & Instrumentation (E&I)
- Service and maintenance

Due to our experience in the area of control panels, electrical and instrumentation enables us to deliver reliable installations. Our professional knowledge offers you an integral approach from the designing process to realisation, pre-operational and start-up, maintenance and services.

ABC-Techniek provides products and services for the renewable energy industry, oil- and gas industry, petrochemical, processing industry and electrical engineering (ATEX/IECEx).

ABC-Techniek has a modern workshop with a surface area of 1400 square meters in total. Units up to 12 meters long and weight up to 13 ton can be moved to and in our workshop.



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We focus on the societal acceptance of Hydrogen. For this we host one of the major Dutch Hydrogen Websites. And we organise the 'Hydrogen Experience', practical and interactive workshops on Hydrogen for Companies, Schools and Government institutions.

In these workshops we let people actually experience Hydrogen by making it, storing it and using it in many ways during the event. And we advise others on how to involve stakeholders in their Hydrogen projects. We believe the end users should be involved from the beginning and not at the end.

We organise practical and interactive workshops on Hydrogen for Companies, Schools and Government institutions. In these hands-on events we let people experience Hydrogen in many different ways. We make Hydrogen, demonstrate how our (miniature) Hydrogen car works, show our Hydrogen scooter and our Hydrogen Drone. And we bake some Dutch pancakes on our Hydrogen Stove.

It is an ideal event if you are looking for Hydrogen inspiration as a kick-off for Hydrogen Projects. But we also love to visit schools to teach children and students, communities or inspire business teams.

#### AMF Bakery Systems – AMF Den Boer

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Bakeries and food producing companies around the world partner with AMF Bakery Systems – inclusive of AMF Tromp and AMF Den Boer – for best-in-class unit equipment and complete system solutions, from mixer to marketplace. Through innovative, precision engineering informed by our master bakers' expertise, AMF designs integrated production solutions for soft bread and buns, artisan bread and rolls, pizza and flatbreads, cakes and pies, pastries and croissants, and beyond. Single units machines and complete lines, at market standard and sometimes tailor made is what we offer and market for many years. Den Boer is our oven building company, where we produce production ovens, tunnel ovens or band ovens for many food applications, like bread, cake, muffins, pizza, pie, pastry, crackers, rusk, cookies and many more. AMF Den Boer has introduced the world's first

Hydrogen fuelled tunnel oven, than can bake at 0,0% emission and thus improve the bakery footprint immediately. Our Hydrogen burners can be retro-fitted onto existing ovens, and also Hybrid models are available, where natural gas and Hydrogen are combined, to make a first sustainable step for bakeries, until prices of Hydrogen drop more. AMF Europe is part of a global company with facilities in the United States, Latin America, United Kingdom, the Netherlands, China, and Singapore, collaborating with more than 600 teammates worldwide.

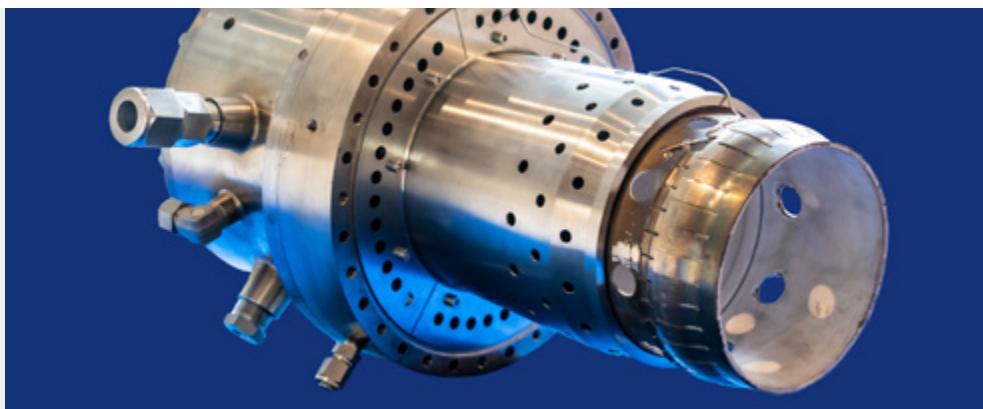
With a mix of global networking and local charm, the AMF Europe teams encompass a culture of passionate people who are committed to developing better food and better lives for their teammates, families, customers, and community.

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Ansaldo Thomassen (ATH) is a leading supplier of technologically advanced aftermarket gas turbine components, performance upgrades, in-house component repair and outage services for existing GE heavy-duty gas turbines. We offer flexible and comprehensive Service Agreements (FSA's), ranging from parts supply and reconditioning to full scope agreements including remote monitoring and diagnostics and inventory management.

Our vision is to supply cost effective advanced retrofit solutions for a Clean Energy World. ATH is leading a consortium targeting the demonstration of gas turbine retrofit technology for hydrogen. Together with our partners we are currently working on our High Hydrogen Retrofit Project.

Major objective of this project is to develop a cost-effective ultra-low emission (sub 9ppm NOx and CO) combustion system retrofit for existing installed gas turbines in the output range of 1 MW to 300 MW. At the centre of this innovative high-technology project is the patented and novel aerodynamic trapped vortex FlameSheet™ combustion technology platform. Fuel flexibility and stable operation from 100% natural gas to 100% hydrogen and any mixture thereof, is a key requirement.

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The energy transition is taken place right now and we are living it together. Green hydrogen will play a key role in regulating our energy needs based on supply and demand. Therefore the storage of renewable energy and the infrastructure is an important part of the whole process.

Antonius can be your industry partner for storage and transport design of energy. We are an experienced fabricator that can design your production process and build your newly developed product. Your idea will be transferred into a design ready for production. As your partner we will take care of the complete project management, fabrication and assembly of your product. Over 80 years of craftsmanship in shaping metals brought us to the level we are at

right now. With our extensive knowledge of materials and production methods, with the best qualified welders in the industry and our special machines we can produce high quality products against all applicable standards. Our craftsmanship is the reason why customers and engineering firms do contact Antonius at an early stage. We have an ideal situated production location (40,000 m²) with a direct waterside connection, to transport big parts by ship worldwide.

Meet our strength and challenge us to experience our craftsmanship. Let's work together and make this green deal! ANTONIUS.



#### AquaBattery B.V.

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AquaBattery is a deep-tech company based in the Netherlands working to revolutionize green energy storage. Our mission is to cut energy bills and catalyse the development and uptake of renewable energy technologies across the EU and beyond. We recognize that renewable energy is only part of the solution, and only through pairing it with cheap and scalable energy storage solutions can truly make an impact. AquaBattery was founded in Leiden in 2014 to commercialize the world's cleanest energy storage solution: a battery that can store renewable energy in water and salt (such as seawater). Our team is composed of leading experts in water membrane technologies and the energy storage industry, combined with the leadership of visionary founder Dr. Jiajun Cen. Together, the team combines 50+ years of engineering experience with 25+ years in business and management. We are supported by

a network of exceptional partners, such as Climate-KIC, TU Delft, The Green Village Delft, and technical experts at Imperial College London, REDStack, and Wetsus. Our technology has been successfully demonstrated through several prominent installations in the Netherlands and in Italy and has reached TRL 6. Our saltwater battery is a flow battery where power and storage capacity are decoupled. The user can decide on how large the respective components of power or storage capacity need to be in order to suit the application. The cost for scaling up the storage capacity is low, one just needs a larger tank, some salt and water. At locations where space is not the limiting factor, we can realise virtually unlimited storage capacities. This makes our battery very well suited for long-duration storage (10+ hrs).

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## Berenschot

We work with Dutch and European organizations in the energy sector, users, industries and governments to conduct system studies, roadmaps, strategic- and policy advice. Our services related to hydrogen are embedded in a systemic view:

**Scenario studies:** we provide insight into the consequences of choices with regard to our energy system, both economically and energetically. Recently, we developed four national scenarios for a low carbon future in 2050 (II3050). In all scenarios hydrogen (green & blue) plays a pivotal role in system balancing, storage and decarbonisation of sectors.

**Flexibility and system integration:** we provide support in quantifying the potential and feasibility of flexibility measures like power-2-gas and

hydrogen storage. Currently, we are developing a blueprint for a Hydrogen Exchange in the Netherlands. We analyse the technical, energetic and economic consequences of flexibility measures in the short and long run. We often work together with the energy industry.

**Techno-economic analysis:** we help to translate ambitions into plans for technology options like heat pumps, heat networks or carriers like hydrogen in order to arrive at the best future-proof solution with low costs and high durability.

**Implementation of the strategy:** we have extensive experience with organizations that operate in a mix of a regulated playing field of government and business. We help you with your strategy, design of the organization and the optimization of business processes.

#### Bosch Rexroth B.V.

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**rexroth**  
A Bosch Company

Green hydraulics: basis for efficient H<sub>2</sub> supply. The political framework is in place. Now it is important to find the right technologies for the rapid introduction of green hydrogen. Hydraulics is one of them, as it can compress hydrogen highly efficiently and safely. Last but not least, filling stations are thus particularly reliable and energy efficient.

Proven industrial hydraulics solutions are a major help in building the H<sub>2</sub> infrastructure. With Bosch Rexroth as a partner, the players benefit from needs-based support. This ranges from robust and safe components to engineering support and complete solutions.

When setting up H<sub>2</sub> filling stations, manufacturers and operators can choose from several approaches: For H<sub>2</sub> compression up to 900 bar and a delivery rate of approx. 100 kg/h, either highly dynamic cryogenic pumps or highly efficient compressors with linear or rotary drives can be considered. If smaller delivery rates are required, servo-hydraulic compact axes generate advantages because they require little space, especially for retrofitting in urban areas, and can be put into operation quickly thanks to the Plug & Produce preconfiguration.

Safety shut-off blocks and valves from Bosch Rexroth also prove their worth when transporting H<sub>2</sub> in pipelines. In addition, the hydraulics expert's close-knit service network creates the best conditions for optimum on-site maintenance.

#### Bredenoord

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Bredenoord is an independent family-run business that develops, supplies, maintains and operates the most reliable and cutting-edge decentralized energy systems worldwide and, consequently, provides its customers with energy security. Bredenoord continuously works on developing the energy solutions of the future and is one of the initiators in developing hydrogen applications in mobile and temporary energy, with a focus on sustainability, low emission and safe operation. Development of the first hydrogen genset started as early as 2006 and resulted in the Purity in 2009, which has powered various events, among other projects. With over ten years of experience with the Purity, Bredenoord continues the development of a hydrogen genset and takes part in various demos and pilots.

Through a clever combination of fuel cells and battery packs the Purity can be used straight away for projects with a low power demand. Bredenoord keeps aiming for innovative use of hydrogen technology for mobile power installations and, for example, also researches the use of hydrogen in combustion engines for gensets. These various research projects take place in collaboration with a variety of partners. Bredenoord is always open for new collaborations in this field.



## Brigh2

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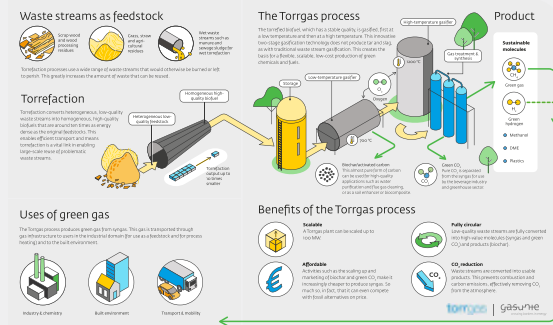
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## Torrefaction and gasification

Innovative and scalable technology that produces a sustainable synthetic gas



Brigh2 : The Renewable Alternative. Brigh2 plans to start a 50 MW gasification unit to produce 6300 mtpa renewable hydrogen, pure bioCO<sub>2</sub> and Biochar. The Demonstration plant will be situated on Brightlands Chemelot Campus and will serve the industrial users on the Chemelot site, but also intends to produce Fuel Cell grade Hydrogen for the mobility sector.

The project is in the feasibility phase at the moment. The location of the plant on the Chemelot campus fits exactly with the circularity target of the campus and the site. The feedstock will be torrefied biomass, where torrefaction does create a significant extension of the area where the biomass is gathered. Torrefaction also creates an uniform feedstock for the delicate process, reducing the investment costs per ton of renewable hydrogen to the max, but has proven

itself in the quality of the syngas produced and the potential for uninterrupted continuous production.

Next to the hydrogen production, Brigh2 also provides a long term sustainable route for CCU processes due to the biogenic origin of the CO<sub>2</sub> produced, as well as negative CO<sub>2</sub> emissions by connecting to the CCS infrastructure under development on the Chemelot site. Alternatively the CO<sub>2</sub> prevents an additional fossil CO<sub>2</sub> emission once applied in greenhouses.

The Biochar is of exceptional quality and suitable for a large number of applications now dependent on petrochemical coke of low sulfur.

The technology is developed in Groningen on a 1 MW scale and is further scaled towards a 2 x 12.5 MW unit to produce Methane from syngas in Delfzijl.

## Bürkert Fluid control systems

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Bürkert Fluid Control Systems is one of the world's leading manufacturers of measuring, control and regulating systems for liquids and gases. Bürkert products are used in a wide range of industries and applications, ranging from labs to medical, bio-engineering and aerospace technology. With a portfolio of more than 30,000 products, Bürkert is the only supplier to offer all fluid control system components, from solenoid valves to process and analytical valves, from pneumatic actuators to sensors. With its headquarters in Ingelfingen in Germany, the company has a wide-ranging sales network in 36 countries and more than 3,000 employees. Bürkert develops customized solutions and innovative products at its five Systemhaus locations in Germany, China, and the USA. The product portfolio is topped off by extensive services, from consulting and conception,

through implementation, to maintenance and training.

A rule of thumb applies in the language of engineers: the quality of a system is proportional to the quality of its components. In fact, the peripherals are coming more to the fore among experts – with control and regulating system modules as well as intelligent process related coupling of these components. This is where Bürkert has been active for over 60 years. As one of the few providers who can cover the entire process chain involving measuring, controlling and regulation.

It is no wonder, that the Bürkert product range includes precisely those components which are optimal for use in hydrogen technology: certified modules with low power consumption, a wide temperature range, chemically resistant properties and a good price-performance ratio.

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Cenex NL is an independent not for profit research and consultancy organisation on zero emission mobility and related infrastructure, and the circular economy with regards to mobility. Cenex NL is not driven by shareholders or returns-on-investment and was founded in 2018 for the purpose of accelerating transition to clean transport by providing technical expertise and disseminating lessons learned across Europe.

Cenex NL is a strategic partner of the UK's first Centre of Excellence for Low Carbon and Fuel Cell Technologies (Cenex UK – est. 2005). The Cenex organisations are established players in the European hydrogen community through:

- Active on-going participation in European R&D work:
  - H2ME (2016-2022): EU's largest FCEVs and refuelling infrastructure demo;

- ZEFER (2017-2022): Commercial and operational viability of high-usage vehicles;
- HyTrec2 (2014-2020): Hydrogen vans, trucks and refuse collection vehicles in North Sea Region.
- Market studies that analyse the European hydrogen market, enabling conditions and policy landscapes for technology take-up.

We offer expertise to automotive industry, early adopters of FCEVs and policy makers looking to implement strategies to accelerate the use of clean hydrogen in mobility. Examples include:

- Performance analysis of vehicle and refuelling infrastructure at real-world operations;
- Customer value proposition and business case of hydrogen in land transportation;
- Life Cycle Analysis of FCEVs and refuelling infrastructure.

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Special Hazard Fire Detection & Suppression

Desu Systems strives to make hydrogen production, storage and the fuelling process as safe as possible. Being the European Master distributor for Spectrex flame detectors, we supply to OEM's, contractors and fire safety companies.

We have several flame detectors in our portfolio that can detect an (invisible to the human eye) hydrogen flame within (milli)seconds. Our products are known for their long life and fault-free operation.

Our Hydrogen flame detectors are already in use in many hydrogen filling stations, hydrogen powered large vehicles and equipment and in storage facilities all over the world.

With our skilled staff and local stock we strive to provide fast and friendly service. Is your hydrogen project safe? Just give us a call.



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Duiker specializes in developing, designing, supplying, installing and servicing advanced combustion solutions, tailored to customer needs for liquid and gaseous fuels for the oil refining, chemical- and process industry worldwide.

At Duiker we believe in jointly realizing inventive solutions that make a meaningful contribution to people and the environment and hereby Duiker's motto is 'Thousands of process solutions, you can rely on our experience'.

The following products & technologies in relation to hydrogen are relevant:

Stoichiometry Controlled Oxidation (SCO) for conversion of coal fired power stations into sustainable (green) ammonia (as hydrogen

carrier) fuelled power stations for zero CO<sub>2</sub> emission electricity.

Multi-Fuel Combustion Technology: engineered flexible solutions for revamping existing process heater/furnaces from fossil fuels into low carbon or renewable fuels.

Stoichiometry Controlled Oxidation (SCO) for conversion of (green) ammonia (as hydrogen carrier) into (high) temperature heat for high temperature process industries.

Duiker participates in the Dutch 'Field Lab Industrial Electrification' with the proposition of the Multi Fuel Burner as an engineered solution to strongly reduce the CO<sub>2</sub> emissions of the fossil fuel fired process industry.

#### Dutch Boosting Group

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At Dutch Boosting Group, we are system thinkers for the living environment. Always with the bigger picture in mind. Continuously looking for new ideas. Our working method is based on a systematic approach. By explicitly balance needs and interests we believe to create sustainable solutions. We are driven by improvement and curious about new ideas and future-proof solutions. We innovate, we improve, we accelerate: that's how we boost!

We have been successfully applying our expertise for many years in complex Infrastructure projects, Spatial Development and Energy Transition. Sectors in which we see a crucial role for the application of hydrogen. In order to create the highest impact, we boost the application of hydrogen on various levels. Some examples:

- Quick Scans for organizations to determine the most suitable set of solutions, including hydrogen to attain its sustainable energy goals.
- Network analyses for governmental organizations to steer their policy making, by providing overview of stakeholders needs to adopt hydrogen applications, spatial distribution of local potential hydrogen availability and demand.
- Program/Process management of regional hydrogen programs and processes in order to accelerate the development and to stimulate local initiatives in order to boost innovation.

The challenges we face are complex. To find solutions, we are always open for joint ventures and collaborations in order to boost the implementation of hydrogen.

#### Dutch Marine Energy Centre (DMEC)

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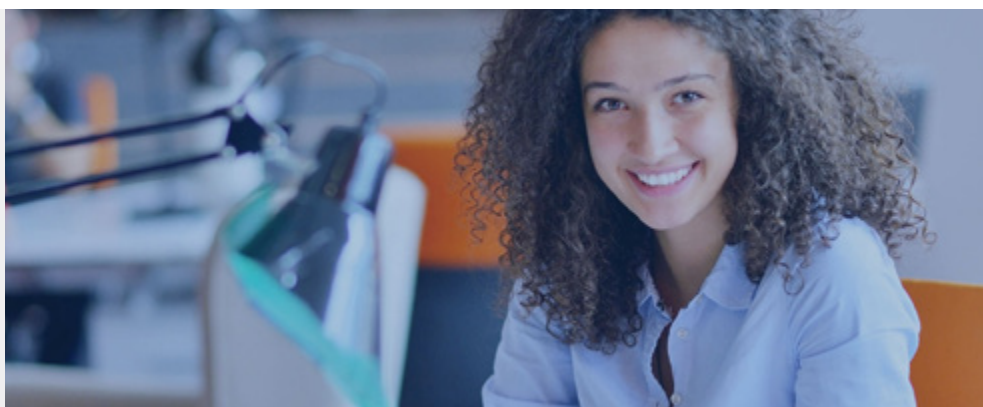
DMEC is an international accelerator and service centre for marine energy solutions. We believe that marine energy will be a crucial driver to realise our global energy transition and foster sustainable growth. By advancing innovation, mobilising capital and shaping policies, we create multipurpose energy solutions for a wide variety of markets, including green hydrogen production.

Electricity produced using marine energy applications can be used for offshore or nearshore green hydrogen production. Possible ways of doing this vary from using wave energy converters for producing hydrogen at decommissioned platforms, to future use of salinity gradient technology and tidal turbines to produce hydrogen at existing infrastructures like the Afsluitdijk or the Eastern Scheldt barrier. We foresee a promising future for green hydrogen and marine energy is ready to be a part of this.

#### E&E advies

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Consultants of E&E advies focus on connecting the energy transition to economic development. E&E advies supports governmental organisations, the industry and public-private partnerships to develop ambitions, strategies and policy. We perform exploratory research, we advise on policy and strategy, we monitor and evaluate policy or business cases and provide program- and project management.

Our result-oriented approach is based on our wide experience with clients in industry, governmental organizations and research institutes and strong analyses based on both quantitative and qualitative data.

Recently, we worked on several hydrogen projects:

- We developed energy roadmaps for Dutch Provinces and municipalities;
- We performed exploratory research on hydrogen production, infrastructure and use in Fryslân and Drenthe. Based on in-depth research and interviews, we identified regional opportunities and actively involved stakeholders from industry, governmental organizations and universities in our research;
- We have performed analysis that provide insight in the economic value of the energy transition and presented the results in factsheets;
- We monitor climate ambitions of several Dutch municipalities and provinces.



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For over 110 years, Eekels has been operating in the Marine & Offshore and Industry & Infrastructure markets. Its employees, totalling almost 600, carry out projects and maintenance & service operations in technical automation, electrical engineering and mechanical engineering.

Eekels has specific expertise in electrical drive systems, shore power connection systems, ship systems (including alarm and monitoring systems) and process automation. Eekels takes care of the entire process from engineering, panel building, implementation and start-up to maintenance and service.

We design, build and commission fuel cell systems including electrical conversion in a range from 100 kW to 500 kW and integrate them for vessels.

For the infrastructure we provide energy storage systems and provide electrical power with hydrogen as an energy carrier. These setups provide energy for construction sites and in harbour areas as mobile shore facility.

#### Ekwadraat Advies BV

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Ekwadraat guides and advises companies and entrepreneurs in the realization of projects in the field of energy saving, sustainable energy and energy saving.

For hydrogen projects, Ekwadraat provides (among other things):

- feasibility studies;
- subsidy applications;
- permits;
- certification;
- justifications for subsidy obligations and legislation and regulations;
- and PPA's.

#### Elestor BV

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electricity storage  
at an unrivalled cost level

Elestor is a developer of stationary, industrial electricity storage systems, based on the Hydrogen Bromine Flow Battery principle. With a worldwide patented design, Elestor introduces a highly scalable product, featuring storage costs per kWh far beyond what is achieved with conventional technologies.

Starting 2016, several pilots have been carried out successfully in the field. Currently, Elestor prepares for rolling out her technology commercially from 2021 onwards.

Elestor has been recognized with several (international) Awards, a.o. the European IDTechEx Award Berlin, for 'Best Development in Storage Technology', juried by Fraunhofer Institute, Technical University Berlin and Toyota Motors Europe.

Since the Elestor storage systems produce hydrogen during charge (and consume exactly the same amount of hydrogen during discharge), the technology offers a unique capability to integrate the worlds of 'electricity storage' and 'hydrogen production'.

The combination of the Elestor electricity storage technology and electrolyzers enhances the utilization of electrolyzers by ensuring long duration availability of low cost electricity. This also largely reduces the maintenance costs for the electrolyser, while the battery itself becomes simpler and offers electricity storage at even lower storage costs per kWh.

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Eltacon Engineering supplies gas treatment systems for the Power Industry and Oil & Gas market. Located in The Netherlands, Eltacon is an independent engineering contractor since the year 1987. Over the years we have obtained an excellent reputation in the design and fabrication of tailor made equipment.

For applications on the energy transition and related markets we have supplied several hydrogen treatment and mixing stations. In order to reduce carbon emissions hydrogen can be mixed to the current fuel gas stream to a suitable fuel gas mixture. By means of flowmeter, pressure reduction, measurement of Wobbe index etc. the downstream mixture will be regulated automatically. Eltacon will supply the complete treatment system based upon skid mounted units.

Reference projects have been delivered to (among others) Russia, Poland and Belgium and include natural gas mixing with hydrogen, nitrogen, BOG's and COG's.

For end-users, EPC contractors, turbines manufacturers and other clients Eltacon delivers high quality products with flexible services. The company itself is very flexible and is able to meet the variety of requests from the market.

The same as our clients, we are constantly striving for new solutions that minimize environmental impact. Conversely, they want to maximize productivity while generating a reliable supply of energy. Eltacon Engineering can meet those market needs, and others, thanks to our extensive experience and recognized know-how.



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ENGIE is an international leading company in the business of technical services and renewable energy generation. The 6.000 employees of ENGIE in the Netherlands support consumers, institutions and commercial companies to make the change to a more sustainable way of working and living. At ENGIE, we believe that Hydrogen will accelerate the transition to green energy in regions around the world for the benefit of all. Green Hydrogen, produced through the process of electrolysis will provide:

- Decarbonised solutions in mobility on both water and land
- Grid stabilisation services to solve congestion problems
- Storage capacity of intermittent energies

Renewable hydrogen, or hydrogen as a by-product, is a versatile energy vector that can be used to decarbonize many applications. At ENGIE, we offer solutions that are present across the entire value chain: strategy, design, engineering, construction of energy efficient assets, digital platforms, operations, and financing. We are committed to delivering the expected results. Our proximity to our customers allows us to enhance local resources, through production and decentralized Hydrogen storage for local uses.

Are you a company or local authority looking for partners capable of providing you support and advisory to develop carbon free solutions? ENGIE can work with you in your zero carbon transition goals, design integrated turn-key energy solutions that meet your specific needs.

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ERIKS is a specialized industrial service provider that offers a wide range of technical products, co-engineering and customization solutions, as well as related services for all possible hydrogen applications. We help customers in a variety of industrial segments to improve their products' performance and reduce their total cost of ownership. 6500 skilled colleagues worldwide serve customers in their original equipment manufacturing (OEM) and maintenance, repair and overhaul operations (MRO).

Our technical know-how is the basis of our specialism. We have built up deep expertise in the areas of sealing & polymer, gaskets, valves & instrumentation, industrial & hydraulic hoses, industrial plastics, power transmission & bearings and tools, maintenance & safety products.

We supply A-brands as well as our own ERIKS products. Besides we have our own departments for engineering, clean manufacturing, assembly, condition monitoring, smart asset management, inspection and field service engineers.

At ERIKS, we stand for doing good business. We value long-lasting relationships with all our stakeholders and contribute to a better and more sustainable society. ERIKS sees hydrogen as an important sustainable energy carrier for the near future. We are working on building this hydrogen fuelled world by combining hydrogen knowledge and products available in all our expertise areas. Our team of hydrogen specialist in the Netherlands is at your service for a customized solution.

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Feenstra started in 1947 and is since its establishment a major player in the Dutch market for installation and services of energy supply systems in dwellings. Both for private residential and housing corporations. These energy supply systems consist of solutions for heat, cold and electricity generation and storage. With more than 800 field service engineers, Feenstra is also active in the field of renewable energy solutions and the energy transition. We are front-runners with our partners in the field of hydrogen-projects, for existing and new buildings. For Feenstra's 800,000 customers we are always looking for new solutions whereby sustainable and comfortable living play a central role.

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TCE Van der Klok Beheer and TCE FINN are Netherlands based companies. They started in 2011 to streamline research, engineering, design and manufacturing components to finalize and bring to market innovative, green technologies designed to operate in the current world infrastructures.

This is a brief history summary of the TCE companies including the development of its technologies and products. In addition, an overview of the principles involved, a description of the products, testing protocols and results, and the current and future outlook for the company. This will be followed by sales projections, market development strategies and opportunities, growth needs and recognized challenges.

TCE has many years experience in engineering and production Hydrogen electrolyzers. The TCE Hydrogen System is a patented electrolytic retrofit technology for diesel engines. The product gases (oxygen and hydrogen) are an enhancement additive to the diesel fuel, not a fuel replacement. Using water, the product gas is produced in pods via an electrolytic process near the engine. The amount of gas produced is directed by the integrated computer system and determined by the power load of the engine. The harder the engine works, the more product gas is produced. It is then safely injected into the airstream just prior to combustion. TCE is specialist in machining high precision volume Electrolyser part and Electrolyser assembling.



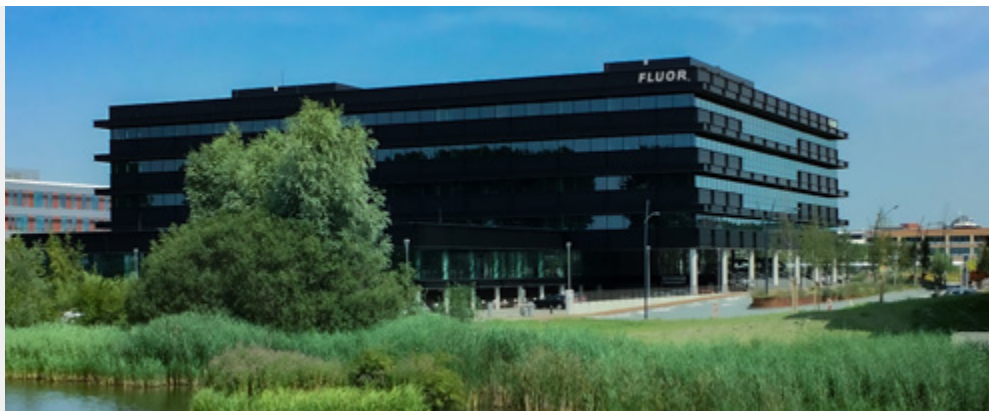
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# FLUOR®

Fluor is a global, publicly traded engineering, procurement, construction (EPC) and maintenance company. We work with clients in diverse industries around the world to design, construct and maintain their capital projects. Fluor has more than 46 years of experience in the hydrogen industry with 50 plants producing a total of more than 2,300 million cubic feet per day of hydrogen, including the world's largest hydrogen production plant at the time. Moreover, Fluor has its own independent electrolysis expertise, and knows the licensors of the basic elements and the developers of the hydrogen electrolyzers applying these technologies. With this knowledge, we can assist clients to select the right application for their objectives.

Fluor in The Netherlands offerings:

We successfully executed projects in Europe for

more than 75 years using a multi-office execution approach. With Fluor's offices in Hoofddorp, Bergen op Zoom, Geleen and Rotterdam, plus Stork, A Fluor Company, we can support clients with additional technical and project support. Our comprehensive solutions span the entire project life cycle and deliver capital efficiency. Industries served includes Advanced Technologies & Life Sciences, Oil & Gas, Refining, Chemicals & Petrochemicals, Gas Processing & Underground Gas Storage.

- Conceptual Studies, Full Front End Engineering and Design
- EPC and Project Management Consultant (PMC) capabilities
- Zero Base Execution
- Value Improvement Programs
- Organizational Effectiveness
- Integrated Partnership Programs

## FME

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FME is the Dutch employers' organisation in the technology industry. The 2,200 affiliated companies include technology start-ups, trading companies, small and medium-sized industrial enterprises as well as large industrial conglomerates. Our members are active in the fields of manufacturing, trade automation and maintenance in the metal, electronics, electrical engineering and plastics sectors.

Around 400 members are active in the renewable energy sector and 130 members in the hydrogen sector. Together with our members we coordinate and participate in multiple hydrogen projects in the Netherlands and in an international setting.

FME members employ a total of 220,000 people, have a combined turnover of € 91 billion and their exports total € 49 billion.

We connect and mobilize companies, knowledge institutes, end users and investors in order to find solutions to the global challenge for a greener future. Please connect with us if you are looking for a specific company, product or service. Let's work together!

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Frames Renewables; the best of both worlds. We are a manufacturer and supplier of renewable energy systems with the flexibility and innovativeness of a start-up and the professionalism and reliability of a renowned industrial supplier. Specialized in design and turnkey supply of installations for hydrogen generation (electrolyser systems), hydrogen storage and hydrogen applications for industry, horti- and agriculture and mobility. At Frames Renewables, we work closely together with our clients to put the unique power of our knowledge, skills and dedication into action in order to offer the best possible solutions.

Frames was founded in 1984. For 35 years we have built a reputation of quality and reliable systems to serve the international oil & gas industry. Driven by our ambition for sustainability,

Frames Renewables was founded in 2010. Our Drive is based on two things.

First of all we feel the responsibility to put our know-how to work to create a cleaner and better world of tomorrow. We know, this sounds fluffy, but at Frames Renewables we don't stop at bold statements and bullshit claims. We develop and deliver solutions that help you reduce CO<sub>2</sub> footprint, turn waste into value or switch to sustainable applications.

The second thing that drives Frames Renewables is our relentless drive to solve problems. With our technical background we accept any challenge and what better way to do this then together with customers on real-life problems.

We collaborate with clients around the world to provide tailor made or standardized plug-and-play products.



#### Fujifilm

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Fujifilm is the world's largest imaging company. Many of Fujifilm's new products find their roots in the company's original product: photographic film. However, our activities nowadays extend over a much wider area than only photographic film. Using the experience and know-how from our imaging history, we have diversified into many new markets. Today more than 70% of the products sold by Fujifilm have been developed over the last decade. These include medical and life science applications. But also highly functional materials have been developed for semiconductor, photovoltaic, automotive, water treatment and gas separation applications. Based on our long standing knowledge in coating thin functional layers onto substrates, Fujifilm is developing membranes for various industries. The first achievements of Fujifilm membrane technology are in the field of water purification

and natural gas treatment. In those business areas, membranes are increasingly competing on price and performance with conventional purification techniques. The development of Fujifilm's ion exchange membranes and gas separation membrane technology takes place at the R&D labs of Fujifilm in Tilburg, The Netherlands and in Tokyo, Japan.

With the growing need for green energy and carbon neutral future, hydrogen electrolyser technologies become an important cornerstone to meet the national, European and global CO<sub>2</sub> reduction targets. Membrane technology will play an important role in this for with several electrolyser types like Alkaline, PEM or AEM. Besides the technology, economy of scale will be required to meet cost down targets for green hydrogen as indicated by the international institutes and governmental roadmaps.



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gAvilar specializes in gas pressure regulation. We produce regulators and systems (stations) including safety devices for network companies and industry in the world. Mainly still for natural gas but more and more for other gases, because of the energy transition, like biogas (green gas) or hydrogen.

Our products are suitable for hydrogen, confirmed by Kiwa for some specific ones, and are therefore used in several pilot projects in The Netherlands. One of them called H2@Home that is going to test a special regulator in a typical 'home' situation at The Green Village, a test location at the Delft University campus where they installed a small hydrogen network to be able to heat a standard house with hydrogen.

This product closes the hydrogen supply based on external sensors, gas detectors, that are installed in the most critical places inside the house. The project is subsidized by the Dutch Government.

Also for the purpose of hydrogen blending we have developed an electronic volume converter that can calculate the calorific value of the gas. It works with an optional gas quality sensor and enables the invoicing for real energy instead of cubic meters.

**H2 Circular Fuel BV**

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H2 Circular Fuel is a Dutch company. It has specialized in building applications to extract  $H_2$  from H2Fuel ( $NaBH_4$ ), reducing it to  $NaBO_2$  and to regenerate this Spent Fuel back to  $NaBH_4$ .

H2Fuel is a patented technology for the production, storage and release of hydrogen. For its production, no electrolysis is required. The hydrogen is stored under normal atmospheric conditions in a powder. Release takes place without additional energy, using ultrapure water. Not only is one hundred per cent of the hydrogen stored in the powder released but, as a bonus, the same amount of hydrogen is released from the water, as well.

In dry powder form, the hydrogen can be stored for an unlimited period, is in energy terms the maximum attainable result, has no safety risks and, throughout the production process from production through consumption, features no harmful emissions at all. Once the hydrogen has been issued, the residual substances can be returned to the powder state with hydrogen stored in them: this makes H2Fuel the world's first circular fuel. H2Fuel can be deployed in all sectors of society and the economy and, as a result, forms by far the preferable alternative to both fossil fuels and other sustainable alternatives.

#### H<sub>2</sub>O Systems Holland BV

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H<sub>2</sub>O Systems Holland (H<sub>2</sub>O) designs and produces systems that generate 'Warmth from Water'. Hydrogen extracted from water is widely seen as the most valuable alternative fuel.

H<sub>2</sub>O introduces the 'next generation' hydrogen powered home heating systems. The system converts water into hydrogen by low power electrolysis and burn the hydrogen to produce heat.

H<sub>2</sub>O systems are designed for consumer use in single home units and in the future also available for multiple units and apartment buildings. The system is developed as an alternative for the currently used fossil fuel powered systems. The system is fully emission (CO<sub>2</sub>) free.

The system's unique points are being a 'closed system' that 'on location' and 'on demand'

generates hydrogen. Burning hydrogen makes sure the system generates energy and subsequently supplies heat for house warming and tap water.

The critical elements 'closed' and 'on location' imply no transport, no infrastructure nor any storage of gas is required. Dangerous and expensive transport and storage are completely eliminated. The key element 'on demand' implies that the H<sub>2</sub>O systems generates hydrogen 'on location' and 'on call' when the consumer turns on the system needing heat or heated tap water. This high potential research company holds the Intellectual Property (IP). Currently worldwide is no comparable system available. The Company's potential is based on international expansion as well as financial performance, shareholder and stakeholder value.

#### HAN University of Applied Sciences

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**HAN** UNIVERSITY  
OF APPLIED SCIENCES

The HAN H2Lab is a shared R&D facility, part of the HAN University of Applied Sciences. It is a meeting place for research, education and industry and has a focus on the development, testing and validation of small and intermediate hydrogen applications as well as feasibility studies.



## Hinicio

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Hinicio is a strategy consulting firm specialized in sustainable energy, with areas of expertise including hydrogen, renewable energies, energy storage and transport. Since 2007 Hinicio has developed a leading European competence centre on hydrogen and fuel cells. Our team collectively combines many decades of experience in the sector, including working in senior positions with leading industry players.

With offices in the EU, China and Latin America and an extensive partner network in Australia, Canada, USA, Korea, Japan, Hinicio supports customers globally on topics ranging from strategic assessments, innovation and marketing strategies, business plan appraisal, innovative business models development, market and techno-economic feasibility studies, due diligence, etc.

Hinicio has been working for players involved at every step of the value chain, from upstream (industrial gas companies, utilities, O&G companies, TSOs/DSOs), to chemical companies, equipment manufacturers (electrolysers and fuel cells), car makers and suppliers, fleet owners, public and private investors as well as industry associations and public institutions at all levels.

Over the years, Hinicio has developed world-class expertise on the development of infrastructure, a unique proprietary industry database on hydrogen and transport technologies, in-house modelling tools as well as knowledge on the (upcoming) regulatory framework.

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Howden is one of the world's leading manufacturers of air and gas handling solutions. We enable our customers' vital processes for a more sustainable world. We address the challenges of the energy transition with highly innovative solutions to contribute to the deployment of renewable and low-carbon hydrogen. Today, Howden has the knowledge, drive, expertise and experience to contribute to the development and deployment of hydrogen as a viable energy carrier supporting growing renewable sources: solar, wind, biomass energies. We do this by providing the compression full lifecycle from new build to service, sharing our customer focus relative to availability, reliability and total costs of ownership of their solutions. 'Compression through the hydrogen value chain' says it all. The hydrogen applications are numerous and whether

gasification or electrolysis are involved, there is always room for Howden's hydrogen high volume, high pressure and/or high purity compression. To help our customers reach their sustainability goals, Howden design compression solutions to integrate large or small-scale infrastructure applications to increase energy and production efficiency while minimizing carbon emissions in the mobility, industry and energy sectors. Working in tandem with our customers, our engineering DNA and experience deliver the winning combination by creatively balancing technical specifications, interface requirements, ambient considerations and future operating conditions. This approach results in the delivery of compression solutions fit to the purpose of the applications infrastructure they ought to serve providing peace of mind to our customers.

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Hy-Cell is a fuel cell stack and system development partner, with a design team based in The Netherlands and a 20,000m<sup>2</sup> high-tech manufacturing and R&D site in China. We are specialized in the design, testing and manufacturing of heavy-duty fuel cells for trucks, trains, busses, marine and energy storage solutions. Hy-Cell can provide cell plates, fuel cell stacks, fuel cell systems and do the fuel cell system integration into your product or provide assistance for system integration. Our experience of over 15 years, plus our holistic approach enables us to make design and manufacturing decisions to minimize the Total Cost of Ownership (TCO) of your application, while guaranteeing high quality, durability and safety.

Our Design & Sales office is based in Arnhem, the Netherlands. From here we design fuel cells and serve our Western customers. Our 20,000m<sup>2</sup>

high-tech manufacturing site is located in Jinan, China. From here we develop, produce and test fuel cells and serve our Asian customers. Our design team covers all steps of the fuel cell development, allowing us to efficiently support you with the design of the cell plates, stacks and systems. Our experienced production team verifies our designs in-house and produces your high-quality fuel cells and components with state-of-the-art production and testing equipment.

Hy-Cell significantly invested in testing equipment and uses a high-end short and full stack test station up to 200kW. The test stations, including software, are designed in-house and have extensive safety features to ensure stack and operator safety. Hy-cell's ISO 9001 compliant plant is equipped with high-tech international test equipment.

#### Hydrogreenn Platform

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Hydrogreenn Platform is an association of multiple companies and entrepreneurs in Northern Netherlands, who are involved with the hydrogen economy. By sharing information about innovations, the latest developments and ideas for further scaling up the hydrogen economy. Hydrogreenn stands voor HYDROGen Regional Energy Economy Network Northern Netherlands. VNO-NCW MKB North is an employers association and forms the secretary. Members of the Hydrogreenn network participate for example in the project 'Hoogeveen', where a newly built residential area is engineered on hydrogen.

Members of Hydrogreenn are ambassadors for hydrogen, the region and the development of this regional hydrogen economy. With the co-operation in the project Groene WaterstofBooster by Hanzehogeschool the Hydrogreenn network has a strong link to education, innovation and research facilities.



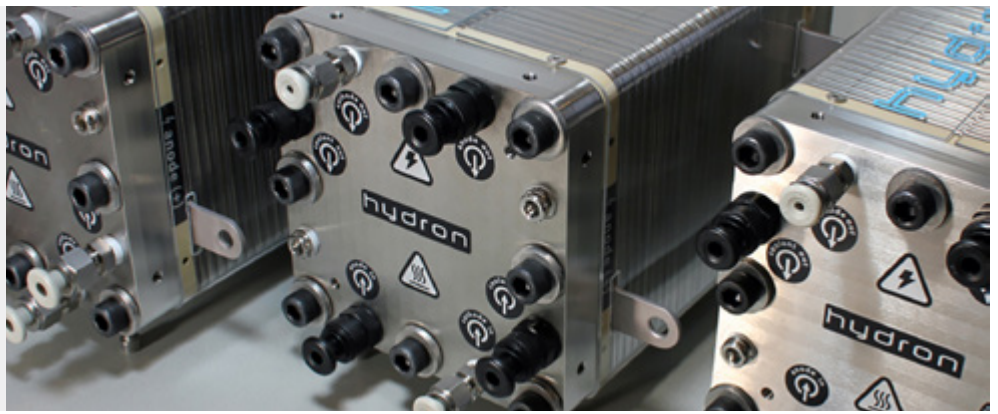
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Hydron Energy is a technology innovator that develops and manufactures advanced electrolyser stacks for hydrogen production equipment.

Hydron's cutting edge Polymer Electrolyte Membrane Water Electrolyser (PEMWE) technology offers an efficient, cost effective and reliable way to produce hydrogen (and oxygen) out of water and electricity.

Our technology delivers high performance and efficiency, with an exceptional small footprint. Hydron's electrolyser stacks feature a wide operating range and excellent dynamic response, making the technology ideally suited to be coupled to intermittent renewable energy sources. Because of the application of state-of-the-art membranes, hydrogen can be produced at high pressure and purity.

The company's product portfolio consists of a range of electrolyser stack platforms that can be used in various applications: from flexible screener cells for materials development, to robust large capacity stacks for application in industrial processes.

#### HyET Hydrogen B.V.

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HyET Hydrogen is an international company based in Arnhem, the Netherlands. HyET Hydrogen is a leading SME in the field of electrochemical hydrogen compression, extraction and separation, also referred to as Hydrogen Processing Technologies. HyET Hydrogen was founded in 2008. HyET has introduced the first commercially viable Electrochemical Hydrogen Compressor (EHC) in 2017. HyET enters partnerships with key stakeholders all over the world to develop products with a focus on application within the Hydrogen value chain. HyET's headquarters are located in Arnhem, the Netherlands and is run by an experienced interdisciplinary team. HyET Hydrogen had expanded its focus to the USA with a subsidiary, HyET Hydrogen LLC based in Colorado. HyET's Electrochemical Hydrogen

Compression (EHC) is completely silent, safe, cost effective, energy efficient and has no moving parts. The fact that the electrochemical compressor has no moving parts is also advantageous because it avoids wearing of parts which reduces the overall maintenance costs. The absence of moving parts contributes significantly to the reduction of maintenance costs and the prevention of damage, when compared to mechanical compressors. HyET's Electrochemical Hydrogen Processing technologies can significantly lower CAPEX and OPEX in the  $H_2$  supply chain for many existing industrial  $H_2$  markets as well as for the upcoming FCEV markets. Besides compression of Hydrogen, HyET Hydrogen also developed a technology which can extract and purify Hydrogen from mixed gas streams.

#### HyGear

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Our company is built on a vision that Hydrogen will be the fuel of the future. Once this happens, the current supply method of central hydrogen production and delivery by road transportation is no longer an economically viable option.

At HyGear, we developed technologies to generate and recycle hydrogen at the end-users' site. We have been applying these technologies in many different industrial applications over the past decades offering advantages in reliability, cost, and environmental impact.

In years to come, we will continue to focus on these industrial applications as well as grow our install base in hydrogen energy applications and thus become an enabler for a clean and sustainable future.

Most industrial gases in the bulk segment are produced at central locations and delivered to the end-users by road transportation. This method of supply is inefficient and expensive as the amount of gas that can be delivered is bounded by the limitations of the storage capacity on the trailers and distances are often large.

At HyGear, our focus is to downscale gas generation and purification systems to a size that matches the needs of bulk users. This creates independence from suppliers and also the limitations dictated by existing sources. Our technologies guarantee a major step forward in a more efficient supply of industrial gases and can act as enablers for the upcoming transformation of our energy system towards hydrogen as a carrier.

#### HyMove B.V.

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HyMove is builder and integrator of the most efficient fuel cell systems and integration techniques for heavy-duty applications such as buses in city and regional transport, trucks, construction equipment and inland vessels.

These systems work on hydrogen and oxygen from the air and supply electricity and heat. They only emit water. Due to their high efficiency and long lifespan, the HyMove systems are suitable as the 'heart' of hydrogen applications in transport, construction and shipping. The nitrogen reduction achieved through the use of hydrogen fuel cell systems in vehicles and construction equipment is 100%.

Theo Hendriks is mainly concerned with the question how zero-emission applications can be implemented. This is usually not a question of technology or money, but of bringing together the entire supply chain of committed parties. The transition is not a matter of an individual, it is a change to do together.

The technology that HyMove uses is now mature, ready for the market and can be rolled out. HyMove now has a number of years of experience. These systems have been proven in buses for urban and regional transport in Gelderland. Ten buses are under construction for Münster in Germany.

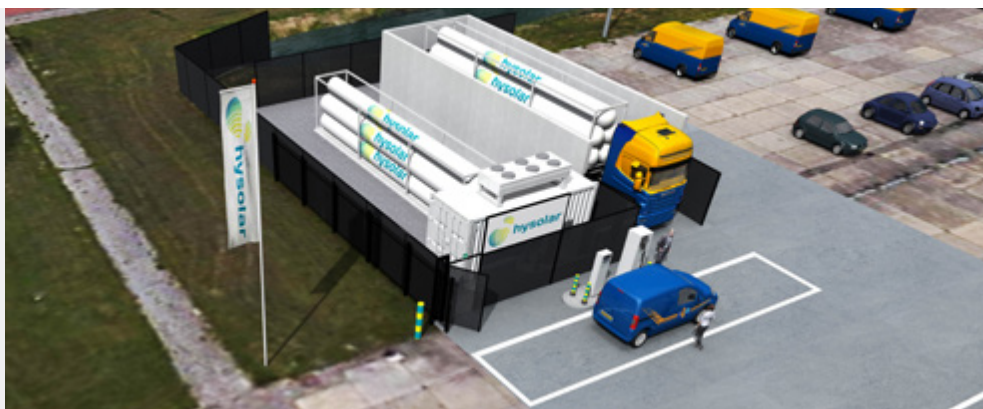


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Hysolar, founded in 2019, focuses on green hydrogen for mobility. In our vision, green hydrogen is a key element in a circular economy. Relying on practical experience in combination with scientific know-how we develop green hydrogen ecosystems, where continuous innovation is crucial. Hysolar activities are twofold:

1. The production and supply of green hydrogen as of 2021 in Nieuwegein, NL. Using local solar power Hysolar realises a 2 MW electrolyser to supply 250 tons of green hydrogen to our public 350 and 700 bar hydrogen refuelling station. One of our shareholders, is becoming a major user of green hydrogen for heavy duty jobs in civil works.
2. Innovation and consultancy activities to support businesses, local governments and

other parties in their transition towards green hydrogen.

Over the course of the year we have helped several municipalities and businesses with our innovation and consultancy activities. We've developed solutions in which grid congestion, caused by renewable electricity production, is solved by producing green hydrogen. The hydrogen will be utilized for heavy transport. Furthermore, we work closely together with an inland shipping company in order to decarbonize their activities.

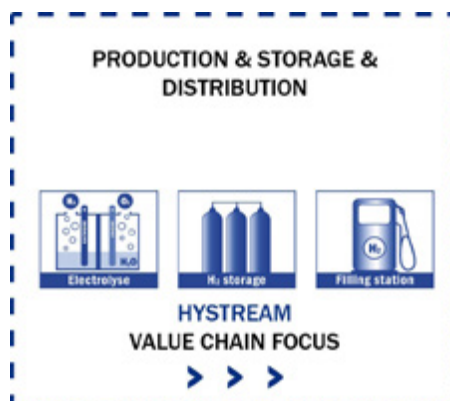
Last but not least our innovative 'dual fuel' solution has led to the launch of the first tractor on hydrogen. We are busy applying this innovation into other heavy machinery such as excavators. For more ongoing projects and related news, follow us on [www.hysolar.nl](http://www.hysolar.nl).

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Hystream develops and realizes state-of-the-art local green hydrogen solutions. Our objective is to decarbonise society by realising end-to-end green hydrogen solutions for mobility, such as transport, cars, inland shipping and utility buildings. As such, we are committed to realize and manage an emission-free hydrogen value chain that simultaneously creates value for all stakeholders involved in this value chain. Our collaboration with local partners and stakeholders is central to this. In this way we can accelerate the energy transition locally and make industry and mobility more sustainable. Our partners can provide all the necessary elements of the hydrogen value chain.

Our solutions resolve grid congestion problems, provide zero-emission construction power and make hydrogen available on-demand at different locations. Examples of current projects are hydrogen-based stable supply of green electricity whenever and wherever required, the local production of green hydrogen from solar or wind power and the realization of filling stations for the distribution of green hydrogen for cars, busses and trucks in areas where hydrogen is not yet available.

Hystream aims to realize a local public network of hydrogen production and distribution points for different types of users.

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**HYZON**

HYZON Motors was established in the US in January 2020 as a spin-off from Singapore based Horizon Fuel Cell Technologies Pte Ltd. HYZON is a global supplier of zero-emissions hydrogen fuel cell powered commercial vehicles, including heavy duty trucks, buses and coaches.

Headquartered in Rochester, NY and with operations in Europe, Singapore, Australia and China, the company is led by HYZON co-founders George Gu, Craig Knight and Gary Robb and commercializes Horizon's 17 years of hydrogen technology development for the transport sector. Prior to its spin-off, HYZON was known as the Heavy Vehicle Business Unit (HVBV) of Horizon and was responsible for the development of fuel cell vehicle platforms and the delivery of about 400 fuel cell-powered commercial vehicles in 2019 alone.

Its establishment as a standalone entity was to focus on accelerating the energy transition through the manufacturing and supply of hydrogen fuel cell-powered commercial vehicles across the North American, European, and Australasian regions.

Heavy trucks are the realisation of the 'think big, start small' motto adopted by the HYZON co-founders throughout their journey in hydrogen and PEM fuel cell technologies. HYZON heavy trucks contrast with the six-inch operational hydrogen fuel cell miniature car that was named Time Magazine's Best Transport Invention of the Year in 2006, as the first fuel cell car consumers could buy. This was one of many firsts along the 17-year journey for George, Craig and their team.

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Kenter is a Dutch energy solutions provider, currently serving over 30,000 customers in the Netherlands. Specialized in metering services, energy infrastructure and electric vehicle charging solutions, we help organizations to optimize their energy use and adopt innovative solutions to aid the process.

As a leading energy solutions provider, we're also specialized in hydrogen metering. This can be applied in various ways and with different purposes. For example, when you want to know the exact amount of produced hydrogen.

Kenter is at the heart of today's fast-moving energy world and is ready for a challenging future. As an independent part of Alliander, we are an experienced and knowledge-intensive partner. From the local bakery to large multinationals and from sport clubs to municipalities. They can all count on the expertise of more than 300 specialists working at Kenter.

We provide a complete package of energy services and metering solutions based on an up-to-date understanding of the market and innovative technologies. Would you like to learn more? Contact us by calling +31 (0)88 191 15 55 or send an e-mail to [info@kenter.nu](mailto:info@kenter.nu).



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# kiemt

Kiemt is a triple helix network organization located at Industriepark Kleefse Waard (IPKW) in Arnhem. As Energy Valley Bureau, Kiemt accelerates the development of innovations for energy transition and circular economy in the Eastern part of the Netherlands.

More than 200 members are participating in this active innovation network, consisting of knowledge institutions, SME's (start- and scale-ups) and (semi-)governmental organizations. These members are frontrunners in the field of energy and/or circular economy. Kiemt accelerates opportunities by scouting and screening of innovations, connecting these with the triple helix network and initiating projects and programs. By doing so, innovative, viable and sustainable products, services and companies arise from their original ideas.

Kiemt programs and organizes a regional hydrogen cluster, consisting of more than 30 SMEs (start-ups and scale-ups) and knowledge institutions. The aim of this cluster is to stimulate innovations for the further development of the East Netherlands as a hydrogen technology research & development region. This facilitates the implementation of hydrogen technology on a large scale and strengthens the regional economy at the same time.

The cluster focuses on:

- Starting up and accelerating initiatives;
- Matchmaking of parties to value chain(s);
- Exchange of knowledge and information.

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Kiwa is a world-leader in Testing, Inspection and Certification (TIC), Training, Engineering and Consultancy. With a background of more than 90 years in water, energy, and gaseous fuels Kiwa is a knowledge institute, and international quality authority.

Our services in the field of renewable energy production and hydrogen (low & high pressure) cover the complete value chain: Generation, Transportation, Distribution, Storage and Application of Hydrogen.

Key Services:

- Wide range of Solar and Hydrogen Testing Facilities 17025 accredited;
- Inspections of Solar, Wind and Hydrogen installations, including pre-compliance and consultancy inspections;
- Certification of components and systems like automotive tanks and components, fuel cells, appliances and pipes and fittings;
- Consultancy supporting R&D programs, feasibility studies, support in innovation and transition, technical due diligence, business and investments planning, pilots design and development, risk analyses, material research, failure analyses, etc;
- Training and qualification of personnel working in the renewable energy production and hydrogen fields.

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The Koedood Marine Group observes an increasing demand for electrification and sustainable inland shipping. Our group is comprised of several specialized companies centred around the development and implementation of future proof marine power trains. Koedood is the largest dealer of Mitsubishi engines in The Netherlands. With an innovative heart Koedood leads the development in the inland marine sector by example. Our group has knowledge stretching far wider than the inland marine sector alone and we are active in all markets involving maritime activities. Koedood now exists for over 40 years and has always been a driving force in the Dutch maritime industry.

Our mission is to maintain a leading role in sustainable technology for the maritime sector. With more than an decade of experience with hybrid systems and almost half a century of experience in the Dutch marine sector, our hydrogen technology can be seamlessly integrated in modern hybrid vessels. Our vision is to develop systems that can sail completely zero-emission on longer routes.

We seek strategic partners and contribute to several hydrogen projects and consortia. In the role of system integrator we take part in the Rh2ine consortium and actively develop hydrogen enabled drive train systems to further green the European waterways.

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Royal Van Twist is a family owned business with a history of more than 180 years. 80 years ago the distributorship for Perkins Engines was acquired. Based on the strong core engine Royal Van Twist started the development for gas fuelled engines 40 years ago. This resulted in the approval as Perkins official gas partner in 2014. The current gas engine range goes from 10 to 1200 kilowatt electrical.

During the 40 years of history we developed a great amount of knowledge with a large variety of gasses as Natural gas, Biogas and LPG. The last 10 years we have focused on gasses with a low methane number, mainly for thermal waste recycling processes. During these processes waste as tires, plastics, MDF and even medical waste is heated to high temperatures resulting in products like nafta (raw gasoline), carbon black, active coal and ash. As by-product a waste gas is

produced. This is used as fuel for the gas generator providing electricity to the grid). As low methane gasses could cause serious engine damage we have developed our own engine control systems. The systems are tested in our state of art in-house test facility.

As hydrogen could be considered as a gas with a low methane number we asked ourselves if it would be possible to use hydrogen as a fuel for our engines. After a positive conclusion from the feasibility study during the first half of 2019 we started the technical design at the end of 2019. The design includes a custom-built hydrogen injection block which is connected to the inlet manifold of the engine. The hydrogen engine was first started in October 2020. The first pre-production engines will be available for trail applications in the first quarter of 2021. Full production will start by the end of 2021.

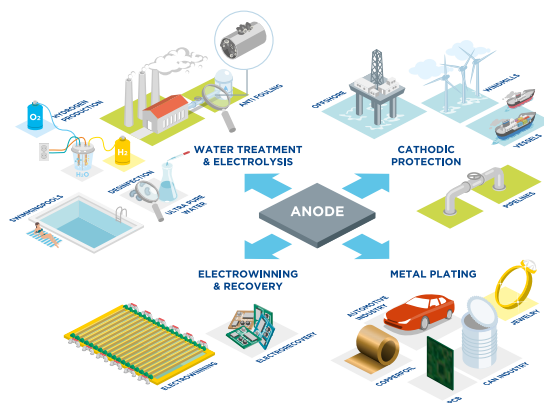


#### MAGNETO special anodes B.V.

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**Magneto**  
Special Anodes  
EVOQUA

MAGNETO special anodes strives to be the best designer, producer and supplier of titanium anodes for electrochemical applications. Inventor and proud supplier of high-quality titanium anodes and electrochemical cells for a variety of applications, MAGNETO has been catering to the electrochemical industry for more than six decades. We aim to ensure our customers are satisfied with their anodes.

The right anode is key for electrochemical applications. Selecting the correct one can lead to substantial cost savings. MAGNETO understands that your application – whether it's metal plating, water treatment, electro winning, cathodic protection, or hydrogen production – has its unique features. That's why we pride ourselves on our ability to manufacture custom

electrodes that meet your requirements, regardless of the specifications. In fact, we're well known in the industry for providing the optimal anode for every individual application.

A green economy will increasingly make use of hydrogen produced by water electrolysis. It is expected that water electrolysis will play a pivotal role in the future energy landscape. MAGNETO produces several components for PEM electrolyser systems in a cost-efficient and flexible manner.

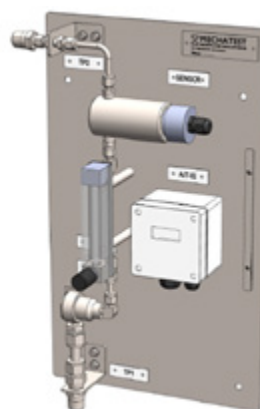
We're committed to designing, manufacturing and supplying titanium anodes for hydrogen production systems that fit your needs, withstands the test of time and reduce your operational costs.

#### Mechatest Sampling Solutions

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**MECHATEST**  
SAMPLING SOLUTIONS

Mechatest, is a leading certified manufacturer and worldwide supplier of analyser and sampling solutions specific for the Hydrogen market but in general for the petrochemical, chemical, oil & gas, pharmaceuticals, and power industry.

We offer advice, engineering 3D design and manufacturing capability for the supply of Hydrogen measurement solutions, our solutions are suitable for outdoor use in an industrial environment and ATEX Zone 1 or 2.

Hydrogen (wet gas) analyser or detection systems should be considered for product quality control and/or protection of the environment. The major challenge in measuring hydrogen samples in wet gas in an electrolyser system is to protect the

hydrogen sensor and ensure a long service life and high-quality measurement.

The output of the electrolyser is Hydrogen and Oxygen as a gas composition and might be saturated with water vapour. To take in a wet gas a Hydrogen sample is not easy, most sensors for this typical measurement in this acceptable price range are mostly not suitable for wet gasses.

Mechatest designed for the new electrolyser unit a Hydrogen gas measurement solution that allows for analysis of the wet gas Hydrogen stream in Oxygen composition and the Oxygen in Hydrogen composition. For more information go to:

[www.mechatest.com/hydrogen-measurement/](http://www.mechatest.com/hydrogen-measurement/)

#### Metalot Future Energy Lab

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Metalot Future Energy Lab aims to accelerate the energy transition by boosting the development and market introduction of promising technology in the sustainable energy domain. Particular focus is placed on Metal Power, Hydrogen and Energy Storage.

Within the Hydrogen domain Metalot Future Energy Lab currently develops the Hydrogen Community. Metalot Hydrogen Community focusses on the acceleration of experimental Hydrogen technology from TRL 4 and up, for Hydrogen production, storage and application.

Together we achieve acceleration by:

- Building new value chains together with knowledge institutes, governments and companies;
- Developing joint visions on technology application and adoption in the market;
- Developing joint R&D roadmaps based on concrete projects for the visions to become reality;
- Developing innovative technology and equipment together with the value chain partners;
- Joint commercialization of potential Intellectual Property.

For more information check out [www.metalot.nl](http://www.metalot.nl) or contact us via [info@metalot.nl](mailto:info@metalot.nl) to get in contact with the Hydrogen Community.

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MTSA Technopower develops decentralized energy management systems that convert green electricity into hydrogen and vice versa to make green energy available 24/7 and to prevent peak loads from solar and wind farms on the electricity grid.

Sun and wind energy is sustainable, CO<sub>2</sub> free and can be generated almost anywhere. On location, however, most of the day's yield is usually produced in just a few hours, while during the rest of the day hardly or no green power is available. Often the 80/20 rule applies.

Another obstacle to the large-scale application of solar and wind energy is the current grid capacity. This is often not sufficient to handle peak production from (planned) wind and solar parks.

MTSA Technopower offers a solution. MTSA Technopower develops product lines for:

- Power to Gas (P2G): Electrolyser systems for the production of green hydrogen in the capacity range of 1-10 MW.
- Gas to Power (G2P): Fuel cell systems for the production of electricity from hydrogen in the capacity range of 0.5-5 MW.
- Power to Power (P2P): Integrated energy management systems that combine hydrogen and electricity production.

Please visit our website: [www.mtsa.nl](http://www.mtsa.nl) or [www.mtsa.nl/lines-of-business/waterstof-technologie/](http://www.mtsa.nl/lines-of-business/waterstof-technologie/)



#### Micro Turbine Technology BV (MTT)

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Historic city centres and energy transition: Where heat pumps fail, and solar PV cannot be used, the Energy Transition for build environment has serious challenges to overcome. This is especially the case in Europe's historic city centres, which are essential for our European culture, identity and economy. Regulations prescribe that historic buildings must be preserved. Modern energy technologies (wall insulation, solar panels, double glazing or floor heating) are not desirable, not allowed, or have severe restrictions. Heat pumps cannot be used because low-temperature floor heating will affect building structures.

EnerTwin solution: The EnerTwin is the perfect solution to improve the energy efficiency and CO<sub>2</sub> emission reduction of a building. EnerTwin is a small-scale heat and power plant combined in one sustainable device. Its core is a micro turbine that drives a generator. Micro turbines have great

advantages in terms of reliability and lifetime, and bring low maintenance, high-efficiency and significant CO<sub>2</sub> emission reduction. EnerTwin is also suitable for clean fuels such as green gas, biomethane and gas mixtures with up to 23% hydrogen, but it can also run on natural gas. By using renewable fuels, 100% green electricity is produced. Moreover, this leads to additional CO<sub>2</sub> emission reductions. Plug and play installation (no renovation required) makes EnerTwin the perfect solution for rapid energy transition of historic buildings in city centres.

Hydrogen: The EnerTwin is currently CE certified for fuels with up to 23% Hydrogen (mix). It will be adapted to 100% Hydrogen in 2 steps (50%, 100%), while backwards integration is still possible in case there is not yet a hydrogen infrastructure available. A 50% Hydrogen solution is expected to be already available by the end of 2021.

#### Netherlands Enterprise Agency (RVO)

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Netherlands Enterprise Agency

The Netherlands Enterprise Agency stimulates entrepreneurs in sustainable, agricultural, innovative and international business. It aims to improve opportunities for entrepreneurs, strengthen their position and help them realise their international ambitions with funding, networking, know-how and compliance with laws and regulations. As a government agency, it operates under the auspices of the Ministry of Economic Affairs and Climate Policy, and its activities are commissioned by the various Dutch ministries and the European Union. The Netherlands Enterprise Agency runs a number of programmes and supports business initiatives with various grant schemes.

Energy and Climate is one of the agency's key topics. The Dutch government is investing billions of euros in energy efficiency, sustainable energy and CO<sub>2</sub> reduction. In line with this, the Netherlands Enterprise Agency supports Dutch and international entrepreneurs and researchers in developing sustainable projects related to energy, climate and the environment. Innovation and public-private partnerships are key to the Dutch approach: the government, private sector, and academia co-operate on topics such as sustainable energy technologies, green materials, built environment, sustainable mobility, chain efficiency, sustainable electricity, new gas, and greenhouses as a source of energy.

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New Cosmos - BIE is a manufacturer of stationary and portable gas detection equipment, mixing high qualified gas detectors with smart forms of (wireless) communications suitable for applications in the hydrogen industry as well as for many other types of industries. With more than 60 years of experience in gas detection, New Cosmos - BIE serves beside Europe also customers in the Middle East and Africa.

New Cosmos has gas detection solutions for a variety of applications within the hydrogen market including detection at the fuel cell, filling stations, FCV workshops, hydrogen production, hydrogen storage, residential detection for hydrogen smart meters, hydrogen boilers and hydrogen cookers. Together with our R&D team in Japan we can find the best solution to suite your requirement.

Our mission is to create a safer global environment with a reduced number of accidents.

#### Our strengths:

- Sensor technology in house
- Over 60 years of experience
- Reliability
- Unique selectivity
- Long lifetime
- Extended range of sensors for different gases

#### Solutions for the following markets:

- New Energy Markets
- Oil & Gas Exploration
- Chemical & Petrochemical
- Automotive Industry
- Laboratories
- Micro Electronics
- PV Industry

#### New Energy Coalition

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New Energy Coalition is a regional development and cluster organization for the energy industry in the Northern Netherlands. It focuses on the development and valorisation of growth potential of the energy sector in the provinces of Groningen, Friesland, Drenthe and the Northern part of the province of Noord-Holland. The foundation is a triple-helix organization funded by public and private parties as well as knowledge institutions. As an intermediary organization it aims at accelerating knowledge sharing, energy projects, investments and job creation in the energy sector. New Energy Coalition was created in 2017 when three renowned energy institutes merged: Energy Academy Europe, Energy Valley and Energy Delta Institute. This created a comprehensive coalition of knowledge and educational institutions, companies that play a

key role in the energy transition and governments.

New Energy Coalition is the catalyst behind Hydrogen Valley, a six-year European programme in which more than thirty public and private parties are contributing to the construction of a hydrogen network in the Northern Netherlands. From large-scale production of hydrogen to the expansion of the number of hydrogen vehicles and refuelling stations, and from underground hydrogen storage to hydrogen to heat residential areas. All these initiatives are being developed in conjunction in the Hydrogen Valley ([www.newenergycoalition.org/en/hydrogen-valley](http://www.newenergycoalition.org/en/hydrogen-valley)), which has put the region on the international map as the exemplary region for hydrogen.



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Our aim is to make Dutch society more sustainable through the development and application of hydrogen technology and fuel cells. We do this by means of the following activities:

Combining strengths: the NWBA combines the strengths of governments, industry and research institutions in order to accelerate the development and application and create opportunities for the Dutch business community.

Sharing knowledge: the NWBA gathers relevant knowledge and shares it with its stakeholders. The NWBA acts as an advisor and knowledge partner in this regard. Training and education is also provided.

Representing: the NWBA represents the Netherlands in European initiatives and conveys the Dutch vision on hydrogen and fuel cell technology both nationally and internationally.

**NXT Mobility**

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Due to environmental and climate challenges, the demand for more sustainable mobility is growing. There are good alternatives to petrol and diesel available, but the availability of these alternatives is not yet optimal.

NXT Mobility is a total concept to make mobility more sustainable. We offer climate-neutral mobility cards and charging solutions for electric vehicles. With NXT Energy Hubs, our filling stations of the future, we already offer less environmentally and climate-damaging fuels and energy solutions.

We increase the availability of more sustainable fuels and make the energy transition locally possible. In addition to traditional fuels, we offer more sustainable variants at our NXT Energy Hubs such as LNG, HVO, electricity and hydrogen. The first hydrogen filling point will be realised at our NXT Energy Hub in Alkmaar in 2021.

#### Port of Amsterdam

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## Port of Amsterdam

The Port of Amsterdam is currently one of the leading energy hubs in Europe with availability of large scale flexible tank storage terminals, supported by extensive blending infrastructure for oil products, and its role as a supplier of kerosene to Schiphol Airport through a direct pipeline.

The Port of Amsterdam is however strongly committed to play an active role in the transition towards sustainable energy production and use in both local, regional, national and international supply chains. The Port of Amsterdam therefore aims to become the largest hub for the storage, blending and transit of renewable and synthetic fuels in Europe. In addition, it enhances the investment climate for existing and new companies to establish production facilities for these types of fuels.

The port is working closely with different partners to establish new value chains based on for example hydrogen, synthetic kerosene, and methanol. Therefore the proposal presented by the Port of Amsterdam reflects the strategy of the port in the development of creating the 'building blocks' for the Future Fuels Hub containing the following clusters of projects:

#### Infrastructure projects

- Regional Integrated Backbone (RIB): development of a newly constructed regional hydrogen pipeline connecting production sites (e.g. project Hermes / 100 MW electrolysis with Nouryon and Tata Steel) as well as the national hydrogen backbone, with partner Gasunie.
- Development of a hydrogen distribution network in the port area.
- Development of a (green) CO<sub>2</sub> distribution network in the port.

#### Port of Rotterdam

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## Port of Rotterdam

The objective of the Port of Rotterdam Authority is to enhance the port's competitive position as a logistics hub and world-class industrial complex. Not only in terms of size, but also with regard to quality. The core tasks of the Port Authority are to develop, manage and exploit the port in a sustainable way and to render speedy and safe services for shipping.

It is our ambition to continuously improve the port in cooperation with various partners in order to be the most efficient, safe and sustainable port in the world. Not only to strengthen the competitive position of the Rijnmond region, the Netherlands and Europe, but also to improve the quality of the living environment in and around the Rotterdam port area. To achieve this ambition, the Port Authority focuses on the following themes:

Innovation: we want to attract, facilitate,

encourage and accelerate innovation and renewal, so that the port of Rotterdam will grow into the smartest port in the world.

Accessible port: to strengthen our position as the largest logistics and industrial hub in Europe, we are working with several partners to improve accessibility.

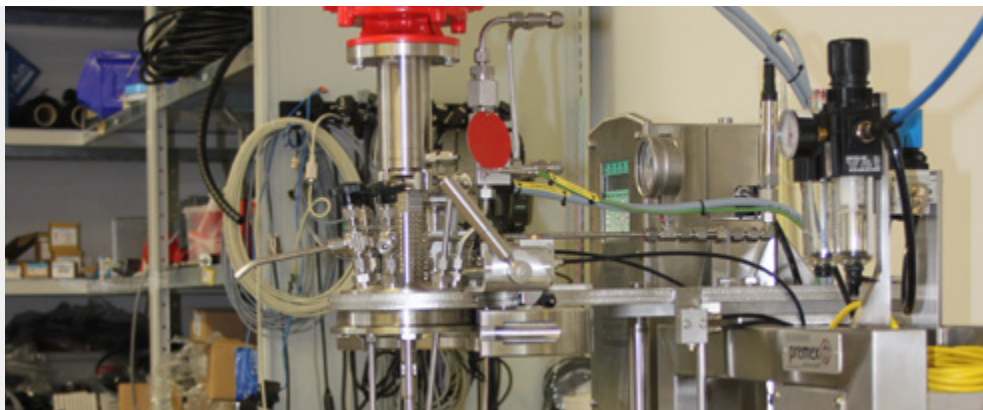
Sustainable port: we have the ambition to be the most sustainable port in the world. By sustainability we mean the greening of industry and logistics and the quality of the living environment.

Safety and supervision: Rotterdam is a safe port, both on water and on land. This is a basic condition for the functioning of the port of Rotterdam. In this respect, all players in the port have their own responsibility.

**Pro Control Process Automation BV**

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Pro Control is an engineering company with a very clear focus on the delivery of process control (PLC controls) and data acquisition systems for process installations (lab, bench and pilot scale) and skids. We have been doing this for over 20 years and work for well-known organizations active in the world of Chemicals, Oil & Gas, Seed Breeding, Aerospace and Defence. We distinguish ourselves through our knowledge and expertise of measurement & control technology applied in these demanding and often complex environments. We have knowledge of Siemens, Eurotherm, Honeywell, DeltaV, Rockwell, Beckhoff, Hitachi, Wonderware, iFix, Reliance and National Instruments LabVIEW (we are NI Alliance Partner). Supplemented with our expertise in the field of measurement and control technology, integration of analytical instrumentation (GC, MS, FTIR, etc.),

recipe control, data processing and the fact that we can deliver E&I projects turn-key, makes us a serious discussion partner in the field of automation and control engineering.

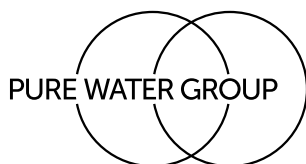
To give you some examples:

- For several skid builders active in Petro Chemical environments we are supplying the automation for the process skids they developed. Units have spread all over the world;
- We are an automation partner for a seed breeder in Enkhuizen and we supply turn-key machine controls and carry out extensions/ adjustments/renovations to the automation of existing installations;
- For the space authority we supply the automation (software, cabinet, cabling) of a vacuum set-up in which materials are tested in extreme conditions.

**Pure Water Group**

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Pure Water Group is a leading manufacturer of advanced and sustainable water purification equipment. We partner with innovative technology suppliers to develop and expand our product range. Core technologies include: Electro Deionization (EDI), Membrane Degassing (MD) and Electro Dialysis Reversal (EDR) which are used for the production of High Purity and Ultra Pure Water or the treatment and recovery of challenging water streams. Pure Water Group cooperate globally with water system integrators who fully rely on our expertise, extensive experience and dedicated support. Pure Water Group: engineering purity.



#### REDstack BV

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REDstack is an impact scale-up company, developing and implementing technology and membrane-stacks, for per example:

Reversed Electro Dialysis for sustainable and continuous power generation out of 2 waterflows with different salinities. The Pilot-Plant at the Afsluitdijk is running successful, and now ready for upscaling into a 0.5 MW Demonstration-Plant. The stacks generate DC, full continuous and very suitable for feeding directly into Hydrogen Electrolysers.

Electro Dialysis for water desalination. The new developed ED-technology and ED-stacks from REDstack have a significant lower energy consumption than traditional stacks. Industrial Electro Dialysis applications, per example for Nutrient recovery.

The stacks and system-design and supply is done in close cooperation with companies within the group: W&F Technologies and Pure Water Systems.

As REDstack has significant experience in designing and assembling various membrane-stacks, REDstack is a good partner in developing and realizing alkaline Hydrogen Electrolysers.

#### Resato International

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Resato is a Dutch provider of smart high pressure solutions with the aim to increase the productivity of its worldwide customers. It is our mission to meet and exceed the expectations of our customers. With more than 25 years of experience in high pressure technology, we are equipped with the knowledge to provide reliable and safe solutions. We want to support the hydrogen mobility sector with our high pressure solutions.

Therefore we have developed hydrogen refuelling stations to tackle the 'chicken and egg' dilemma: there is a lack of hydrogen filling stations due to a shortage of hydrogen cars, and vice versa. Resato's vision is to meet this challenge with compact and efficient refuelling solutions that support the development of a hydrogen economy.

For smaller hydrogen-powered vehicle fleets, such as cars and buses, hydrogen is still not readily available. By developing a compact and cost-efficient refuelling station (Fleet Owner Station), the first step has been taken to break through the high investment and make it possible for companies with fleets to refuel with hydrogen.

This way, the number of hydrogen filling points can be increased. When demand grows, the compact stations can be replaced by a centrally located public hydrogen station, where you can refuel your car within 3 minutes. This makes it easy to expand the network by relocating the compact filling stations.

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Semiotic Labs is a Dutch technology company that offers a SaaS predictive maintenance system to eliminate unplanned downtime and energy waste at industry leaders worldwide by using a combination of IoT sensors, artificial intelligence and machine learning algorithms.

The system SAM4 is a plug-and-play predictive maintenance solution for AC motors and rotating equipment that installs inside the motor control cabinet, not on the asset in the field. Sensors generate high-frequency data round the clock that is sent to an online platform for automated analysis using machine learning algorithms. Anomalies and failure modes are detected, classified and communicated to the client up to 5 months in advance via API, mobile or dashboard.

What is it good for? It immediately delivers clear value to the business by reducing maintenance costs, eliminating unplanned downtime and improving condition/energy insights.

What is the innovation behind? Unlike traditional solutions based on vibration analysis, SAM4 uses motor current signature analysis (MCSA). Current and voltage measurements are translated into a frequency spectrum that visualizes the motor baseline. Upcoming faults have an effect on the magnetic field of the motor, resulting in wrinkles on the sine-waves. From the wrinkles deviations from the baseline can be identified, often including the specific failure mechanism at play.

**SHV Energy N.V.**

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SHV Energy is a Netherlands based, family owned multinational distributing LPG, LNG and sustainable fuels servicing the energy needs of over 30 million customers worldwide.

We are proud to provide energy for hundreds of applications, ranging from cooking to heating to powering low-polluting vehicles. Through our local brands including Calor, Primagaz, Ipragaz, Liquigaz, Supergasbras, Xiwei, Supergas and Pinnacle Propane, we serve our customers through our market-leading LPG companies on four continents: Europe, Asia, North and South America. It is our mission to help clients find unique energy combinations, going beyond our responsibility of simply supplying energy.

Everyday we provide people and businesses beyond the gas grid with the opportunity to switch from high-polluting, carbon-intensive fuels to cleaner forms of energy. In 2018, we pioneered the launch of renewable propane (also known as bioLPG) to offer our customers a drop in replacement with up to 80% carbon reduction. Our activities within our Sustainable Fuels team are to explore, encourage and develop solutions for decentral off-grid domestic heating and cooking, industrial process heat and transportation applications. We already operate Hydrogen infrastructure in China and we see long term potential for global growth. Our focus is on collaborative action to tackle the challenges of green hydrogen for off-grid production and usage.

#### Sia Partners

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Sia Partners is a next-generation consulting firm focused on delivering superior value and tangible results to its clients as they navigate the digital revolution. Sia Partners was founded in Paris in 1999. Today, Sia Partners is still headquartered in Paris but developed into an organization with over 1800 consultants, active in 31 offices around the world.

With its global expertise in the energy sector and its recognized know-how in business transformations, Sia Partners is able to seize the opportunities offered by hydrogen to its clients from a business and technology perspective. The added value of Sia Partners:

1. Our teams work on projects all along the energy value chain – from strategic to operational steps – and are therefore familiar

with a large spectrum of actors/possible partners;

2. Sia Partners' expertise on the energy sector, especially on the stakes of energy transition and;
3. Sia Partners' knowledge on the hydrogen market and the actors of the ecosystem, which is deeply fragmented.

So far, Sia Partners has helped major gas infrastructure companies, energy producers, energy suppliers and research and knowledge institutions on a wide variety of hydrogen projects. Examples of Sia Partners' project focus areas are contextualization and challenges of the hydrogen sector, definition of hydrogen development strategies, support for project management and development of analytical tools.

#### Siemens Energy B.V.

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Energy systems around the world are undergoing fundamental changes: the balance of fossil fuels and renewable energy sources is shifting. Global demand for energy could increase by around 25 percent by 2040 – and, if we don't act, the amount of climate-damaging greenhouse gases could rise accordingly. The central question is: How can we meet the rising demand for energy worldwide and at the same time protect the climate – and do so in an economically sensible way? Siemens Energy can deliver answers.

We are convinced that a climate-neutral energy supply is not only technologically feasible, but also economically profitable. In this sense, the global energy transformation offers many opportunities that we intend to seize with determination.

We energize society around the world and thus enable successful and sustainable growth – that is our promise, indeed our purpose. As a competent partner and advisor, we want to enable our customers to realize their ambitious goals and commitments. All along the entire energy value chain, we accompany our customers on their way to a more sustainable future – no matter where they are.

Siemens Energy has a complete portfolio of products, solutions and services, ranging from the generation of (renewable) electricity, power transmission, to conversion into (green) hydrogen or e-fuels, including compression and industrial heat production, heat storage and heat recovery solutions. Together with our customers, we energize society worldwide.



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**HYDRO  
MOTION**

an initiative by  
TU Delft Solar Boat Team

We are the TU Delft Solar Boat Team, a group of 21 driven students from Delft University of Technology. With our multidisciplinary team, we aim to accelerate the transition to green energy. Within a year, we design, build and test a boat that completely sails on green energy. Every year, our team is fully committed to making our boat perform optimally in spectacular races. Here we can show all the applications of our advanced technologies.

This year, our team is building a boat that sails on hydrogen. We call this project HYDRO MOTION. For the last 15 years we have been building boats that sail on solar energy. This year, we switch from generating energy to storing energy in a green way. To show the potential and power of

hydrogen our boat will race at the world championships on the open sea of Monaco. We want to inspire the entire maritime industry by showing what is possible with a hydrogen boat. Together we can take the necessary steps towards sustainable shipping.

This project gives our students the opportunity to gain practical experience and learn what it is like to work together in a multidisciplinary team towards an ambitious goal. Over the course of one year, they will gain skills that will benefit them for the rest of their professional careers. By combining the creative and technical skills of our team with the knowledge and experience of our partners, we shape the engineers of a sustainable future.

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# SoluForce®

SoluForce is the originator and technological leader in long length high pressure Reinforced Thermoplastic Pipe systems (RTP, also known as Flexible Composite Pipes or FCP). They are used for many applications, such as hydrocarbons, water, offshore and mining.

The SoluForce RTP system has been certified for hydrogen applications up to 42 bar of operating pressure. Unique in the world of hydrogen transport and a global first. This significant milestone has a major impact on the feasibility of hydrogen, and is a new step towards a sustainable energy mix.

The SoluForce system is completely flexible, meaning it can go round corners, up hills, down slopes, across gullies, under water and more with ease. Being non-metallic, it is also fully corrosion-free, does not suffer from hydrogen embrittlement and is quick and simple to install. Our solutions further include various fitting systems that make it easy to connect our pipe systems to existing infrastructure.

First application of the SoluForce Hydrogen solution will be at Groningen Seaports, where four kilometres (2.5 miles) of SoluForce infrastructure will be installed. This infrastructure will ultimately distribute green hydrogen produced by wind mills in the North sea to companies in the chemical and industrial sectors in the Eemshaven.

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R. Stahl Electromach is an international leading design company with an extensive engineering and manufacturing expertise in explosion proof control systems. Our components and systems can be applied in areas where gas and dust explosions may occur. Therefore, we are the obvious partner of choice for oil, gas, petrochemical and offshore applications such as in refineries and oil and gas.

All safety solutions by R. Stahl Electromach are customer-based and include the development of application software, manufacturing, assembly, testing and on-site commissioning. R Stahl Electromach offers these solutions as full-service packages, from consultation and conceptual design to operation. We also take care of all international certification and providing after-sales support.

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Stork, a Fluor company, is a value-driven provider of fully integrated operations, maintenance, modifications and asset integrity solutions. By setting new standards of excellence in various sectors, we aim to be the industry reference. Every day, everywhere. Our global network includes our headquarters in the Netherlands, plus operations in the UK, Continental Europe, Americas, Middle East and Asia Pacific. Stork has a global workforce of 18,000 employees.

Stork has more than 60 years' experience in Hydrogen projects and is involved in several green Hydrogen projects. Stork has conducted market studies on Hydrogen for the EU and on various Hydrogen applications for companies. Stork has built the first 1 MW electrolyser in the Netherlands, builds and maintains Hydrogen fuel stations and is frontrunner in Hydrogen and Oxy

fuel combustion. Stork is the consortium lead and project manager for the development of a hydrogen house heating project in Hoozeveen, involved in energy and Hydrogen partnerships, education and Hydrogen standardization.

Stork is part of Fluor Corporation, one of the world's largest publicly traded engineering, procurement, construction and maintenance companies. Together Fluor and Stork are your partner for total Hydrogen assets lifecycle solutions, from feasibility to construction and maintenance.

With its more than 190 years of industrial experience, Stork is committed to play its leading role in the energy transition, also announced as 'the next great economic revolution'.

#### Summit Engineering B.V.

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Your partner in CO<sub>2</sub> reduction

“Leaving a world to thrive in for future generations.”  
We want to use our personal energy for that.

Summit Engineering was founded by Arjan Hartemink and Robbert van der Pluijm after a trip to Mount Kilimanjaro. The journey to the top and back, has inspired them in many ways. The glacier at the summit is becoming smaller every year due to global warming. Being confronted with this so closely, was the final push: we have to do something.

Summit Engineering now supports companies and governments with their Energy Management and Sustainable Energy Projects. We also share our knowledge with the future generation by teaching classes at universities. Together we

work on reducing CO<sub>2</sub> emissions and on taking steps towards a CO<sub>2</sub> neutral world. Hydrogen can play an important role in achieving this goal.

At Summit Engineering we have experience in the various aspects of the hydrogen supply chain. From production, to transport storage and utilisation in different areas. We provide concrete advice and excellent project support you can count on. Whether you are at the concept phase of your project or already working towards project implementation.

We use our knowledge, experience, as well as our extensive sector network, to provide a tailor-made programme for achieving optimal results.

#### SuWoTec B.V.

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To secure a sustainable future for generations to come, We develop sustainable circular technologies that are inspired by the way nature works.

First understand nature.

Nature has its own unique ways and systems to create, utilize and recycle. These are proven processes, fine-tuned over thousands of years. More often than not, the way we humans have built today's energy and transport infrastructure, however, follows completely contrary ideas. Then, develop game-changers.

Identifying nature's fundamentally efficient and resilient processes, we develop game-changer technologies that are circular by design and feasible over time. Our work must have a positive effect on people and planet, right where it matters most.

One of the game changers is the development of non-corrosive electrodes and membranes. Ongoing development for electrolyzes, fuel cells, batteries, water cleaning and carbon capture. Electrodes with longer life time and not participating in the process. We expect suitable for multiple energy carriers next to hydrogen.



#### Tieluk BV

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After several years of testing, Tieluk has developed a hydrogen generator that can produce a significant amount of green hydrogen. The hydrogen produced by electrolysis is demand-driven and mixed directly (on location) at a gas-fired water heater. The first 10 systems have been installed in for example a flat, office complex and theatre.

The hydrogen generator developed by Tieluk is unique in the market. The patented green hydrogen generator can be used within the built environment, supplying industrial process heat and processing surplus energy. In addition to the highly efficient production of hydrogen, all energy released during the electrolysis process is also put to good use, which further increases the efficiency.

Tieluk's green hydrogen generator is distinguished by:

- Direct savings on the use of natural gas of to 50%
- Strong reduction of CO<sub>2</sub> emissions
- Local, on demand generation of hydrogen
- Direct processing of hydrogen in the combustion at a water heater
- High efficiency by making very efficient use of hydrogen production and residual heat
- Suitable for both high, medium and low temperature heating
- For larger power demands (> 100 kW), the system can be cascaded up to a few MW

#### Realized projects:

- Milieudienst, Groningen
- Stichting Woningbouw Achtkarspelen, Buitenpost
- Kantoorcomplex 'Da Vinci', Leeuwarden
- DUWO Studentenhuisvesting, Amstelveen
- Huis van de Schoone Kunsten, Apeldoorn

#### TKI New Gas (Topsector Energy)

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**TKI NIEUW GAS**  
Topsector Energie

Topsector Energy (TSE) is the driving force behind innovations that are necessary for the transition to an affordable, reliable and sustainable energy system. The Dutch Knowledge and Innovation Agenda, as a part of the National Climate Agreement, determines the priorities of the TSE.

The specific innovation agenda of TKI New Gas focuses on the following topics:

- Hydrogen: full hydrogen chain as well as the system role that hydrogen can play;
- Green gases from biomass through different processes, such as digestion, gasification and supercritical water gasification;
- Capture, Utilisation and Storage of CO<sub>2</sub>;
- Geo energy, with focus on subsurface innovations regarding energy storage and geothermal energy.

Hydrogen is a cross-cutting theme for the Topsector Energy because it deals with all sectors of our national climate agreement as well as addressing the system role which could be beneficial for all stakeholders in the energy transition.

Our main activities include 3 types of activities:

- roadmapping, such as defining innovation agendas together with Dutch stakeholders;
- facilitating innovators, for example finding partners, matchmaking and access to funding opportunities;
- communication and information on activities, projects, research programmes and relevant developments.

## TNO

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TNO is an independent research organization. TNO believes in the joint creation of economic and social value. TNO connects people and knowledge to create innovations that boost the competitive strength of industry and the well-being of society in a sustainable way. This is TNO's mission and it is what drives the over 3,200 professionals in their work every day. In 2018 TNO came together with ECN to form a Unit solely dedicated to the energy transition, with 1,000 energy professionals covering the full breadth of knowledge disciplines to support industry and drive sustainable innovations forward to reach their 2050 CO<sub>2</sub> neutral goals. TNO is one of the leading applied research institutes in the field of hydrogen. More than 15 research departments spread over 5 units are collectively working on innovations along the

entire hydrogen value chain from production to infrastructure, storage and final applications. We bring engineers, business analysts and social scientists together to create insights into the future of hydrogen technologies. TNO is involved in over 50 hydrogen related projects in 2020 only. From developing new materials for PEM and SOE in our Faraday lab, test on industrial scale up to 2.500 cm<sup>2</sup>, 250 KW in the Hydrohub and in our new power2X fieldlab Rotterdam. We work on pre-feasibility and engineering studies for large scale deployment in project such as NorthH2 and the Gigawatt project. In the unit Traffic & Transport we work on amongst others fuel cell integration in heavy duty vehicles and energy management. With our facilities it is possible to speed up the R&D process and time to market for the industry.

## TNO Process Safety Solutions

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Testing the behaviour of dangerous chemicals and to perform chemistry at extreme process conditions; that is the domain of TNO Process Safety Solutions. We apply our recognized hazardous chemistry expertise, explosion safety knowhow and highly specialized infrastructure to support safe chemical handling and improved process performance.

We have a proven track record in customized testing of processes and materials and this also includes hydrogen related activities. We can help you identify whether a material, equipment or process can handle harsh temperatures, pressures or explosions. Our fume hoods, analysis equipment and testing infrastructure are placed in fortified bunkers. With this, we are able to perform experiments at extreme conditions such as temperatures ranging from -180°C to

1000°C, from 0 to 2000 bar, from no hazard to high explosive material and from lab scale to pilot scale. Our expertise include:

- Explosion Safety: detonation and deflagration tests;
- Stability and Sensitivity: reactive chemicals, energetic reactions, hazardous materials;
- Permeability and Compatibility: tests with dangerous chemicals;
- Customized and standard testing: cryogenic conditions, elevated temperatures, high pressure.

Our team of multi-disciplinary specialists and facilities allow a broad range of possibilities and enable our customers to explore innovative production routes, develop new materials/ applications, or intensify their current process without compromising on safety.

### Toyota Material Handling

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# TOYOTA

## MATERIAL HANDLING

Toyota Material Handling helps businesses of all sizes across Europe meet today's materials handling challenges with a full range of Toyota counterbalanced forklift trucks, BT warehouse equipment, and services and added value solutions, including service contracts, short term rental, used forklift trucks and the Toyota I\_Site information service.

Active in more than 30 countries across Europe and with headquarters in Sweden, TMHE has a European Office in Brussels and production centres in Ancenis (France), Bologna (Italy) and Mjölby (Sweden).

With nearly 5,000 service engineers, around 10,800 employees, along with a network of independent distributors and dealers, TMHE is the

European regional organisation of Toyota Material Handling Group (TMHG), which is part of Toyota Industries Corporation (TICO) – the global leader in materials handling equipment. Since the acquisition of Vanderlande and Bastian Solutions, it's TICO's ambition of becoming the first-choice partner in the material handling business as a total solution provider for projects of all sizes.

Our customers are our number-one priority. By staying in close contact with you we can understand your needs and provide the solution, technology, energy, service and financial flexibility that fits your operation. We can do this by working according to TPS and TSC (Toyota Service Concept), and by continuously improving.

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# Tradinco

## Instruments®

Tradinco instruments, is a supplier for sensors, calibration, equipment, services and software. We have an excellent track record since 1963 and have strong links with the process industry and equipment manufacturers. With our knowledge and hands-on experience, we provide expert advice and if necessary we can design and supply custom instrumentation to match requirements in your application. Customizations can range from small modifications on existing equipment and sensors to completely new developed instruments and software. Our calibration test benches and AutoCal+ calibration software are used around the world. With our ISO17025 accredited calibration lab, we offer facilities and knowledge to do research or qualification tests.

Specifically for hydrogen applications, we offer dedicated sensors and can calculate expected service life of pressure transmitters based on the process conditions and advice on the best option for your application. Our sensors are already used for many years in hydrogen installations for the automotive and semiconductor industry. Next to this we offer customized test, measurement and calibration solutions. Please contact us and find out for yourself.



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**TOTAL SUPPORT**  
*group*

TSG Group is a Dutch engineering company headquartered in Eindhoven with subsidiary at Brightlands Chemelot Campus. We design, develop and realize new products, special machines and industrial automations including tools and web applications. Portfolio in the field of novel development of sustainable energy systems, is present.

TSG Esempio is active in the field of new products with Industrial & UX Design. We also make use of CAE tools like FEM, CFD and topologic optimization. We create and build prototypes including functional models and proof-of-concepts. We have our own workshop in Eindhoven. We are also experienced in pilot production, ramp up and industrialization. TSG Innoteq has a focus on development and realization of special machines, automation of

processes and the tools that come along in this trajectory. This includes automatic packaging lines and custom test equipment. One of the specializations can be found mass production techniques for plastic deformation of metals and in joining and assembly methods.

TSG Engineering provides technical capacity and knowledge for projects at our customers' offices. Finally, sister company Finetic build websites, web portals and web based applications. An inhouse developed CMS called Wenetic, is the stabile and proven system where everything is based on.

Within TSG Group, this combination of expertise, knowledge and skills under one roof, can offer integral solutions for technical challenges and engineering projects.

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TSG Solutions is a global solutions provider. TSG Solutions has a large sales and service network across Europe and Africa. Thousands of TSG engineers and technicians across 30 countries serve our customers promptly and efficiently: Wherever the client is located TSG is around the corner. TSG provides a wide array of solutions combining equipment sales, services and projects to the energy distribution networks both retail and non-retail (industry) aimed at fuelling mobility systems through its six business segments. The business Segment TSG Gas is focusing on solutions for alternative fuels based on gasses CNG, LNG, LPG and Hydrogen.

Regarding the hydrogen market, TSG Gas is a system integrator of storage, mobility, marine and industry applications. We can provide several products from electrolyzers, hydrogen fuel stations for mobility and marine sector until hydrogen storage systems in an EPC project approach. TSG Gas has a high level service degree and can provide 24/7 services to their customer due to the automated field services system. Currently we are working on several projects mainly focused on hydrogen mobility systems. If you have any questions or requests do not hesitate to contact TSG Gas.

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**VDL Energy Systems**

VDL Groep, headquartered in Eindhoven, the Netherlands, is an international industrial family owned business group. The group consists of 104 operating companies, spread throughout 20 countries, with over 16,500 employees. The VDL companies break down into four divisions: Sub-contracting, Car Assembly, Buses and Coaches and Finished products. (See [www.vdlgroep.com](http://www.vdlgroep.com)). VDL ES is part of the VDL Group and focuses on developing, testing and manufacturing of new products, for power generation and -storage. The objective is to develop environmentally-friendly and innovative hardware and software solutions. Applications for Zero-Emission (ZE) power generation and storage. With a background in packaging of turbines and compressors for the oil and gas industry, we now use our competences to produce Battery Energy Storage Systems (BESS), Fuel Cell systems, Electrolysers, and solutions for

Heat Re-Generation. With batteries and fuel cells we create stationary power solutions for energy, utility and maritime industries.

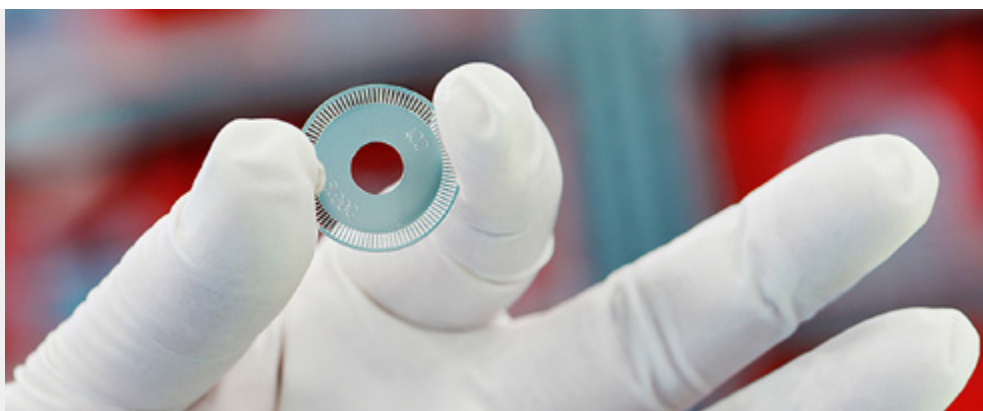
VDL has an extensive knowledge and experience in the field of ZE services. As one of the European Pioneers VDL realized the first introduction of large scale deployment of ZE bus fleets in Europe, VDL has gained a lot of knowledge of the challenges of additional 'beyond the bus' demands. Securing and providing enough clean renewable energy, on specific locations and times needed is the key of daily success. Especially as this is a major driver in the Total Cost of Operation (TCO) and thus the main driver of customer acceptance. The current challenge through the arrival of new ZE services is accelerating the efforts to improve the air quality in the growing cities with Green Energy, with more and more smart technology to be used in stationary and mobile applications.

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Veco is a world-leading manufacturer of micro-precision metal parts. It serves the world's most innovative, hi-tech companies from industries that demand high quality and precision. To meet customers' specifications and demands, Veco has developed high standards of performance in Electroforming. This technology allows a powerful combination of precision and economical production; for high volumes and prototypes, standard and custom-made products.

Veco's Ni-E<sup>3</sup> electrode solutions with surface enlargement up to 20,000 times. With the worldwide ongoing energy transition from fossil into green energy, electrodes are gaining more and more interest. Veco's electrodes solution with its unique properties can be used for Electrolysis, Fuel-cells, and Desalination.

The main difference and advantage of Veco's electrodes is the enlarged surface area that can be achieved. Up to 14 times enlargement has been achieved when this Ni-E<sup>3</sup> process is used. In addition, several coatings can be applied that can further result in a surface enlargement of up to 20.000 times resulting in yields that are unprecedented in today's world. The process is sustainable due to zero waste, making it a very cost-effective and future-proof technology in producing Electrodes.

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Vecom is specialist in chemical technical cleaning on-site (worldwide) with over 65 years' experience. We can also carry out metal surface treatments in our metal laundries, located in The Netherlands, Belgium and the United Kingdom.

Vecom focuses on customer and process-specific solutions for complex contaminations and strives to be the best quality service provider in metal surface treatment. Knowledge and experience is combined with flexibility and operational perfection. When it comes to metal surface treatment, Vecom has the knowledge, expertise and equipment to deal with chemicals, metal and waste streams in a responsible way. Safety for people, the environment and your assets are key.

What can Vecom do for the H<sub>2</sub> network? When changing from natural gas to H<sub>2</sub> gas, the existing piping may need to be cleaned depending on fouling. Vecom has the knowhow and experience to chemically clean and/or decontaminate piping systems with a proven method of removal of hydrocarbon and sulphur contaminations. Optionally also rust and other inorganic contaminations can be removed. If ultraclean specifications apply, oxygen cleaning and DNV approved methods will be used.

Furthermore, prefab parts for H<sub>2</sub> handling equipment can be pickled and passivated in our metal laundries. If required, the oxygen cleaning method can be applied as well. Please contact our specialists for suitable solutions.

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**Visser & Smit Hanab**  
brengt energie

Visser & Smit Hanab, a VolkerWessels company is highly motivated to realize the energy transition. We have been building underground and above-ground infrastructure and installations in the fields of energy, electricity, water and industry for more than 150 years. Hydrogen related activities are design, built and maintenance of new hydrogen pipeline infrastructure, as well as refurbishing existing natural gas pipelines for built environment, industry and hydrogen refuelling stations. We distinguish ourselves by working with the best in-house professionals such as installers, welders, low, medium and high voltage technicians who enable our clients to make the necessary change to sustainable energy.

Visser & Smit Hanab has its own engineering team with advanced specialist knowledge and the most modern 3D scanning equipment. Our professionals, together with a dedicated network of suppliers and subcontractors, ensure that we get the job done safely, on time and on budget. With respect for people and drive to protect the environment.



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VONK (fka Ampulz) is a solution provider for Power Conversion, Electrical & Instrumentation and Control & Automation Challenges. Inspired by technological innovations we contribute to a more sustainable society. We are an internationally recognized specialist when it comes to Power Conversion & Power Electronics. With our expert knowledge and extended experience as our foundation, we strive at all times to rise to the challenges of tomorrow. Current developments in the field of energy transition play an important role in this.

The incorporation of large-scale renewable energy sources requires power conversion solutions which can be used on a Megawatt level. The power converter determines the behaviour to the electricity grid, the extent of reactive currents and other power quality issues.

Cooperation with VONK will result in a power supply that exactly fits the electrolyser, with better integration characteristics and the lowest possible cost per kW. We aim for a collaborative approach and use standard building blocks to ensure rapid development for power supplies ranging from 1 to 250+ Megawatt. VONK has developed its own innovative electronics control platform to support our solution. The control platform is the heart of the power converter and is capable of forcing the maximum power point of the electrolyser. With its dedicated communication links it can align energy from fluctuating sources with the electrolyser capacity, to optimize the use of available renewable energy.

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Royal Vopak is the world's leading independent tank storage company. We store vital products with care. With over 400 years of history and a focus on sustainability, we ensure safe, clean and efficient storage and handling of bulk liquid products and gases for our customers. By doing so, we enable the delivery of products that are vital to our economy and daily lives, ranging from chemicals, oils, gases and LNG to biofuels and vegoils. We are determined to develop key infrastructure solutions for the world's changing energy and feedstock systems, while also investing in digitalization and innovation. Vopak is listed on the Euronext Amsterdam and headquartered in Rotterdam, the Netherlands.

Vopak is exploring how to set up new renewable hydrogen supply chains between production and

demand centres in Europe and beyond. Next to pipelines, other infrastructure will be needed to enable safe, substantial, flexible and cost-effective international transportation, storage and distribution of hydrogen. Vopak aims to provide solutions by creating open access terminal infrastructure at both export and import locations. Together with partners in various countries, Vopak aims to develop storage and transportation, using three technologies: Liquid Organic Hydrogen Carriers, Green Ammonia, and Liquefied Hydrogen.

Vopak is also a partner in the H-vision project that aims to substantially reduce emissions of the Rotterdam industry through low-carbon hydrogen. Please visit [www.vopak.com](http://www.vopak.com).

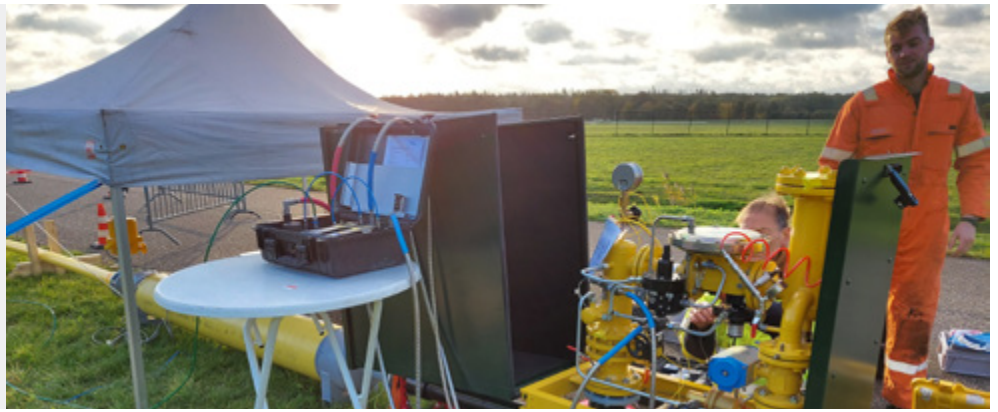
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Wigersma & Sikkema was founded in 1921 in the city of Leeuwarden by the two Frisian gentlemen who form the name of the company. The company started its life as a technical trading company. After the big natural gas reserve of Slochteren was discovered in the Netherlands in 1957 the gas grid started to be built. Wigersma & Sikkema participated as a gas station builder in this development. This is how the company became involved more and more in the natural gas business. It continued to build gas stations until the year 2000. This activity was then stopped as the company wanted to focus on higher value added businesses it had developed in the meantime.

On October 22nd and 23rd of 2020, on behalf of Netbeheer Nederland, KIWA investigated whether existing gas pressure regulation stations for natural gas are suitable for use with 100%

hydrogen. The Dutch gas network Rendo made a regular gas pressure regulation station for this test. Among other things, this gas pressure regulation station had an RS350S DN50 regulator from Wigersma & Sikkema built in. In addition, the pressure regulator station was equipped with the BMA and BDA system connections to connect the PLEXOR inspection system. Furthermore, a UNIGAS 300 electronic volume conversion device from Wigersma & Sikkema was used in the test set-up to measure and record pressure, temperature and flow. For a number of the tests, use was made of the PLEXOR inspection system made available by Wigersma & Sikkema for this field test.

By means of field tests, insight was gained into the operation and suitability of a gas pressure regulation station if, instead of natural gas, the medium hydrogen is used.

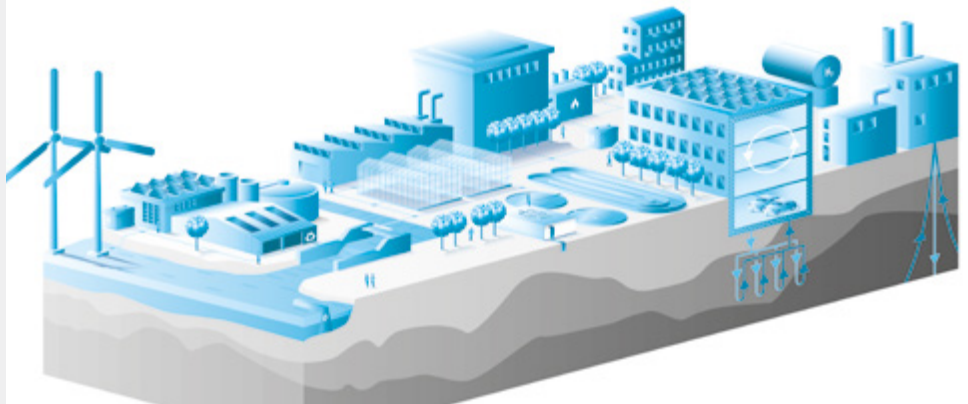
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Witteveen+Bos is an international consultancy and engineering firm that offers solutions to complex engineering and societal issues in the fields of energy, water, infrastructure, the environment and construction. We strive to operate at a high-quality, international level of engineering. Our staff of some 1,300 employees work in multidisciplinary project teams on innovative projects all over the world. The energy transition, climate adaptation, flooding problems, healthy cities, the circular economy and large-scale replacement of infrastructure are just some of the major challenges which we can help to overcome. Specifically for hydrogen,

Witteveen+Bos offers services on the following topics: system integration, risk assessments (QRA), safety (HAZID/HAZOP), permits, techno-economic feasibility, roadmaps (vision and strategy), innovation, engineering, stakeholder management, grant support, project management and consortium formation.

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zepp.solutions develops hydrogen fuel cell systems for clean, mobile power generation. Our systems are based on a highly scalable and modular platform to allow the fast adaption to different use cases and applications. This technology enables the emission-free propulsion or operation of any application, vehicle or vessel without any drawbacks.

We also support concepts and projects with our consulting and engineering services.

Some of the current projects include the development of hydrogen fuel cell powered yard tractors with vehicle OEM Terberg Special Vehicles. These vehicles enable an emission free horizontal container transport in ports and distribution centres. The first prototype is in active operation.

Furthermore, we develop different size fuel cell system solutions for the maritime sector. Examples are the first hydrogen fuel cell powered Watertaxi in the Port of Rotterdam and a scalable, high power fuel cell module for auxiliary or main propulsive power in large vessels and shipping operations.

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Are you looking for a partner, which provides the expertise in designing and building process systems to prove your scaled-up technology? As the world's leading Designer and Builder of innovative lab scale systems, pilot plants, demonstration plants and small modular production plants, Zeton helps its customers bring their processes from lab to market, faster, with less risk and lower cost. Our projects are realized in a vast range of industries, amongst which CO<sub>2</sub> utilisation, Pharma, Chemicals, Biobased fuels and chemicals, Petrochemicals, Oil&Gas, Food, Paper & Pulp. In many of these industries projects are realised which use hydrogen either as raw material, intermediate or product. Our full suite of pilot plant and engineering solutions allows us to deliver scale-specific

projects with design, procurement and fabrication executed in parallel – compressing the overall project schedule and maximizing cost-efficiency with our unique project methodology. Your intellectual property is protected as our engineers optimize the design and build of your project, allowing you to take your process technology to market sooner. With state-of-the-art, integrated design-build facilities in Enschede, The Netherlands, and Burlington, Ontario, Canada, Zeton has successfully completed over 800 projects in 35 countries across six continents. For more information, please visit our website [www.zeton.com](http://www.zeton.com)

ZETON, one partner from early phase concept to real built process plants.



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Would you like to present your company profile worldwide in the next edition of the NL Hydrogen Technology Guide? Please send your request to [hydrogen@fme.nl](mailto:hydrogen@fme.nl).

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