



Kiwa **Hydrogen**
Services and Capabilities

www.kiwa.com



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01

About **Kiwa**

Creating trust in the quality, safety and sustainability of our customers' products, processes and services.



Industry Assets



Medical Devices



Fire Safety



Renewable



Construction



Water



Food, Feed, Farm



RF & Electrical



We ARE Kiwa

We are Kiwa, a global leader in Testing, Inspection and Certification (TIC).

With our certification, inspection, testing, training, consultancy and data services we create trust in our customers' products, services, processes, (management) systems, personal capabilities and environmental performance. Ambitious, reliable and engaged. Thus, we help them to improve their businesses.

As a Partner for Progress, we work in many industry sectors and market segments, ranging from (drinking) water and renewable energy, construction and industry assets to medical devices, food, feed & farm, radio and wireless and fire safety. We support customers in manufacturing and process industries, (business) services, public and private utilities, governments and international institutions.



Present in over
35 countries



Top 15 leading
TIC Companies



More than
10,000 employees



1.2 Billion €
Operating Income



About **Kiwa**

Three companies form our organisation today: Kiwa, Inspecta and SHV. In 2021, Kiwa joined the SHV Family of Companies whose values and purpose, 'Courage to care for generations to come', align perfectly with our customer and CSR commitments.

Kiwa stands for Trust, Quality and Progress. From the foundations up, everything we do is built on trust.

We are proud to be a partner for progress, acquiring other partners to help us fulfil our commitment – to create trust around the world.

We empower our employees to use their skills, knowledge and expertise to create the best products and services possible for our customers. In turn, this enables them to instil trust in their customers, and so the cycle continues.



Founded in the Netherlands in 1948, Kiwa is now present in over 35 countries with operations across the globe, but our core values, ideals and drive to create trust remains key.

02

About **Kiwa Hydrogen**



Our **Vision**

Being the recognised authority for advancing the **AWARENESS, INNOVATION** and **PRACTICAL APPLICATION** across all aspects and uses of hydrogen, and in doing so contribute towards a safer, cleaner and more sustainable environment for everyone.

Markets

Looking for concise, actionable expert opinion and advice on matters relating to the early adoption and transition to Hydrogen fuel.

Product/Service

Consultative, testing and educational resources that deliver robust, innovative, compliant and ultimately safe and cost-effective approaches to hydrogen usage.

Company

Using our knowledge and experience combined with our uniquely holistic approach to hydrogen usage that informs, reduces risk and assists in the safe implementation of Hydrogen transition plans.

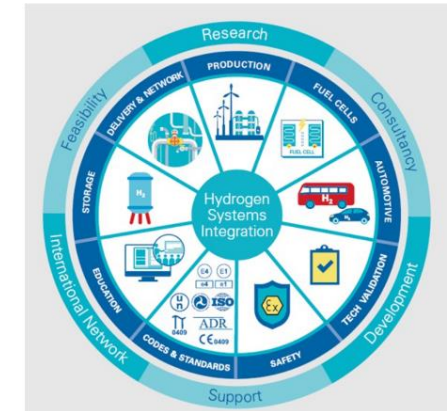
Our Purpose

As true hydrogen believers, Kiwa look to provide **INDEPENDENT, HONEST** and **ACTIONABLE SOLUTIONS** to build confidence and support the hydrogen transition for individuals, businesses and communities alike.

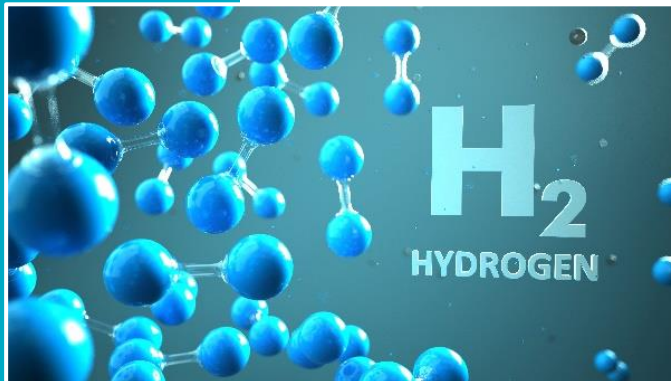
About Kiwa Hydrogen

At Kiwa, we are 'hydrogen believers', that is why we offer such a wide range of services to support our customers' conversion to hydrogen. At the same time it will take education and engagement with all stakeholders to make such changes acceptable and a reality. This holistic approach all forms part of our engagement."

The mission to decarbonise UK industry is a core part of the government's ambitious plan for the green industrial revolution to meet the emission reduction targets by 2050. Over the next decade we will begin the journey of switching from fossil fuel combustion to lower carbon alternatives, such as electrification and hydrogen.



Kiwa's Holistic approach to a seamless integration



The work undertaken in the 2020's will be crucial to lay the bedrock for industrial decarbonisation, and it is our vision to assist industry and our partners to identify, design and deliver solutions that reduce the carbon emissions from the challenging and hard to abate areas, such as industrial heat.

Kiwa's expertise in the gas sector combined with our wide knowledge of infrastructure, clean technologies and renewable power generation give us a unique stance in the hydrogen market. Our core values are built around trust, quality and progress which support the work we have delivered as trusted advisor to both public and private sector clients and continues to underpin the collaborative work that affects change.

“At Kiwa tomorrow’s energy issues are today’s opportunities. Together we work on sustainable solutions for our future energy supply.”

Giulia Botta
International Business Development Manager Hydrogen

Our greenhouse gas emissions auditing (C:sense verification) quantifies energy users’ contributions to the CCL under what was the EU ETS and will probably become the UK ETS.

Kiwa acquired Moroni & Partners, bringing together Technical Due Diligence and Energy Engineering activities into the Kiwa family, increasing our global capabilities in renewable energy and contributing to an annual turnover of over half a billion Euros. [BP1]

The utilisation of hydrogen in an industrial application has many possible use cases, including potential onsite production from renewable energy sources. Our capabilities cover the whole energy system, from production, storage, distribution and consumption, both in the industrial process either for heating or chemical process, as well as vehicle fleet infrastructure and energy balancing across multiple sites.

We have more than 15GWe of clean energy production experience within the Kiwa Group providing a wealth of expertise and knowledge in onsite hydrogen production projects and techno-economic feasibility studies.

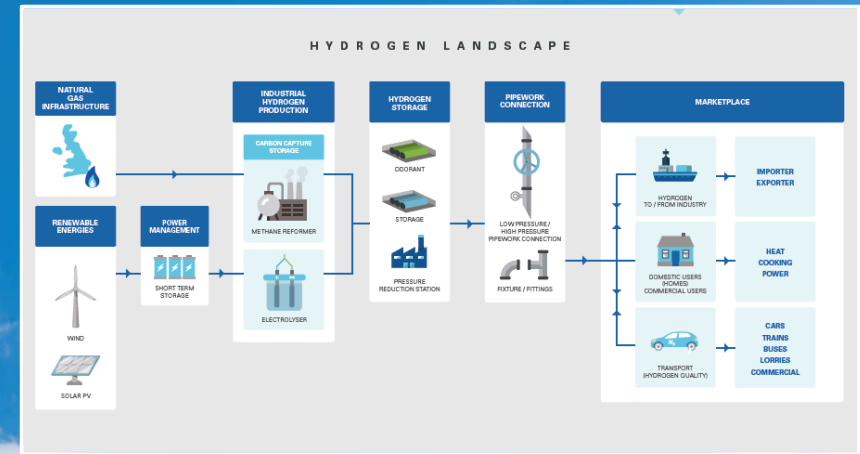


About The Energy Transition

Zero-emission transportation, greater flexibility of the electricity grid and cleaner industrial processes are all necessary to realise energy transition. Hydrogen, thanks to its characteristics, has the potential to contribute significantly to the achievement of this ambitious goal.

A timely global energy transition depends on the collaboration of governments, businesses, knowledge organisations and investors.

Clean and abundant, hydrogen is versatile – it can play a role in power generation, storage, heating, fuel cells for vehicles – answering the challenge of delivering new energy systems to the point of use.





“Our aim is to support the different stages of each country’s transition to a hydrogen economy. By sharing and learning from these experiences across the Kiwa Group, we help our customers reduce the lead time on hydrogen evolution in their specific contexts.”

Dr Mark Eldridge

Divisional Director, Kiwa UK, and Kiwa Hydrogen Sector Lead,

Kiwa Are **Committed to the Energy Transition**

The world needs a low carbon, inexpensive and secure energy supply. Hydrogen is a feasible alternative energy and is a environment and transport sectors.

Like natural gas, hydrogen is flammable and colourless. Unlike natural gas, it is biologically inert and burns to water, without producing damaging emissions. One exciting application area for which hydrogen is being explored is the conversion of some natural gas networks to hydrogen on a localised and national basis. The goal being to decarbonise and provide energy solutions to current users of natural gas – including industry, commerce and domestic sectors. In domestic heating, the well-known intersessional variations in energy demand between existing natural gas networks and electricity grids today create multiple challenges.

Within the UK 86% of homes rely on natural gas for heating, with circa 30% of UK CO2 emissions derived from such domestic heating. Equally across Europe, in locations such as The Netherlands (parity on UK gas usage), where existing

natural gas supplies are at risk (or under pressure to decarbonise), hydrogen offers an elegant alternative to energy systems with ‘existing’ infrastructures, extendable to transport and industrial use.

Zero carbon emissions from vehicles and heating Hydrogen at the point of use creates zero carbon emissions. This means using hydrogen in existing gas networks would reduce heating emissions to simply the by-product of water. While hydrogen vehicles are available today, they suffer from the lack of an economic infrastructure, with the appropriate purity of hydrogen gas to support fuel cells. Hydrogen networks, with gas scrubbing technologies, will enable fuel cell infrastructures.

When compared to the equivalent cost per mile of electrical infrastructure, hydrogen delivered through the existing gas network is a far cheaper decarbonisation method – and the infrastructure is already in place.

03

Why **Kiwa**

Why Kiwa **Key Strengths**

Kiwa is leading the facilitation of the international acceptance of hydrogen as an energy vector. With an extensive hydrogen test laboratory (the only one of its kind in Europe), and expert hydrogen certification and consultancy teams, Kiwa has a unique standpoint when it comes to hydrogen.

Kiwa's facilities are capable of testing up to 4500 barg pressures, across trains, buses, domestic and commercial vehicles; so whether it is re-fuelling certification services, or testing of hydrogen systems, or a focus on key infrastructure projects we are able to assist at looking at different aspects of conversion to hydrogen throughout the supply chain. We are unrivalled in our breadth and scale of knowledge and services.

Indeed Kiwa are taking the initiative to support the marketplace and were amongst the first to provide piped hydrogen capabilities, high pressure and hybrid technology testing facilities, both in a lab or at scale for industry.

In the Netherlands our investments in tank testing provide world class facilities, while numerous projects are underway with the UK/Dutch networks to rapidly accelerate network transition in collaboration with the stakeholder to deliver our climate change commitments.



End-to-End H2 Infrastructure

About **Kiwa**

Follow the QR to learn even more about our services for the Hydrogen sector





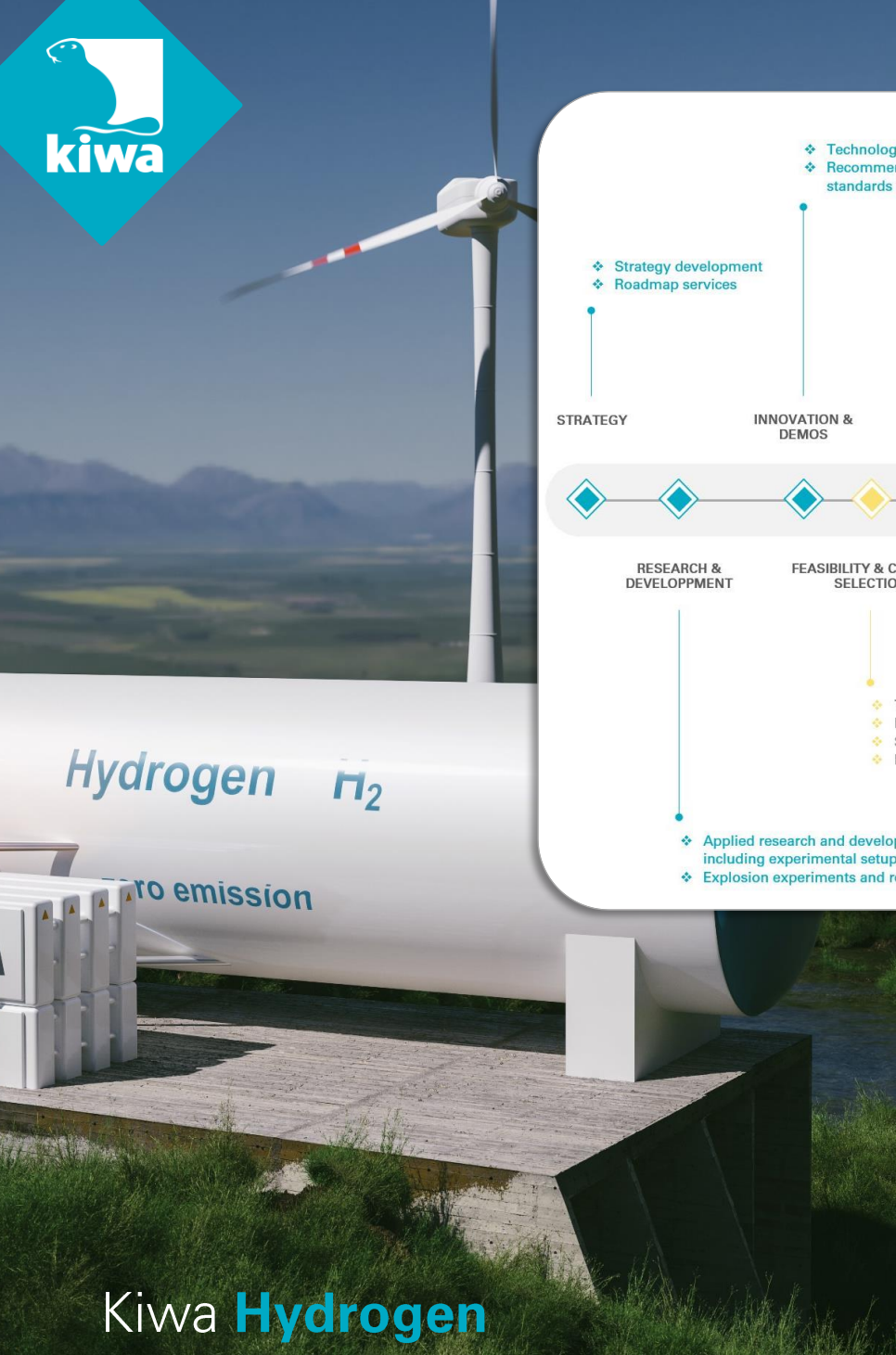
Kiwa is leading the facilitation of the international acceptance of hydrogen as an energy vector



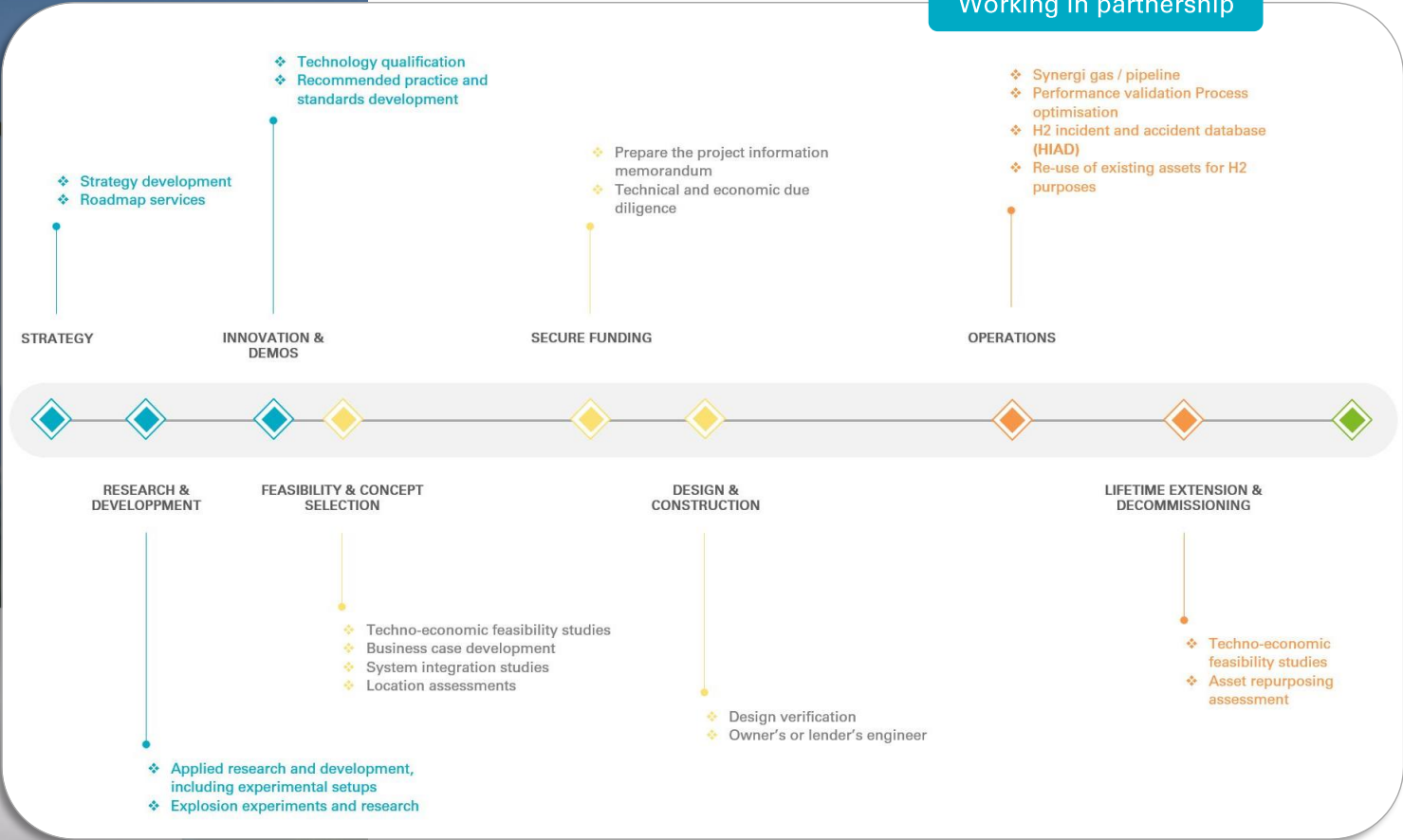
Kiwa helps research and develop future decarbonised energy solutions. Kiwa offers unrivalled hydrogen knowledge, expertise, research and testing for this alternative to natural gas.

Our experts play a vital role in investigating the feasibility of converting large parts of our energy systems to hydrogen aimed at reducing CO2 emissions.





Working in partnership



One of the unique benefits of Kiwa is the breadth of experience that we can provide in assisting our clients throughout the life span of their projects incorporating the design, construction, management and operation.

Having Kiwa as your primary partner from initial concept stages will reduce the risk of subsequent design changes, reduce potential complications in planning consent; giving you confidence and saving your project time and money. In addition, consultation with Kiwa will allow for optimisation of your plans without compromising any safety aspects.

Kiwa **Hydrogen**

Expert advice and unique insight... at every stage of your project

04

Kiwa **Services**

Hydrogen **Production Processes**

Green hydrogen is produced from renewable energy sources such as wind and solar power, following the process of electrolysis, whereby water molecules are split into oxygen and hydrogen molecules using electricity.

Green hydrogen, although now representing only 5% of total production, has a key role in the energy transition of our economy, because in its various uses and during its life cycle it does not generate CO₂ emissions.

Hydrogen **Distribution and Transportation**

One of the main fields of application for which hydrogen is being explored is the conversion of conventional gas distribution networks into hydrogen networks.

Studies conducted by Kiwa at Netbeheer Nederland and as part of the Leeds H21 City Gate project by Kiwa UK, show that existing gas networks can be reused to distribute hydrogen, albeit with some adaptations.

Once the configuration of hydrogen distribution networks is completed, hydrogen will be transported directly to its point of use, avoiding expensive storage in pressurized tanks or even more in liquid form.

Hydrogen **Storage Solutions**

Another challenge for the entire hydrogen supply chain and specifically for car manufacturers is storage.

Hydrogen has a very low density, which means it has to be stored at high pressure. Tanks, dedicated to the accumulation or storage of hydrogen, must therefore be robust and made of composite materials to allow safe and efficient storage.

Our hydrogen laboratory has been testing automotive tanks for more than a decade in anticipation of a large increase in hydrogen vehicles as part of the energy transition.



Hydrogen Appliances and Fuel Cells

The heating industry can play a leading role in the technological reconversion and consolidation of the hydrogen supply chain.

Despite the challenges, including the still necessary adaptation of distribution networks; European nations are beginning to open up market opportunities for heating appliances powered by hydrogen blends in various percentages and for fuel cell micro-cogenerators (micro-CHP), as well as accessories and components.

Kiwa can support the testing and certification of these new and emerging technologies, thanks to our experience in the gas sector and our wide knowledge obtained in recent years at national and international levels.

Hydrogen Mobility and Refuelling

Hydrogen produced from renewable energy sources can make an important contribution to reducing greenhouse gas emissions from transport.

Kiwa has an extensive testing capability including a state-of-the-art testing laboratory for hydrogen vehicle components.

At this unique facility it is possible to test in extreme conditions up to 1050 bar of hydrogen, between -40 °C and 120 °C.

Hydrogen Industrial Processes

Hydrogen produced from renewable energy sources can make industry less dependent on natural gas and coal, improving the sustainability of energy intensive industrial processes.

Kiwa can support a broad range of industrial sectors in improving the sustainability of energy-intensive processes, using hydrogen both as an alternative energy source and as an industrial raw material.

Hydrogen is already used in the production of ammonia; oil refineries use hydrogen in their hydrotreating and hydrocracking processes; and in industries with applications requiring temperatures above 250°, Hydrogen is proving a viable alternative fuel source.

Creating trust in the quality, safety and sustainability of our customers' products, processes and services.

We offer independently accredited Testing, Inspection and Certification services in virtually every market around the world, including energy and power generation, renewable energy and hydrogen, oil, gas and chemicals, manufacturing and industrial, process industry, transport and mobility, utilities, construction, infrastructure and fire and safety.

Many of these areas compliment the energy transition and the decarbonisation of heat agenda, especially in the hard to abate areas of industry where we have multiple areas of expertise.

There is a strict separation between our certification services and activities like training courses and consultancy



Testing



Inspection



Certification



Training



Consultancy



Data services





Hydrogen

H₂ kiwa

H₂



Kiwa 20% Hydrogen Mark

The Kiwa Mark provides assurance to appliance manufacturers and gas network operators that the marked appliances will operate safely on blends of up to 20% hydrogen in natural gas. This is an important step to enable hydrogen blending in the gas networks. Hydrogen blending in gas networks offers a reduction in carbon emissions without the cost and disruption to customers of changing their appliances.

Who is this Mark for?

This mark is perfect for boiler manufacturers wanting to future-proof their natural gas appliances, for gas network operators planning blending pilot projects and for householders seeking to save carbon emissions whilst avoiding the disruption and cost of changing their appliances.

Process for obtaining the 20% Hydrogen Mark

If Kiwa has issued a GAR certificate and a product surveillance contract for a product and the manufacturer has completed the tests specified in the Test Requirements for natural gas appliances burning up to 20% Hydrogen admixture, using EN15502 as the reference standard, then Kiwa may authorise the manufacturer to use the Kiwa 20% Hydrogen Mark.

Will other appliances be granted the 20% Hydrogen Mark in future?

Yes, Kiwa will publish the Test Requirements for appliances tested in accordance with the EN89 (gas-fired storage heaters) and EN613 (independent gas-fired convection heaters) standards soon. Test Requirements for EN30 (gas-fired domestic cookers) and EN203 (gas-fired catering equipment) standards may also be offered, depending on demand.

Kiwa and hydrogen testing

Kiwa, is accredited for testing in accordance with EN15502, and has capability to conduct the tests described in the Test Requirements for natural gas appliances burning up to 20% Hydrogen admixture, using EN15502 as the reference standard at our laboratories in The Netherlands, UK, Italy, Turkey and China.

Kiwa HyFitts Scheme

HyFitts is a certification mark to demonstrate that components of domestic/commercial hydrogen pipework systems are suitable for use with hydrogen. The mark will be licensed to manufacturers of relevant products to demonstrate that they meet certain requirements.

Why is HyFitts needed?

Gas installers are responsible for selecting fittings that enable them to meet the requirements of the relevant UK regulations when they install or make changes to pipework and appliances. There is a gap in the information available and the communication of that information about what equipment can be used in this new situation. Installers may not have the information they need to choose the appropriate fittings for their installation.

The suitability of various fittings for use with natural gas is well established.

Installation of appliances and pipework for use with hydrogen is a new situation in the UK but installers are expected to have the same responsibilities. Currently there is not a means for installers to check whether fittings are suitable for use with hydrogen.

HyFitts certification and the associated product marking will enable fittings suitable for use with hydrogen to be identified.

Who is the HyFitts Scheme for?

People who manufacture or use (specifiers & installers) fittings for carrying gas to end users connected to low pressure networks.

How will the HyFitts Scheme work?

The certification process will bring together key information about the performance of a component and ongoing manufacturing quality. This will include:

- Identify the scope of use permitted within UK regulations (GS(I&U)R).
- Confirmation that design, manufacture and performance are in accordance with one of more recognised British, European or UK Industry standards for the product type e.g. BS, ISO, Gastec QA, BSI Kitemark, CPR certification by an Approved Body) or another national standard.
- Confirmation that the performance with hydrogen is as good as with natural gas in terms of gas containment and control, and this may involve additional tests to be carried out.
- Confirmation that all hydrogen wetted materials of construction are suitable based on the information available. This includes any requirements set in relevant standards concerning use with low or medium pressure distributed hydrogen. Where evidence is not available, additional testing of materials may be required to determine their suitability for long term exposure to hydrogen.

Scope

The scope of HyFitts will be any fitting or pipe used to convey hydrogen at low or medium pressures. It will include:

- Connections, rigid – e.g. pipe couplings, brass unions, (joints, tees etc) with compression ends, press ends.
- Connections, flexible – e.g. anaconda in corrugated steel, bayonet ended appliance connection hose.
- Controls – e.g. emergency control valve, excess flow valve, regulator.
- Tube / Pipe e.g. rigid or semi rigid copper, steel.
- This scope may change in response to developments in the industry.

05

Kiwa **Laboratory Facilities**



Hydrogen Materials Laboratory

We provide material compatibility testing on various materials and components (tensile bars, rings, valves, or complete systems).

In addition to this, H₂-CO₂ permeation tests are carried out on a wide scale of (semi-finished) products. The facilities also allow us to conduct: Risk and engineering assessments, Bespoke test campaigns based on specific polymer materials and applications.

Testing could include polymer hydrogen compatibility studies and permeation measurements. Fluid compatibility Chemical and Physical Analyses Mechanical Tests Microscopy.

Hydrogen Tank and High Pressure Components Test Laboratory

The Hydrogen Tank Test Facility is able to carry out lifecycle and functional testing of hydrogen fuelled products and associated appliances & systems.

Our hydrogen tank test laboratory is able to accommodate large H₂ tanks for full type approval test programs and certification projects.

We are able to test on high pressure 1050 bar hydrogen in various climatized conditions on a wide variety of components.

Hydrogen Gas Laboratory

We offer technical assistance to hydrogen burner manufacturers already in the research and development phase.

Our Gas Laboratory can support manufacturers either with existing burners and appliances (therefore assessing their ability to react to the different admixture of hydrogen and natural gas) or in the development of pure hydrogen burners.



Hydrogen **EMC** **Laboratory**

We can help to demonstrate that a product is fully compliant with a test standard.

Working with manufacturers, importers and suppliers of electrical appliances, our EMC testing lab can test and analyse a wide variety of products, from domestic appliances to medical equipment, to supporting UKCA/CE marking and global approvals.

We can EMC pre-compliance testing, EMC testing, Safety testing (LVD), Ingress protection testing, Radio testing as well as testing emerging technologies (such as getting 5G-Ready).

Should any particular concerns arise during EMC compliance testing, then we are able to work to help resolve those issues.

Hydrogen **SMR** **Laboratory**

Our new state of the art Hydrogen test lab and SMR, is geared up to test appliances, peripherals and network equipment.

Modular testing bays provide a confidential test space and are supplied with hydrogen, natural gas and traditional test gases.

The Hydrogen is supplied directly from new Steam Methane Reformation (SMR) hydrogen production plant located close by. The SMR plant has been specifically designed for use as a research and test bed for associated technologies such as CCUS.

The plant is supplied primarily from a biogas source that provides a low cost hydrogen supply; ideal for appliance longevity testing.

Hydrogen **Other** **Laboratories**

In addition Kiwa also have an number of sites that have been specifically designed to look at testing for the following:

Explosion Chamber

Automotive Laboratory

Fuel Cells and Electrolysers Laboratory

EL Laboratory

Kiwa Laboratory Facilities **Testing**

Hydrogen Laboratory

Kiwa UK's new hydrogen lab has a design capacity of 300kW of hydrogen, and is geared up to test appliances, peripherals and network equipment. The modular testing bays provide a confidential test space supplied with hydrogen, natural gas and traditional test gases.

Our first clients are through the door and enjoying the flexibility of our service offering – it's possible to rent from one to all five of the bays to accommodate bespoke testing needs, and bays can be rented for a day or for several months.

We're also preparing to commission our new Steam Methane Reforming (SMR) hydrogen production plant close by. The plant will be supplied primarily from a biogas source to provide a low cost hydrogen supply to our new lab – ideal for appliance longevity testing. Our new SMR plant has also been specifically designed for use as a research and test bed for associated technologies such as CCUS.



Kiwa Laboratory Facilities **Installation of SMR**



Location of the SMR facility, with the site being marked out with flags by the project team



SMR delivery to Kiwa House for safe storage whilst the groundworks take place on site



SMR and Bullet move from Kiwa House to the new SMR site. A reinforced crane base was laid to take the weight of the bullet move.



Location of the SMR facility, with the site being marked out with flags by the project team



SMR Installed an in location

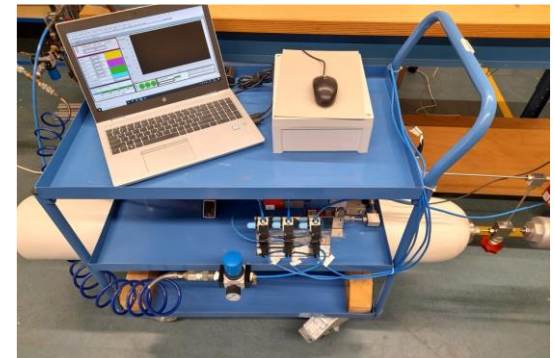
Kiwa Laboratory Facilities **Testing**

Hydrogen Embrittlement Testing According to ISO 11114-4 Method A - Disc Method

Hydrogen will play an important role in the automotive sector as an alternative fuel for vehicles. Hydrogen cars produce no CO₂ emissions, only water vapor, have a long range and can be refuelled quickly. Manufacturers of hydrogen tanks and components are currently setting up mass production.

For this purpose metallic materials have to be tested to demonstrate safe use with hydrogen. Kiwa performs hydrogen embrittlement tests according to the ISO 11114-4's disc method to demonstrate this hydrogen compatibility.

Originally, the ISO 11114-4 was intended as a quality standard for the transport of potentially dangerous substances in gas cylinders. For example, the standard provides guidelines and includes methods for testing the resistance of cylinders to hydrogen embrittlement. Method A, also known as the disc method, is one of the test methods specified in this standard for evaluating the susceptibility of metals to hydrogen embrittlement.



Kiwa Laboratory Facilities **Testing**

The hydrogen and material testing experts of Kiwa have applied the ISO 11114-4 Method A – Disc Method to the testing of the hydrogen compatibility of tanks and components for hydrogen vehicles.

Widely recognized test method

The disc method is widely used and recognized as a reliable test method for evaluating the susceptibility of metals to hydrogen embrittlement. In summary, the disc method is a standard test method used to evaluate the resistance of materials to hydrogen embrittlement. In the disc method, a small, flat disc of the material is placed between two stainless steel flanges. The pressure is increased from one side of the disc with different pressure-rise rates until rupture.

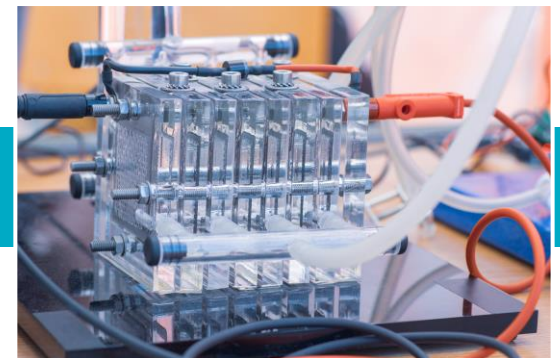
Simulated conditions

The rupture test is carried out with both helium gas and hydrogen gas. The rupture pressures are compared. The ratio between these

pressures is an indicator for hydrogen compatibility. The lower the ratio, the less susceptible the steel will be to embrittlement

Why Kiwa?

Kiwa's alternative fuels and pressure products experts have a lot of expertise in certification and testing for hydrogen applications. We offer service quick responses to client requests and the possibility for a weekly update on testing. We work closely together with Dutch vehicle type approval and registration authority RDW, its German counterpart KBA and Japanese KHK and can also test according to North American standards.



Kiwa Laboratory Facilities **Testing**

Gas Laboratory

The Kiwa Automotive Laboratory in Apeldoorn is a well-known and trustworthy partner in the Hydrogen Automotive market.

We can provide full type approval programs with our Team of highly skilled and experienced Test Engineers. In combination with the State of Art test equipment, our services are known globally and we are able to cover the challenges our customers are asking.

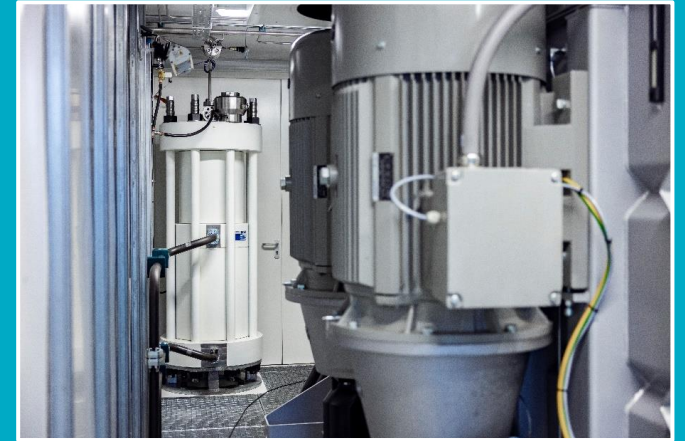
We have the most commonly known automotive standards on our scope and the lab is fully calibrated and accredited according to ISO 17025. We are assigned by the highly renowned European road authorities RDW from the Netherlands and KBA Germany to act as a Technical Service. Type approval on mobile storage applications such as TPED and DoT approval are within our scope of supply on component level and tank level.

Benefit of our recent investment (1,5 Mil €) on our tank testing capacity for 2 additional test bays for very large and high-volume cylinders.

Testing with hydrogen has been done for nearly a decade in our lab and we have created many solutions for customers in their search to product development and validation of their design prior to market entry. So, your ideas are safe with us and we can assist and advise in your development.



Kiwa Laboratory Facilities **Automotive Laboratory in Apeldoorn**



kiwa

C

- ▲ RECEPTIE
- ▶ P KIWA
Bezoekers melden bij receptie
 - ▶ P Examen centrale
 - ▶ P KIWA Training
Ingang gebouw K
 - ▶ P Sterkin
Melden bij receptie
 - ▶ P Hanskamp's Gastherij

- ▶ Ingang gebouw H
- ▶ Ingang gebouw L

Ingang Examen centrale

Kiwa Laboratory Facilities **Demonstration House**

Hydrogen Demonstration House

Kiwa and Dutch energy network company Alliander have opened the Hydrogen Experience Centre in Apeldoorn, The Netherlands, today. This demo house is a demonstration and training location set up as a private home where professionals learn how to convert the natural gas supply in residential areas for hydrogen application.

In this centre, Kiwa and Alliander demonstrate that hydrogen can be used excellently as a fuel in the built environment. At the same time, the centre is intended to train technicians and installers and familiarize them with the natural gas to hydrogen transition. This is necessary because the need for technicians who can work with hydrogen will increase rapidly in the near future.

Knowledge centre

The use of hydrogen in the built environment is put into practice in the Hydrogen Experience Centre. It functions as a knowledge centre where the latest insights into the energy transition and hydrogen applications are shared.

The demo house is furnished as a residential home with a kitchen, a fuse box and a complete heating system. There are two central heating boilers: one that runs on hydrogen and one that runs on natural gas. The heating system in the house can be connected to a boiler of choice for demo or training purposes.

“Kiwa has extensive in-house knowledge of all aspects of the hydrogen system: from production and transport to distribution and end use.

Paul Hesselink, CEO of Kiwa



06

Kiwa **Training Facilities**

Kiwa Training Facilities

Training location

In addition to being a demonstration location, the Hydrogen Experience Centre is primarily intended as a training location. Because most fitters and installers still have little experience with converting gas networks for the hydrogen use, Alliander and Kiwa have joined forces when it comes to training professionals.

Kiwa is the number one trainer in the field of hydrogen in the energy transition in the Netherlands and Kiwa's Apeldoorn location is equipped to work with hydrogen.

"The need for professionals who will put the energy transition into practice is growing rapidly. This demo house offers technicians the necessary training facilities to bring the Netherlands one step closer to achieving the climate goals."

"Kiwa has extensive in-house knowledge of all aspects of the hydrogen system: from production and transport to distribution and end use. We have many experts in the field of gas and materials and Kiwa is an authority in the field of natural gas and other gases, such as hydrogen."

Paul Hesselink, CEO of Kiwa



"The Dutch government has decided that by 2050 all houses in the Netherlands must be rid of natural gas'.

"We consider hydrogen as one of the options for replacing natural gas. With limited modifications, the existing natural gas network can be made suitable for distributing hydrogen into homes. Using the regular gas network for hydrogen is therefore a promising option for the future. The next step is to show what this looks like in practice. With this demo house, we enable homeowners, suppliers and policymakers to experience this for themselves."

Daan Schut, Alliander's Chief Transition Officer



Training Course **Hydrogen and the Natural Gas Network**

A one-day course for professionals working in the gas supply and appliance industries, approved by IGEM for the purposes of CPD.

Who is the course for?

This course is suitable for professionals working in the gas supply and appliance industries, who understand the existing natural gas network and the principles of combustion.

What does it cover?

The course covers the main aspects of hydrogen as a utility, and why this is seen as a potential route to meeting net zero carbon emissions by 2050.

The key areas covered include:

- The environmental benefits of using hydrogen as a fuel
- The principles of combustion and hydrogen-specific aspects
- Why different concentrations of hydrogen deserve consideration
- The fundamental principles of the network conversion process from natural gas to hydrogen
- The fundamental safety issues of hydrogen compared to natural gas
- The fundamental principles of hydrogen production
- How to store and transport hydrogen
- The principal factors relating to appliance modification for conversion to hydrogen
- The economics of hydrogen production and use

By the end of the course, you'll be equipped to answer some of the many questions surrounding hydrogen and its implementation, for example, its odour, leakage, pipe size, cost, and the modification of boilers.



Training Course **Hydrogen Awareness for Installers**

The hydrogen awareness course is a 2-hour interactive webinar addressing the key themes needed for an awareness of hydrogen and its role in the future of the gas network.

Who is the course for?

The course is designed for gas engineers, to gain awareness, knowledge, and references for the key themes associated with the transition to hydrogen with the information provided in context relative to the existing Gas Network. The course is delivered by Kiwa Gastec, part of Kiwa Ltd within the UK, and will be delivered via TEAMs or interactive equivalent.

What does it cover?

The course is endorsed as CPD by the Institution of Gas Engineers and Managers (IGEM). The course introduces the key role the gas network has to play in decarbonisation of the UK and set out how the gas network will support the UK's transition to a net zero economy by 2050. To deliver on this aim there are four themes which form the basis of the course:

- The decarbonisation challenge (introduction to the challenge of heat)
- What is Hydrogen and what are its properties (comparisons to natural gas)
- Hydrogen and the gas network
- Hydrogen in the home

The course has been designed for delivery via a live webinar which gives an interactive experience and allows candidates to concentrate on the issues that they see as most relevant.

Prior Knowledge

The course will cover a large amount of material but will focus on giving a broad overview of the topic and include more detail on areas of relevance to the candidates.

It is assumed that candidates will have some prior knowledge of the need to decarbonise the UK and will have some understanding of climate change issues. The candidates will have an understanding of what hydrogen is but not the properties of the gas and how it compares to natural gas. The candidates will understand the basics for how the gas networks operate (i.e. pressure tiers materials of construction). Have very good knowledge of domestic and commercial systems but not how these will change with the introduction of hydrogen systems.





Training Course **Commercial Hydrogen**

The course gives an overview of the concepts involved with hydrogen and to provide wider context of the principles behind hydrogen combustion. It provides an overview of national and EU hydrogen strategies, global market development and potential infrastructure development timeframes and costs.

Who is the course for?

This course addresses the emerging potential of a Hydrogen Economy. It's aimed at decision makers wanting to understand the key themes associated with the use and transition to hydrogen in a business context, relative to the existing UK Gas Infrastructure.

What does it cover?

The course gives an overview of the concepts involved with hydrogen and provides wider context of the principles behind hydrogen combustion. It touches on national and EU hydrogen strategies and global market and infrastructure development.

Some of the key topics for discussion include:

- The challenge of decarbonising energy in the UK
- Environmental benefits of using hydrogen as a fuel
- Global overview of strategies, market development and potential infrastructure development timeframes and costs
- Hydrogen:
 - principles of combustion
 - safety issues
 - production, storage, transport
 - economic factors
- Principles of natural gas to hydrogen conversion and appliance modification
- Business risks and opportunities from switching from natural gas to hydrogen

At the end of the course, you'll know everything from the basic principles of hydrogen combustion to the economic factors of its production and use. You'll be immersed in an interactive, inclusive learning experience that offers multiple perspectives and principles that can be applied to your workplace.

07

Kiwa **Elemental Success Stories**

Kiwa Case Studies



The Kiwa team has a unique blend of 'boots on the job' engineering experience and a pool of scientists advising government, gas network operators and related trade bodies.

We support decision makers with practical knowledge as well as scientific understanding from teams immersed in the industry and engaged with its stakeholders.



Project Port of Amsterdam

The Port of Amsterdam has a high-grade energy storage and distribution infrastructure. The ongoing energy transition has presented the port with the challenge of maintaining its current role and the opportunity to accelerate the national and regional transition to sustainable energy.

Kiwa was tasked with analysing the technical, legal and financial case for implementing (a) a regional transport route between Amsterdam and IJmuiden and (b) a local hydrogen distribution network within the port area, including the spatial considerations of such an implementation.



Project Overview

Kiwa was commissioned to conduct a study which will form the foundation for the rollout of a hydrogen infrastructure.

The study incorporates the technical, legal and financial perspectives of building gas infrastructure to link IJmuiden and Amsterdam, and creating a network within the Port of Amsterdam area to distribute hydrogen.

Connecting the producers and independent buyers within the port area via a hydrogen infrastructure facilitates an energy transition from fossil fuels to hydrogen. This initiative could potentially achieve an annual CO₂ reduction of 396 kilotons.

There are a number of hydrogen end users (with a potential hydrogen requirement of 66k t/year) within the port area. These all currently use natural gas to produce steam using turbines and boilers – gas is not used as a feedstock. Switching these users to hydrogen would significantly decarbonise the production of steam.



Where will the Hydrogen come from?

Tata Steel (Ijmuiden) will produce 15 kt/year (with the construction of a 100 megawatt electrolyser).

Local production of hydrogen (including the Hemweg power station and small scale mobility applications).

Outside of this project, the feasibility of developing a national hydrogen backbone is under investigation. In the future there is the potential to connect to this, securing delivery of hydrogen in the event of increased demand.

Next steps

- ✓ Obtain clarity regarding the legal framework for hydrogen
- ✓ Obtain/provide greater clarity regarding hardware costs
- ✓ Gain the commitment of end users
- ✓ Clarify the energy costs (hydrogen price, transport costs)
- ✓ Develop the organisational structure
- ✓ Implementation

What is the project outcome expected to be?

The ultimate aim of the project is to provide the technical consultancy and financial project management to facilitate the implementation of a discreet hydrogen network for the Port of Amsterdam, allowing several major gas users to switch from fossil fuel to a sustainable source to power their activities.

Additionally, the potential to install a hydrogen pipeline between Ijmuiden and Port of Amsterdam to bring in hydrogen.

The role of Kiwa

- **Technical lead**
- **Economic scoping**
- **Legal support**



Project **Hydrogen for Leeds**

The existing gas infrastructure in Leeds could be repurposed to deliver hydrogen for heating and cooking, instead of natural gas to the (population 760,000) over the next fifteen years.

Recently the UK has made significant progress in decarbonising its economy, but while its cities depend on natural gas for heating and cooking, there is a limit to how much carbon emissions can be reduced.

Widespread conversion from natural gas to hydrogen would make a huge contribution to achieving Britain's emissions target of an 80 per cent cut in emissions (on 1990 levels) by 2050.



Project Overview

The project redesigned the gas network to establish a high pressure (17 bar) outer city ring main transporting methane (CH₄) to steam methane reforming (SMR) plants for distribution into the network (below 7 bar).

Conversion would be a major infrastructural transformation, and many hydrogen compatible appliances and burners would need to be installed or converted, and a workforce trained to undertake the process. Hydrogen and electricity would become the dominant heating fuels.

Hydrogen would be produced from low carbon technologies such as:

- Steam Methane Reforming (SMR) of natural gas, plus Carbon Capture and Storage (CCS)
- Electrolysis using renewable electricity
- Novel nuclear techniques

The captured carbon dioxide would be stored in depleted oil and gas wells in the North Sea.



What is the project outcome expected to be?

Relative to full low carbon electrification or district heat for Leeds, conversion to hydrogen offers a simple route to full local decarbonisation and avoids the challenge of persuading 23 million homeowners and businesses to adopt a complex mix of decarbonisation techniques of greatly variable efficacy.

The role of Kiwa

- Technical lead
- Principle technical contractor
- Calculation of annual gas use (domestic and non-domestic)
- Establishing annual design load to accommodate lowest temperatures over a 20 year range
- Calculating SMR capacity required
- Determining size of low pressure store /intraday line pack
- Determining design methodology for medium and low pressure network with reference to standard gas industry procedures
- Completing study of number of isolations vs size of change over area
- Identifying several potential sites for SMRs high and low pressure storage
 - ❖ Domestic and non-domestic conversion
 - ❖ SMR
 - ❖ CCS
 - ❖ Pipeline (natural gas, hydrogen, carbon dioxide)



Project **Hydrogen** Experience Centre

Kiwa and energy network provider Alliander have jointly built the Netherlands' first hydrogen demo house in Apeldoorn.

The Hydrogen Experience Centre is a test and demo location set up as a residential home which is also used as a training location for heating mechanics and engineers.

Here they can learn how the current natural gas infrastructure in residential areas can be made suitable for hydrogen. On this page you can read more about the Hydrogen Experience Centre.



alliander

Project Overview

Kiwa and Alliander opened the Hydrogen Experience Centre in Apeldoorn: a demonstration and training location set up as a private home where professionals learn how to convert the natural gas supply in residential areas for hydrogen application.

In the Hydrogen Experience Centre, Kiwa and Alliander demonstrate that hydrogen can be used excellently as a fuel in the built environment. At the same time, the centre is intended to train technicians and installers and familiarize them with the natural gas to hydrogen transition. This is necessary because the need for technicians who can work with hydrogen will increase rapidly in the near future.



From natural gas to hydrogen

The Dutch government aims to rid all homes in the Netherlands from natural gas by 2050. Because the existing gas network can be used for a hydrogen transport and distribution, hydrogen is one of the options for replacing natural gas.

To demonstrate how this works in practice, Kiwa and Alliander's Hydrogen Experience Centre has been designed as a real residential home. It has a kitchen and a fuse box and is equipped with a 100% hydrogen boiler.

In this way, the application of hydrogen in the built environment can be put into practice.

Pilot in Lochem

In 2021, Alliander will start a pilot in Lochem in which existing homes with a natural gas connection will be converted to hydrogen. The pilot's concerns houses that have a landmark status and are not optimally insulated. Due to this, these homes are less suitable for the application of heat pumps or connection to a heat network.

Hydrogen is therefore the best option for sustainable heating. The residents of this district will be able to visit the Hydrogen Experience Centre and experience which adjustments are needed to prepare their homes for hydrogen.

*Kiwa's Alliander
Hydrogen House*

More information

In addition to professionals and residents, municipalities, suppliers and any other interested parties are very welcome to visit the Hydrogen Experience Centre.

Would you like to know more about Kiwa's hydrogen services and the Kiwa and Alliander's hydrogen demo house? Please contact us and we will gladly tell you all about it!



Project **Levenmouth**

This Kiwa Gastec project aimed to develop the first community trial of hydrogen usage in domestic dwellings.

Decarbonising the heat sector is seen as a priority to help the UK meet its commitment to achieving Net Zero targets.

Assessing the feasibility for a 'green' hydrogen production plant, storage and distribution infrastructure that would deliver energy for heating and cooking to some 300-900 homes in Levenmouth, is a test case which, should it prove successful, will shape future energy strategy for the UK.



Project Overview

Kiwa Gastec was commissioned by SGN to conduct a feasibility study on taking renewable electricity (produced by the Offshore Renewable Energy Catapult's Levenmouth wind turbine) and using it to power an electrolyser.

This would split water into hydrogen and oxygen and store the hydrogen locally in tanks, until it is required for heating and cooking by the 300-900 homes included in the study.

How much energy is required by the homes in the study?

Our first task was to estimate the heat demand of the 300-900 homes, based on a housing survey, typical heat demand data for the house types present and temperature data over the previous 20 years.

How much energy is produced by the wind turbine?

Determining the power output of the wind turbine required detailed analysis of historic energy production data, future operational plans for the turbine's use, and historic weather data.

Managing the operational requirements of the electrolyser

The intermittency of wind presents a challenge in that electrolysers perform best when they run constantly. Smoothing out the intermittent energy supply by predicting peaks and troughs in production by analysing weather forecasting data and using grid electricity to even out the energy fed to the electrolyser was a key challenge. A system control strategy and performance model was used to predict the lifetime cost of top-up grid electricity from a range of electrolyser types, which informed the electrolyser selection decision.

Storing hydrogen ready for supplying to homes

Tank storage is relatively expensive for a project of this scale, so a balance was needed between ensuring a sufficient supply and managing the cost of the infrastructure. A cost model was developed for the system to assess the most cost effective combination of production and storage needed to meet the demand.

The role of Kiwa

- Technical lead
- Principal Technical Contractor
- Feasibility study
- Front End Engineering Design (FEED)
- Technical consultancy including high level control system design
- Strategic planning and associated economic modelling
- Data analysis and system performance modelling

What is the project outcome expected to be?

The study demonstrated that local production, storage and distribution of 'green' hydrogen generated from wind power is feasible. Indeed, the study also concluded that as projects reach a scale and number that justify the development of centralised geological storage, the cost of local storage and distribution will be replaced by revenue from a purchase agreement from the centralised store operator, thereby incentivising the development of hydrogen infrastructure at scale.

Project **HG2V**

The HG2V (Hydrogen Grid to Vehicle) project was commissioned by Cadent Gas, and was a collaboration between Kiwa Gastec, DNV GL, NPL and Imperial College London, to determine whether the existing gas network could be re-purposed to supply hydrogen for use in fuel cell electric vehicles.

With a third of the UK's carbon emissions coming from road transport, decarbonising this sector is a priority to meet our commitment to Net Zero.

Hydrogen presents a viable zero carbon fuel for the transport sector if it can be supplied through the existing natural gas network at the quality required for transport.



Project Overview

Fuel cell electric vehicles will be a major user of hydrogen in the future and with a highly effective gas network allowing distribution across the country hydrogen will be available around the country. With fuel cell technology being the technology of choice for hydrogen transport applications the high sensitivity to contaminants of this technology requires a high purity of hydrogen.

The objective of the HG2V project was to determine which contaminants are likely to be present in the existing gas network, which might have an impact on the performance of fuel cells, and so build an appreciation of what purification activities are required at the point of supply.

Cadent

Your Gas Network

In collaboration with:

Imperial College
London

NPL
National Physical Laboratory

DNV·GL

The role of Kiwa

Kiwa's principal role in the project was the design and build of a network simulation rig to enable testing of purification technologies for hydrogen. Kiwa also contributed its extensive knowledge of the gas network which was instrumental understanding the contaminants in the gas distribution network, and assisted DNV GL in exploring the technologies available for purification.

- Technical consultancy
- Design, procurement and build of test environment
- Stakeholder engagement
- Writing of final report



Project **Hydrogen Hubs**

The Hydrogen Hubs project is a Cadent Foundation-sponsored feasibility study investigating if large scale local energy production (Hubs) can provide zero carbon hydrogen to decarbonise challenging energy sectors.

Focussed primarily on heat and transport the project will investigate practical and commercial viability of such a project for the city of Birmingham. Tyseley Energy Park has been identified as the location for the feasibility study as production here could be distributed to key demands in the city.

The project is a collaboration between Kiwa Gastec, Cadent Gas, the University of Birmingham, and Tyseley Energy Park.



Project Overview

It is becoming clear that hydrogen is a viable alternative to natural gas for decarbonising the UK heat and transport sector. Considerable work has been carried out on the future of the gas network and how national scale production and supply of hydrogen could help the UK meet its Net Zero commitments.

This project has identified that further understanding is required for how cities and regions prepare for a future with national hydrogen infrastructure.



In collaboration with:



UNIVERSITY OF
BIRMINGHAM



Cadent
Your Gas Network

The Cadent Foundation has sponsored this project to explore the practical and commercial considerations of localised production and supply. Cities and regions are committing to Net Zero targets, but they now need to develop the hydrogen infrastructure they need to enable them to meet this commitment.

Kiwa Gastec and other project collaborators are conducting a feasibility study to explore the supply of hydrogen to buses, trains, heat networks and domestic and commercial properties.

The role of Kiwa

Kiwa Gastec are leading the project and are conducting the feasibility study. This work on the project has included:

- Stakeholder engagement interviewing key stakeholders in the city and the region.
- A review of hydrogen production technologies and key hydrogen demands in the city
- Concept development of the Hydrogen Hubs project
- Techno-economic analysis of the final concept



Project **Octopus Renewables**

Kiwa Moroni has been engaged by Octopus Renewables to execute vendor technical advisory service aimed to issue a detailed vendor technical due diligence to be shared with the potential buyers of the 173 MW portfolio, consisting of 17 photovoltaic plants located in Italy: Nine plants are located in Lazio, and eight are located in Sardinia.

At the end of the sale process the photovoltaic portfolio has been acquired by A2A, an Italian multi-utility company. A2A generates, distributes, and markets renewable energy, electricity, gas, integrated water supply, and waste management services.



Project Overview

Kiwa Moroni was commissioned to conduct technical due diligence and feasibility study in relation to the possibility to have hydrogen production plants using green energy from the photovoltaic plants.

The feasibility study took into consideration several aspects such as the location of the photovoltaic plants, the distance of the PV plants from the dispatching point of the national gas grid, the space availability for the installation of hydrogen production plants inside the PV plants borders and the maximum yield obtainable on the retail market of hydrogen and oxygen, in the absence of incentives and momentary impossibility of inserting hydrogen in the existing methane gas networks.

It has been hypothesized to create modular hydrogen and oxygen production solutions for sub-clusters, considering the issue of scalability, starting from a basic alkaline electrolysis module with a nominal capacity of 2.5MW.



The Role of Kiwa

Kiwa Moroni acted as Vendor Technical Advisor and, in relation to the upsides due to the green hydrogen production, executed the following activities:

- ✓ Feasibility studies on production of green hydrogen
- ✓ Electrolysers technology review
- ✓ Analysis of water availability
- ✓ Preliminary permitting review
- ✓ Preliminary market review
- ✓ Assessment of revenues and financial model

Why is the Octopus Renewables Project Happening?

Under this vendor due diligence process, Kiwa Moroni, in order to increase the value of the projects, evaluated the implementation of technical upsides to optimize the revenues streams of the photovoltaic plants subject to the sale process.

In particular, the implementation of green hydrogen production system, coupled with the photovoltaic plants subject to sale, has been evaluated by Kiwa Moroni and presented to the potential buyers under the vendor technical due diligence report.

What is the project outcome expected to be?

The purpose of the service was the evaluation of a scenario in which the energy yield of the photovoltaic systems in the portfolio was totally or partially used for the production of hydrogen and oxygen, through the water electrolysis process.

The outcome consists in a preliminary feasibility study including considerations related to the permitting, to the technology and to the potential market with a preliminary estimation of the main economics parameters of the initiative.

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Kiwa
Sir Winston Churchilllaan 273
2288 EA Rijswijk
P.O. Box 70
2280 AB Rijswijk
The Netherlands

+31 (0)88 998 44 00

www.kiwa.com

