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Deutscher Verein des
Gas- und Wasserfaches e.V.

DVGW

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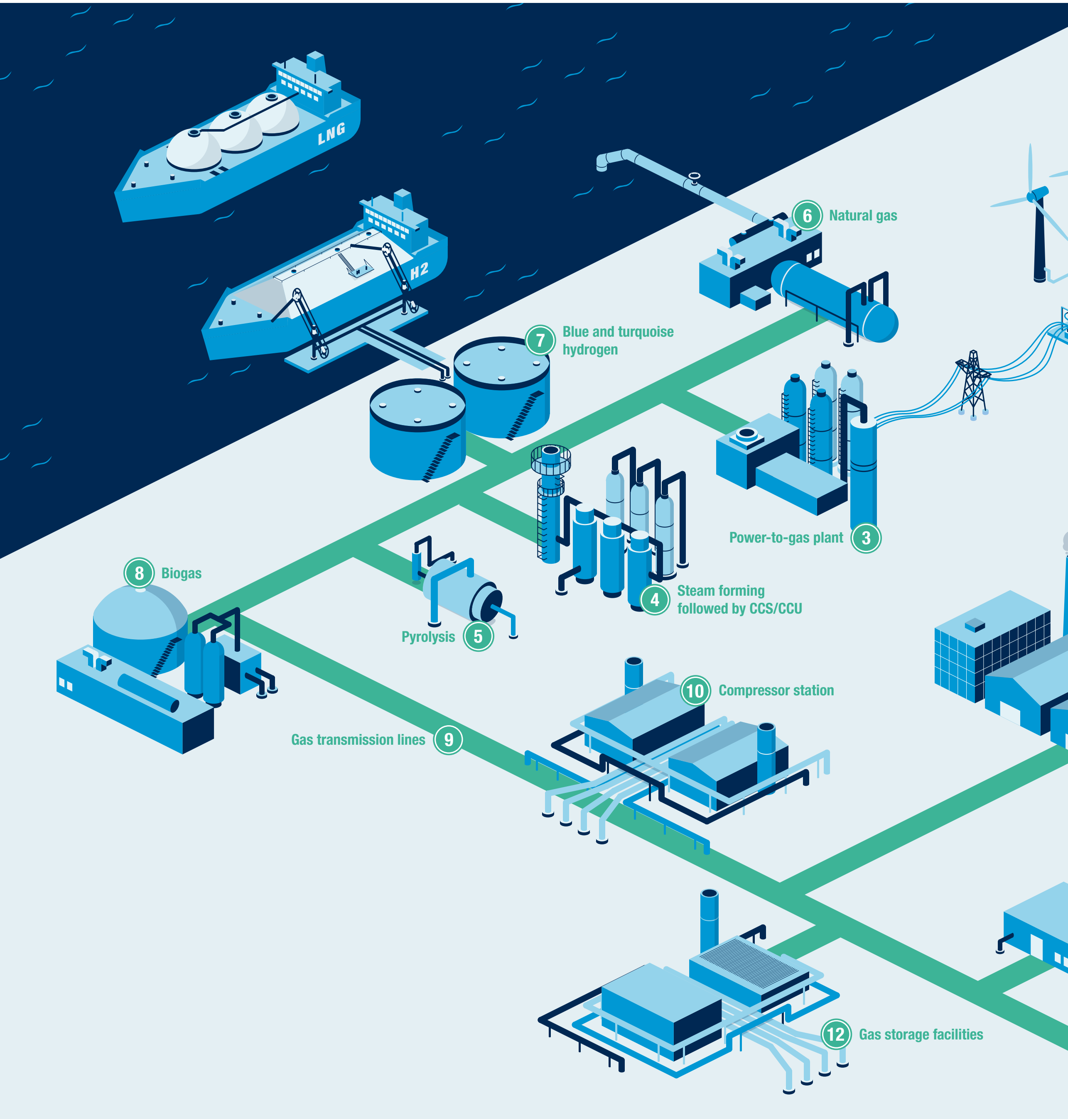
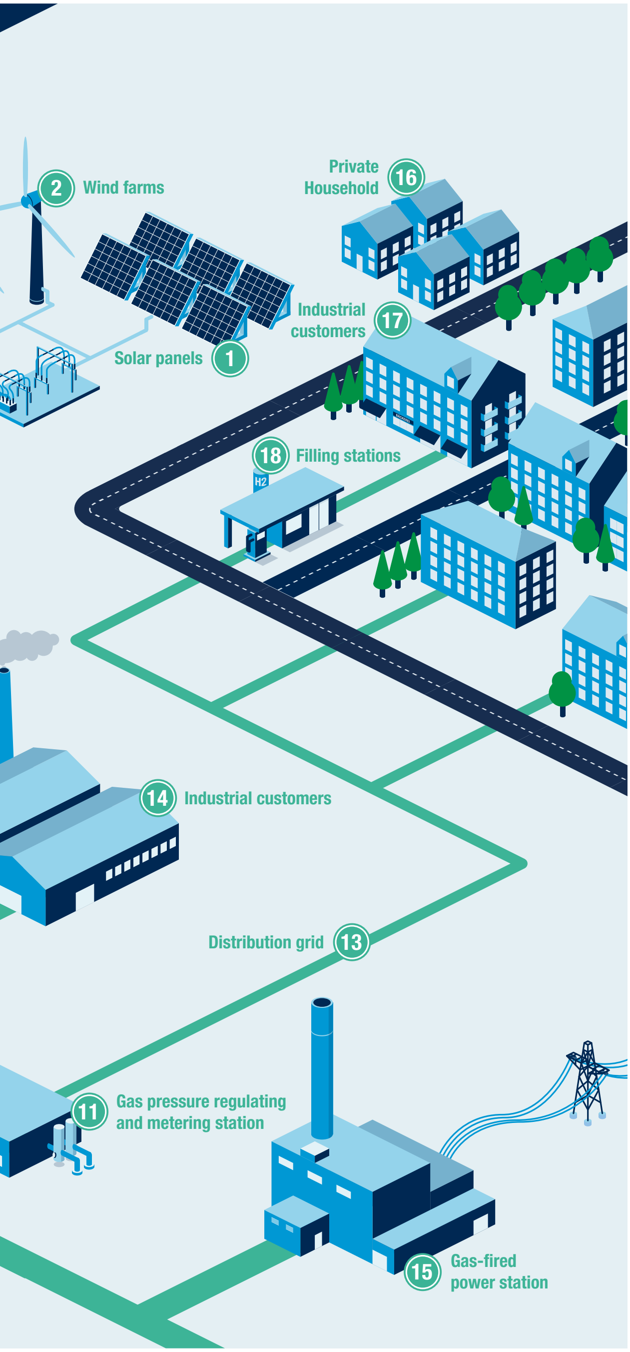
# Hydrogen Research Projects 2022

Time for a Fuel Ch2ange

Shaping the Future with Hydrogen

# The Hydrogen World of the Future






## All parts of the value chain at a glance:

### PRODUCTION

Solar panels 1 and wind farms 2 generate renewable electricity for the production of green hydrogen in the power-to-gas plant 3 using electrolysis. Steam reforming followed by CCS/CCU 4 or pyrolysis 5 produces blue or turquoise hydrogen, either from (liquid) natural gas 6 7 or using biogas 8. Alternatively, hydrogen can be imported via pipelines or by ship 7.

### INFRASTRUCTURE

Gas transmission lines 9 can transport hydrogen over large distances. This requires repurposing all infrastructure elements such as compressor stations 10 and gas pressure regulating and metering stations 11 to accommodate hydrogen. Hydrogen can be temporarily stored in gas storage facilities 12; users are supplied through distribution grids 13.

### END-USE APPLICATIONS

Large industrial consumers 14 or gas-fired power stations 15 can be serviced directly by the existing transmission network, while private households 16, commercial as well as smaller industrial customers 17 and filling stations 18 are supplied through the retail distribution grid, to ensure a large number of consumers directly benefit from the transition to environmentally-friendly hydrogen.

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# Hydrogen Research Projects

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# Foreword

Hydrogen is one of the key components of the energy transition – there is no way around this source of energy to achieve the target of becoming a net zero society. It is essential for the successful integration of hydrogen into the energy system, however, that it is available in sufficient quantities and that adequate technical installations and infrastructures exist that can accommodate the gas. The many research projects of the DVGW focus on precisely these aspects, among others.

The DVGW has been supporting research and innovation with a focus on promoting carbon-neutral gases for more than a decade. The Association is a partner in national and European projects and uses the research findings to repurpose energy grids to carry hydrogen in a way that is compatible with the set of technical rules. This booklet offers an overview of the research projects in which the DVGW is currently involved. All 40+ projects relate to the hydrogen value chain and cover a wide range of research interests and methods, from hydrogen production methods to testing the H2 tolerance of gas appliances in laboratories through to energy system modelling.

A recent study by Frontier Economics that was commissioned by the DVGW confirmed that, contrary to popular belief, hydrogen will be available in sufficient quantities. The calculations showed that about 290 Terawatt hours of low carbon to net zero hydrogen could be produced by 2030, a number that far exceeds the expected demand predicted by all forecasts.

Moreover, findings from numerous DVGW research projects demonstrate that the pipes of the existing gas infrastructure can be used to transmit the environmentally-friendly gas, creating – in combination with H2-ready gas technologies – the best conditions for the use, transport and storage of hydrogen. Admittedly, some gas network components, devices and systems still require retrofitting to ensure the safe and technically sound repurposing of the supply infrastructure to carry hydrogen.

A series of compendiums that has been prepared as part of the DVGW research projects and highlights which assets need to be modified where and how is intended to be published shortly in the form of a digital work of reference.

As Chairman of the Board of Directors Energy and President of the ERIG European Research Institute for Gas and Energy Innovation, I hope you will enjoy reading this booklet and gain many interesting insights.

**Prof. Dr. Gerald Linke**
DVGW Chairman of the Board of Directors


**“Hydrogen is key to ensure a future carbon-neutral energy supply. The DVGW supports the introduction and the safe use of hydrogen through its Innovation Programme and numerous research projects.”**

# Hydrogen – Secure net zero energy supply

In only a few years from now, Germany will need a diversified energy supply that has to become 'Net Zero' by 2045 at the latest. However, the necessary retrofit of the energy system can be implemented successfully only if all relevant technologies and options are considered that swiftly reduce greenhouse gas emissions – while keeping costs and risks within acceptable limits.

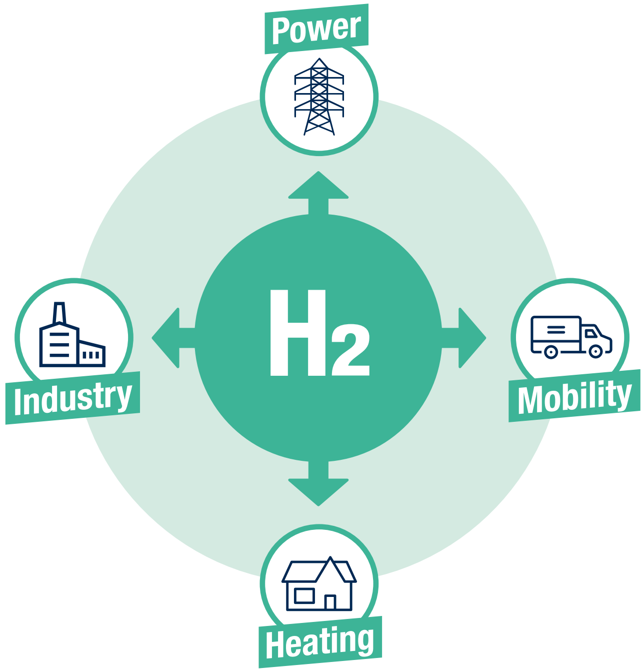
In addition to the expansion of renewable energies and more electric solutions, this also includes ramping-up environmentally friendly gases such as hydrogen ($H_2$), a versatile energy carrier that can be used in all sectors: As fuel for vehicles as well as raw material for the industry or fuel for heating systems. Its production and use do not emit greenhouse gases, which means that it can contribute significantly towards achieving net zero and, consequently, a successful energy transition in Germany.

One of the big advantages of hydrogen is that it can be stored over long periods of time and that it can be transported over vast distances. The existing gas infrastructure plays a key role in this context – its extensive pipeline network doubles as a huge energy storage system that can supply industrial plants, buildings and vehicles with environmentally-friendly gas.

Hydrogen thus presents a great opportunity for coupling the formerly separate power, heating, and industry sectors, relieving and stabilising the power grids in the process, potentially reducing the need to extend the grid and reliably securing safe supply at the same time.

Drawing on its knowledge in this field, the DVGW supports the gas industry to ensure the success of the imminent transition to transporting increasing concentrations of hydrogen in the gas network. For many years, the DVGW has been promoting innovation by providing a research budget for this purpose. Numerous research projects have already been successfully completed in collaboration with both DVGW research institutes and external partners. The results prove that an energy transition that uses the existing gas infrastructure is technically feasible and makes economic sense.

These findings also provided the basis for the **DVGW-Innovationsprogramm Wasserstoff** that was initiated in 2021. This programme has been designed to initiate and promote other projects with different foci on the four elements of the value chain, i. e. production, infrastructure, end-use applications, and being part of the overall energy system.




The many research projects investigate the contribution of net zero gases – notably hydrogen – and the existing gas infrastructure towards a sustainable future energy system, studying technical and economic as well as regulatory aspects.

Some of the projects study the potential for hydrogen production or assess the impact of hydrogen on gas pipeline and gas storage materials, while others investigate the effects on end-use applications such as gas combustion engines or heating systems. Living laboratory and field tests are carried out to determine how much hydrogen can currently be injected into the gas grid; other projects try to find ways to optimally retrofit the energy system and determine the associated cost.

This booklet provides an overview of the relevant projects of the DVGW Hydrogen Innovation Programme as well as of the living laboratories and joint projects with DVGW research institutes that form the **H2-Kompetenzverbund der deutschen Energiewirtschaft** (**H2 Association of Excellence of the German Energy Sector**). It highlights the economic and climate protection potential of hydrogen and shows where the transition process has already begun.

# $H_2$ Research and the DVGW

## PRODUCTION



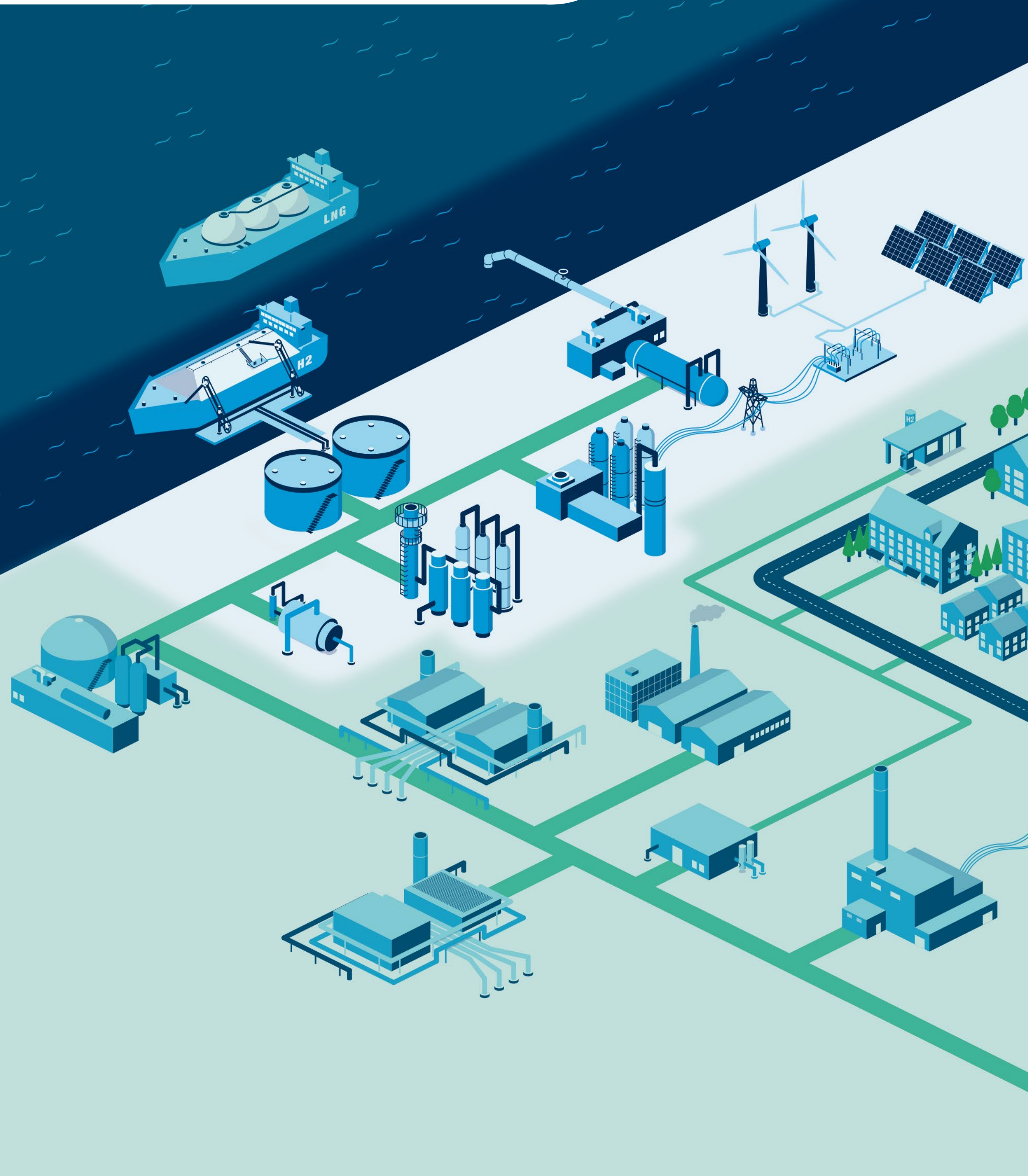
## INFRASTRUCTURE

# END-USE APPLICATIONS



# ENERGY SYSTEM

# Production



# Hydrogen – Energy carrier of the future

Tackling the transition of the energy system is one of the biggest challenges of the century that requires focusing equally on climate protection, resilience and social compatibility. The future security of supply of energy needs to be based on a well-balanced strategy that takes into account both the expansion of renewable energies and the ramp-up of climate friendly gases.

Hydrogen, above all else, is an energy carrier that can pave the way towards a net-zero society. It can power industrial processes and mobility, supply heat to residential buildings through central and district heating systems, and it can also serve as a storage medium.

Hydrogen, in other words, is a key element of the energy transition. It can be produced in a number of ways; the DVGW has already shed light on various aspects such as, for instance, the potential availability of hydrogen in 2030 and 2045, and the cost of making $H_2$ available. Likewise, researchers of the DVGW research institutes have calculated the carbon footprint generated per kilowatt hour of hydrogen produced by different production methods.

**We will need environmentally friendly hydrogen from domestic production AND large imports.**

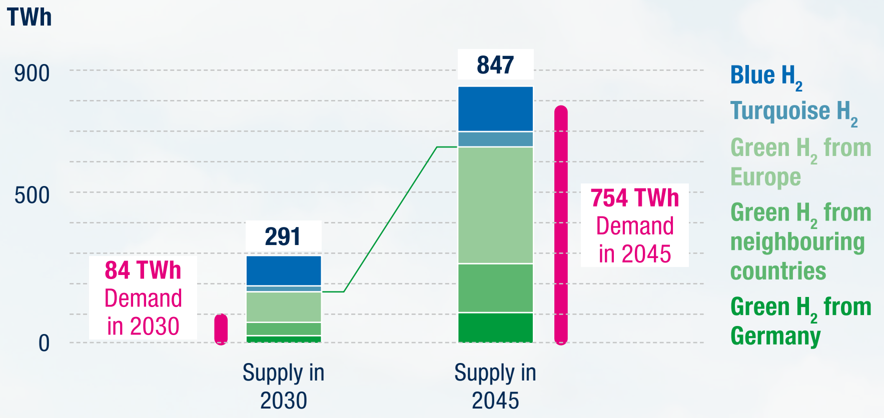
### $H_2 \neq H_2$

**Blue hydrogen** is produced by steam reforming of methane (DR). The $CO_2$ generated during the process is trapped and stored (carbon capture and storage, CCS) and thus prevented from escaping into the atmosphere.

**Turquoise hydrogen** is made using a process called methane pyrolysis that produces hydrogen and solid carbon from natural gas at extremely high temperatures. The solid carbon can be trapped directly.

**Green hydrogen** is made using clean electricity from renewable energy sources to electrolyse water, decomposing it into hydrogen gas ($H_2$) and oxygen. Biomethane reformation or pyrolysis is yet another method to produce green hydrogen by separating the carbon dioxide. This way, a $CO_2$ sink can be created as the carbon was previously removed from the atmosphere by plants through photosynthesis.

**Hydrogen supply in 2040 and 2045 (base-case scenario)**




Source: DVGW (2022) Availability and Cost Comparison of Hydrogen Supply – Merit Order of Climate-friendly Gases in 2030 and 2045 (in German)

## PROJECT COORDINATOR

frontier economics

# $H_2$ availability

Completed

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## PROJECT NAME

Availability and cost comparison of hydrogen supply – Merit order of climate friendly gases in 2030 and 2045 (subproject of the “A sustainable heating sector” project, see p. 60)

## OBJECTIVE

Calculation of the quantities of hydrogen that could be available in the medium and long term under the right political conditions

## BACKGROUND

Due to the current situation Germany intends to reduce its dependence on external energy supply more rapidly than originally planned. Moreover, the German government is under pressure to expedite its climate goals in order to minimise the impact of climate change. Hydrogen plays an indispensable role in securing Germany's future energy supply. The key requirement in this context is to ensure that enough hydrogen will be available to meet the growing demand for energy.

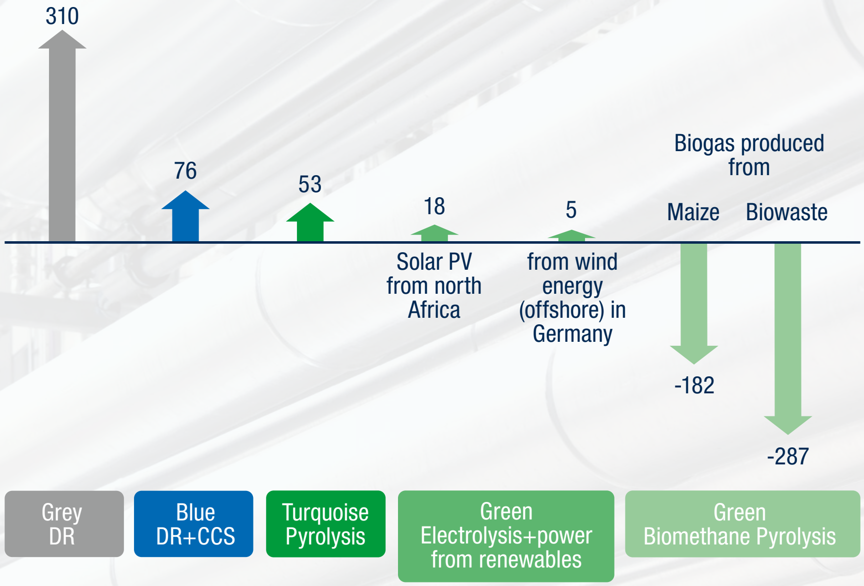
## APPROACH

- Analysis of the market ramp-up and calculation of the future hydrogen supply modelled on the basis of three scenarios (base-case, pessimistic and optimistic scenario)
- Identification of the factors that influence the availability of hydrogen

## RESULTS

- The base-case scenario shows that about 290 terawatt hours (TWh) of either low carbon or net-zero hydrogen could be produced as early as in 2030, and as much as 850 TWh by 2045. At least 60% of this total would be green hydrogen produced by electrolysis in Germany and in other European countries, a number that far exceeds the expected demand predicted by all forecasts.
- By 2045, the average cost of production of hydrogen made by electrolysis may have fallen to between five and seven Eurocent/kWh.
- In the medium term, blue and turquoise hydrogen are suitable interim solutions that can help promote the market ramp-up in many sectors.

**Carbon footprint of hydrogen in 2045, g of $CO_2$ eq per kWh of $H_2$**




Source: DVGW (2022) Ecological evaluation of hydrogen supply - Sensitivity analysis on GHG emissions of hydrogen (in German)

## RESEARCH INSTITUTES

DVGW Forschungsstelle ebi

gwi Gas- und Wärme-Institut Essen e.V.

PRODUCTION

# Carbon footprint of $H_2$ production

Completed

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## PROJECT NAME

Ecological appraisal of different hydrogen production methods

## OBJECTIVE

Calculation of the greenhouse gas emissions generated by different hydrogen production and supply methods

## BACKGROUND

Alternative hydrogen production methods offer the potential to reduce greenhouse gas emissions even today. This project calculated the volume of carbon emissions generated per produced kilowatt hour (kWh) of hydrogen and used the results as a basis for extrapolating the development over the next decades. The researchers calculated the volume of emissions generated by the domestic and foreign production of green, blue and turquoise hydrogen, including biomethane as a possible base material.

## APPROACH

- Sensitivity analysis of emissions data using GEMIS 5.0, taking into account the trend of greenhouse gas emissions from the production of electricity from solar PV and wind power until 2050
- Consideration of the production methods for blue, turquoise and green hydrogen (see info box on page 13)

## RESULTS

- Compared to the conventional production method, the production of blue, turquoise and green hydrogen can reduce GHG emissions by between 75% and 95% in the long term.
- Methane emissions generated by the production of blue and turquoise hydrogen have a decisive impact on the total volume of emissions from the production process. Biomethane offers some potential for negative GHG emissions.
- Emissions from the production of green hydrogen depend on the sources used for power generation. Green hydrogen produced from offshore wind power in Germany offers the highest $CO_2$ reduction potential.


H2

PRODUCTION

# COnnHy
## Net-zero hydrogen production

**Completion: 07/2024**

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### PROJECT NAME
Carbon neutral, methane-based hydrogen production

### OBJECTIVE
Appraisal of low-emission hydrogen production from natural gas and biogas through Boudouard reaction at reduced temperatures, with solid carbon as a by-product

### BACKGROUND
Hydrogen offers great potential for climate protection and is a sustainable, carbon-neutral energy supply option. However, future demand cannot be met solely by domestic production through electrolysis and from electricity based on renewable sources. Consequently, production methods involving the removal of methane from natural gas and the sequestration of carbon or $CO_2$ will have to be used as interim technologies.

### APPROACH
- Identification of the optimal operating range and materials suitable for dry reformation and the Boudouard reaction
- Presentation of a reactor, product and reagent treatment and carbon handling concept
- Creation of a basis for implementation in the form of a trial run at demonstration scale

### CO-SPONSOR
EuroNorm

### PROJECT COORDINATORS
DVGW

DBI GTI Gastechnologisches Institut

### SPONSOR
Supported by

Federal Ministry for Economic Affairs and Climate Action

on the basis of a desicion by the German Bundestag

# $H_2$Mare

## OBJECTIVE

Investigation of options for offshore production, i. e. production at sea, of green hydrogen and secondary products using stand-alone units consisting of wind turbines with integrated electrolysers

## INVOLVEMENT OF THE DVGW GROUP

The DVGW Research Centre at the Engler-Bunte-Institute of the KIT is one of the more than 30 $H_2$Mare partners and participates in the joint $H_2$Wind and PtX Wind projects.

## APPROACH

- Development of a process chain for the offshore production of liquefied methane and of a method for extracting CO2 from sea water through the combined construction and operation of a honeycomb methanation catalyst and a liquefier
- Investigation of technological and ecological problems relating to the water management of PtX processes on offshore platforms, including different wastewater treatment processes
- Technical and economic appraisal of the entire offshore process chain

## SPONSOR

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Federal Ministry
of Education
and Research

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PRODUCTION

# Hydrogen lead projects

Completion: 03/2025

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BACKGROUND

In April 2021 the Federal Ministry of Education and Research (Bundesministerium für Bildung und Forschung, BMBF) initiated three hydrogen lead projects. The aim is to implement the National Hydrogen Strategy and facilitate Germany's transition to a hydrogen economy. The projects intend to help advance hydrogen technologies in three key areas in the next four years: The serial manufacture of water electrolysers; hydrogen production by offshore wind turbines with integrated electrolysers, and hydrogen transport technologies.

## $H_2$Giga

OBJECTIVE

Development of a method for the cost-effective, serial manufacture of high-performance electrolysers, overcoming of the technical challenges associated with the development of this technology and conquering of non-technological innovation obstacles

BETEILIGUNG DER DVGW-GRUPPE

The DBI Gas-technological Institute participates in $H_2$Giga through the joint "Electrolysis Technology Platform: Reducing Innovation Obstacles" project.

APPROACH

- Development of measures designed to reduce obstacles to innovation in education, training and advanced training as well as testing and standardisation procedures, and creation of a legal framework to accelerate the market ramp-up of electrolysers

SPONSOR

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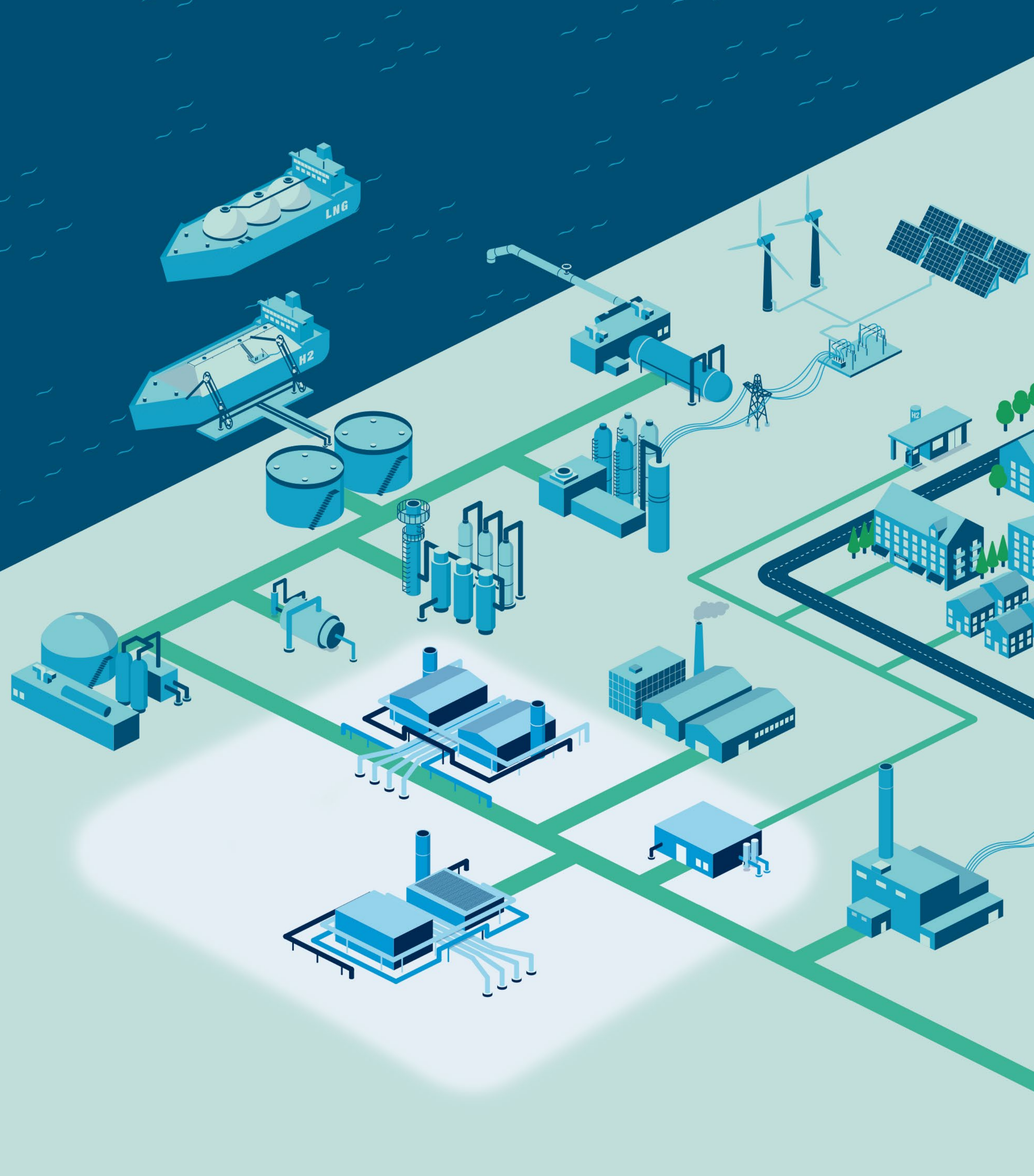
Federal Ministry of Education and Research

# Infrastructure



# Storing, transporting and distributing hydrogen

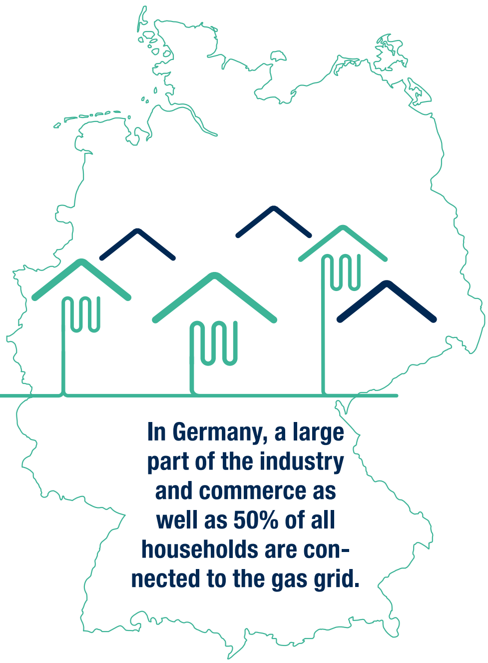
Germany has an excellent infrastructure, totalling more than 540,000km, for the transport, distribution and storage of carbon-neutral gases. Even today, small quantities of hydrogen can be injected and distributed over large distances. From a purely technical point of view, Germany's gas grid is ready to blend a minimum of 10% hydrogen by volume into gas networks, that can be used in many end-use applications.

Growing production and import capacities offer the prospect of increasing the hydrogen blend from ten to 20 percent. It would be possible theoretically to repurpose sub-sections where supply matches demand to accommodate pure hydrogen.

**The existing gas network can be repurposed to carry hydrogen; additionally, a parallel $H_2$ infrastructure can be added at reasonable cost here and there.**

The gas sector has experienced similar retrofits several times in its history. It has therefore both the necessary knowhow and the competence to manage the upcoming transition. In order to support this process and ensure the safe operation of all systems, the DVGW and its associated institutes are conducting numerous research projects to assess the hydrogen tolerance of the entire gas infrastructure, down to the smallest setscrew.

In its capacity as approved regulator, the DVGW is already actively preparing the network, its components and materials for transitioning to higher hydrogen blends and even pure hydrogen. Retrofitting the gas infrastructure network is, however, required to ensure that all network components and end-use gas applications will tolerate increasing hydrogen blends.




Source: DVGW e.V.

Picture: © malp / AbodeStock

# Lead project TransHyDE
## Hydrogen transport technologies

**Completion: 03/2025**

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### PROJECT NAME
Lead project for the advancement of hydrogen transport technologies

### OBJECTIVE
Development, appraisal and testing of hydrogen transport technologies

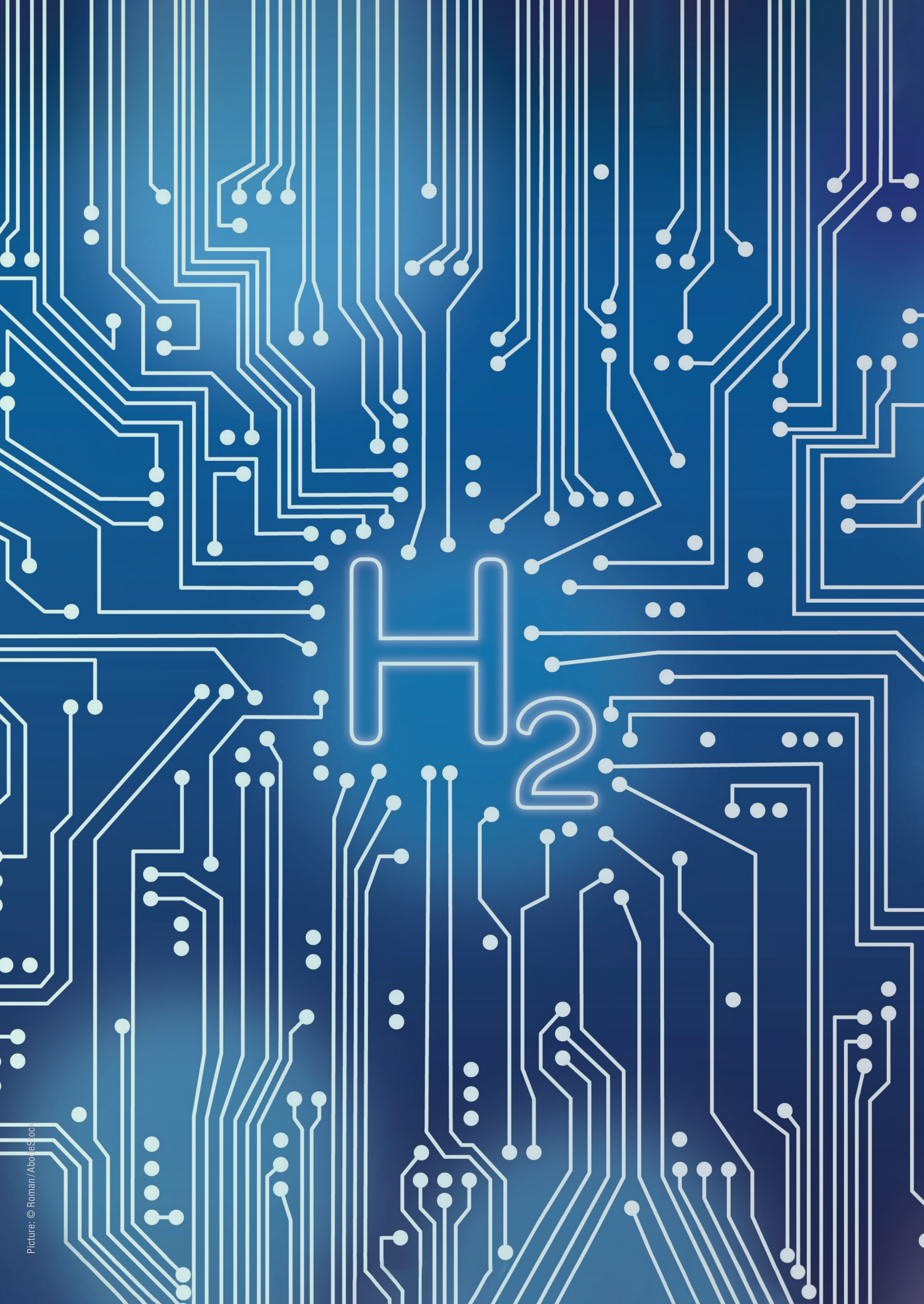
### BACKGROUND
A functioning hydrogen economy depends on an adequate transport infrastructure. New solutions are required, with a focus on hydrogen imports. Indeed, ideas abound – yet it remains unclear which approach is most suitable for a given application, and which transport routes would make the most sense to combine with one another.

### BETEILIGUNG DER DVGW-GRUPPE
The DVGW Research Centre at the Engler-Bunte-Institute of the KIT is involved in the two joint “System Analysis” and “GET H2” TransHyDE projects. Moreover, the DVGW, the DVGW Cert GmbH and the Gas- und Wärme-Institut Essen (Gas and Heat Institute of Essen) are partners of the TransHyDE Research Association “Standardisation, Harmonisation and Certification”, the latter institute being also involved in the “Mukran Hydrogen Centre” $H_2$ storage sub-project.

### APPROACH
- Testing and upscaling of four demonstration projects relating to hydrogen transport technologies: Transport in high-pressure vessels, transport through existing gas pipelines, transport of hydrogen as ammonia and through the use of liquid, organic hydrogen carriers (LOHC)
- Systematic appraisal of the role of $H_2$ in the energy system and preparation of a roadmap showing the possible design of a fully-fledged, future hydrogen infrastructure
- Preparation of possible standards, rules and safety regulations governing hydrogen transport technologies
- Safety assessment of hydrogen transport technologies (substances, materials and sensors) as well as of the efficiency of hydrogen extraction from ammonia and of the filling up of vessels with liquid hydrogen

### SPONSOR
Sponsored by

Federal Ministry of Education and Research

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INFRASTRUCTURE

# $H_2$ database

Completion: 07/2023

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## PROJECT NAME

Development of an online database and digital reference work on the hydrogen tolerance of components and products of gas networks and underground storage facilities as well as on necessary retrofits

## OBJECTIVE

Digital reference work on the hydrogen tolerance of all gas infrastructure components and products, including underground storage facilities, in terms of material and function

## BACKGROUND

DVGW studies show that many components of the natural gas infrastructure are suitable for transporting and storing hydrogen. The DVGW Set of Rules currently specifies a maximum blend of 10% hydrogen by volume in the gas grid, intending however to increase this blend to 20%. Information from completed and ongoing projects is compiled in a database in order to obtain a comprehensive picture of the hydrogen tolerance of the gas infrastructure.

## APPROACH

- Preparation of a reference work on existing knowledge about the impact of a hydrogen blend of up to 100% hydrogen by volume in gas transmission and distribution networks and underground storage facilities
- Description and assessment of components and products in the form of brief “profiles” between one and two pages in length
- Digitisation of existing reference works, creating an online database

## PARTICIPATING PROJECTS

$H_2$ compendium distribution network operators • $H_2$ compendium transmission system operators 1 • $H_2$ compendium transmission system operators 1 • $H_2$ database underground storage facilities

## PROJECT COORDINATORS

DVGW

DBI GUT Gas- und Umwelttechnik

Picture: © Uniper SE

INFRASTRUCTURE

# Transformative pathways
## Underground storage

Completed

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### PROJECT NAME
Hydrogen tolerance of infrastructures for gas storage

### OBJECTIVE
Assessment of the hydrogen tolerance of underground storage facilities and cost estimate

### BACKGROUND
Underground storage facilities can store energy in the form of renewable gases and therefore play an important role in reaching climate change goals. This research project investigates unresolved questions about the hydrogen tolerance of existing gas storage facilities.

### APPROACH
- Compilation of available information about hydrogen concentrations in gas storage facilities
- Description of the necessary transformative pathways and calculation of the investment required for (incrementally) repurposing storage facilities to accommodate hydrogen

### RESULTS
- All salt caverns in Germany are available for storing hydrogen blends as well as pure hydrogen
- Four of the 16 pore storage sites are suitable for storing pure hydrogen. However, the suitability for storing hydrogen needs to be verified individually.
- The underground storage facilities considered suitable have a storage capacity of approximately 32 TWh of hydrogen.

### CO-COMMISSIONED BY
Natural Gas Storage Initiative • German Federal Association Natural Gas, Crude Oil and Geo-energy

### PROJECT COORDINATORS
DVGW
DBI GUT Gas- und Umwelttechnik

Picture: © ONTRAS

# MefHySto

## Metrology for advanced hydrogen storage solutions

**Completion: 08/2023**

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### PROJECT NAME
Metrology for Advanced Hydrogen Storage Solutions

### OBJECTIVE
Research into and advancement of high-precision measurement techniques and methods and of the relevant standards and sets of rules related to hydrogen for different types of hydrogen storage.

### BACKGROUND AND PURPOSE
Storing hydrogen in chemicals is a promising option for storing volatile energy produced from renewable sources as this helps prevent energy supply interruptions. It however also requires reliable measurement techniques, standards, reference methods and suitable materials, which the MefHySto project aims to develop.

### APPROACH AND RESULTS
- Identification and assessment of requirements on the quality of hydrogen required for polymer electrolyte fuel cells
- Precise density measurement of mixtures containing hydrogen to improve the reference state equation that is used for modelling hydrogen blends of up to 20 per cent and serves as a basis for the exact determination of the calorific value
- Development of a validated method to measure and calculate the heat conductivity of hydrogen adsorbed or absorbed by metallic or porous materials

### PROJECT PARTNERS
Bundesanstalt für Materialforschung und -prüfung (project coordinator) • Cesky Metrologicky Institut • NPL Management Limited • National Metrology Institute (PTB) • Commissariat à l'Énergie Atomique et aux Énergies Alternative • DBI Gas- und Umwelttechnik • European Research Institute for Gas and Energy Innovation • Fundación para el Desarrollo de las Nuevas Tecnologías del Hidrógeno en Aragon • MAHYTEC • Max-Planck-Gesellschaft zur Förderung der Wissenschaften • Regasificadora del Noroeste • Universidad de Valladolid • DVGW

### PROJECT LOGO
MefHySto
Metrology for Advanced Hydrogen Storage Solutions

### SPONSOR
EMPIR EURAMET

This project has received funding from the EMPIR programme co-financed by the Participating States and from the European Union's Horizon 2020 research and innovation programme.

# HyBaWe

**Completion: 11/25**

## PROJECT NAME

Upgrade of ISO 18453 to include hydrogen

## APPROACH

- Literature research into published thermodynamic data on substances in natural gas / hydrogen systems
- Experimental determination of thermodynamic data
- Development and adaptation of the calculation algorithm

## RESEARCH INSTITUTE

Ruhr-Universität Bochum – Chair of Thermodynamics

## INDUSTRY PARTNER

OGE

INFRASTRUCTURE

# $H_2$ gas quality

**Completed**

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## BACKGROUND

The natural gas infrastructure can be used for the transport, storage and distribution of hydrogen. This however requires revising the current European and national set of rules. Moreover, more research is needed into possible trace substances and necessary treatment steps as well as on gas quality requirements and standardised calculation methods. The gas quality projects study all aspects mentioned above.

## $H_2$ in the Grid

### PROJECT NAME

Preliminary investigation of aspects of gas quality issues in the transport and distribution of hydrogen through the existing natural gas infrastructure

### APPROACH

- Data research and investigation of sources of contaminants and by-products in natural gas networks
- Evaluation of the requirements of $H_2$-based end-use applications on gas quality

### RESULTS

The study provides an overview of normatively specified gas qualities and their end-use applications.

### INDUSTRY PARTNER

Open Grid Europe

### PROJECT COORDINATORS

DVGW Forschungsstelle ebi

## $H_2$ Quality

### PROJECT NAME

Hydrogen quality in an all-German hydrogen grid (H2-Rein)

### APPROACH

- Presentation of different $H_2$ quality requirements for the production, transport, storage and end-use application of hydrogen
- Discussion of the need for further research

### RESULTS

Large quantities of hydrogen of excellent quality will be needed in the year 2045, requiring appropriate processing methods with different degrees of complexity.

### CO-COMMISSIONED BY

GET H2

### RESEARCH INSTITUTES

DVGW DBI GUT Gas- und Umwelttechnik

frontier economics

Picture: © Tierney/AdobeStock

# R&D into $H_2$
## Hydrogen in gas supply

Completion: 01/2023

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### PROJECT NAME
Research and development as a basis for using hydrogen in gas supply and creation of test specifications

### OBJECTIVE
Creation of a sound knowledge base for the ongoing development of certification programmes and the Set of Technical Rules on Hydrogen

### BACKGROUND
With the energy industry increasingly focusing on hydrogen as a net-zero energy carrier, the DVGW announced as early as in 2019 that it would amend its Set of Rules, aiming to reach two goals with this move: Firstly, raising the maximum hydrogen concentration to 20 per cent hydrogen by volume and secondly, the inclusion of a new gas family containing almost pure hydrogen.

### APPROACH
- Garnering available information through literature research
- Identification of the need for additional research to advance the Set of Rules as well as concretising and conducting the studies during the second phase of the project
- Consolidation of research, sets of rules and certification activities in order to drive the further development of the DVGW Set of Rules in an organised manner to cover gases containing hydrogen

### RESEARCH INSTITUTES
DVGW DBI GTI Gastechnologisches Institut

DVGW Forschungsstelle ebi

gwi Gas- und Wärme-Institut Essen e.V.

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INFRASTRUCTURE

# Reforming $H_2$ to stabilise hydrogen content

Completed

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## PROJECT NAME
Use of reforming to stabilise hydrogen concentration

## OBJECTIVE
Determination of the benefits and drawbacks of the “reforming” method to stabilise hydrogen content in the gas distribution network as compared to methanation and the use of membranes.

## BACKGROUND
While many application technologies tolerate a hydrogen content of up to 20 per cent by volume, they respond very sensitively to fluctuating gas qualities. Current discussions about how to minimise this effect include the concept of steam reformation, a method that could be used to produce variable hydrogen quantities from natural gas and thus help keep hydrogen contents constant.

## APPROACH
- Collection of data on the potential, limit and cost of available reformers and comparison with other concepts like methanation or membrane separation
- Determination of the impact of the use of reformers on the cost of the overall system and the integration of renewable gases

## RESULTS
A combination with other elements (e. g. relief holders) has shown to stabilise hydrogen contents, albeit with the drawback that $CO_2$ is released during the reforming process, requiring sequestration. In order to facilitate an estimate of the cost of stabilisation, the project therefore also investigated $CO_2$ sequestration options. Membranes were found to offer great potential in this regard. From a technical point of view, reformers are advantageous especially during the transition period, when net-zero hydrogen is not yet available in sufficient quantities.

## PROJECT COORDINATORS

DVGW

DBI GUT Gas- und Umwelttechnik

Picture: © ONTRAS

INFRASTRUCTURE

# $H_2$ tolerance of steels

**Completion: 12/2022**

H2-dvgw.de

## PROJECT NAME

Random checking of steels for gas pipelines and installations to assess the hydrogen tolerance of materials in accordance with ASME B31.12

## OBJECTIVE

Random analysis of steels for gas pipelines and installations and validation of the applicability of ASME standards to steels used in Germany

## BACKGROUND

The safe transport of hydrogen through the German gas grid necessitates assessing the hydrogen tolerability of all steel components and revising the DVGW Set of Rules accordingly. So far, only the American ASME B31.12 Set of Rules of December 2019 covers steels for the transport of 100% hydrogen. It is therefore intended to adopt the ASME B31.12 assessment and integrate it into the DVGW Set of Rules.

## APPROACH

- Representative selection of materials used in the German gas network
- Random fracture mechanical testing
- Comparison of the determined parameters with the results that form the basis of the American ASME B31.12 Set of Rules
- Validation of the applicability of the ASME standard to steels used in Germany

## RESEARCH INSTITUTE

Materials Testing Institute of the University of Stuttgart

## PROJECT COORDINATOR

OGE

## Leakage Rates

**Completion: 01/2023**

### PROJECT NAME

Experimental characterisation of the test leakage rates using hydrogen and / or methane / gas mixtures compared to air (ECLYPSE)

### OBJECTIVE

Leak testing with air, observing the safety level

### APPROACH

- Investigation of the flow conditions for measurements of methane, hydrogen and methane / hydrogen mixtures with air and study of flow models for different test media and test pressures
- Validation of the use of test leaks

### PROJECT PARTNER

gwi Gas- und Wärme-Institut Essen e.V.

DVGW Forschungsstelle ebi

## Flange tightness

**Completion: 06/2023**

### PROJECT NAME

Leak testing of flanged joints in installations running on hydrogen and hydrogen-containing gases

### OBJECTIVE

Development of a practical leak testing method for hydrogen and hydrogen blends and improvement of assembly guidelines

### APPROACH

- Leak testing of flanged joints
- Recording and evaluation of leaks and leakiness with different test gases under different test conditions

### PROJECT PARTNER

gwi Gas- und Wärme-Institut Essen e.V.

Picture: © FedotovAnatoly/iStock

# $H_2$ leaks

BACKGROUND

Repurposing the European gas infrastructure to carry pure hydrogen gas or natural gas/hydrogen blends requires pipelines and installations to function impeccably if the project is to be sustainable in the long term. All systems, system components and elements have to be technically leak-tight. As hydrogen-containing gases may adversely affect the tightness of gas-bearing pipelines or components, several DVGW research projects address the important issue of leak detection and look to determine the tightness of certain components.

## $H_2$ detection

Completed

PROJECT NAME

Analysis of the behaviour of gas leaks from buried pipelines transporting hydrogen-containing or hydrogen-rich gases, with reference to G 465-1 ($H_2$BoMess)

OBJECTIVE

Detection of hydrogen leaks in the ground and of hydrogen leaking from the ground, and above-ground leak detection

APPROACH

- Technology screening to identify measuring principles for above-ground hydrogen detection
- Metrological evaluation and assessment of the applicability of measuring instruments

RESULTS

All three $H_2$ gas concentration measuring instruments exhibited a high sensitivity to detect hydrogen. These instruments can be used to examine buried pipelines from above ground. The two (methane) gas concentration measuring instruments that were also tested can be used for examining, from above ground, gas pipelines that transport up to 30% hydrogen by volume.

PROJECT COORDINATOR

DVGW Forschungsstelle ebi

INDUSTRY PARTNER

OGE


# $H_2$ Odor

**Completion: 08/2023**

## PROJECT NAME

Hydrogen odorisation – A safety factor in the public gas supply network

## OBJECTIVE

Study of the use and effect of conventional odorants in fuel cell applications

## APPROACH

- Literature research into the suitability and availability of odorants for hydrogen distribution
- Olfactory appraisal of odour intensity in hydrogen
- Investigation of the impact of odorants on end-use applications and of the possibilities of odorant removal prior to the hydrogen end use

## RESEARCH INSTITUTES

DVGW DBI GUT Gas- und Umwelttechnik | DVGW Forschungsstelle ebi

# $H_2$ odorisation

## Odorisation of hydrogen for fuel leak detection

H2-dvgw.de

### BACKGROUND

It is imperative to take technical safety seriously when retrofitting the gas infrastructure for use with natural gas / hydrogen blends and pure hydrogen. While odorants are conventionally used within the natural gas grid to alert users to a leak in natural gas pipelines, hydrogen-containing gases require extensive testing, and alternative safety concepts will need to be developed in parallel.

## $H_2$ OdoSen

**Completion: 02/2023**

### PROJECT NAME

Preliminary study of an additional, sensor-based feature to complete the safety concept in a hydrogen / gas supply environment

### OBJECTIVE

Assessment of an alternative safety concept using sensor-based monitoring of hydrogen-containing gases

### APPROACH

- Investigation of possible additions to and/or odorisation alternatives for the pipeline-bound distribution of hydrogen
- Research into existing sensor-based technologies and their applicability to hydrogen-containing gases used in all end-use devices, from simple gas detectors to sophisticated gas detection systems
- Inclusion of different operating media, from natural gas to methane/hydrogen mixtures through to hydrogen

### RESEARCH INSTITUTE

DVGW Forschungsstelle ebi

Picture: © ONTRAS

INFRASTRUCTURE

# $H_2$ membrane

## Membrane reactors for separating hydrogen from natural gas

**Completion: 12/2022**

H2-dvgw.de

### PROJECT NAME

Construction and operation of a pilot plant in Prenzlau for the testing of membranes separating hydrogen from natural gas

### OBJECTIVE

Identification of membranes suitable for separating hydrogen and natural gas from a gas blend

### BACKGROUND

Adding hydrogen to natural gas presents a challenge to some elements of the infrastructure, e. g. in CNG filling stations or installations of the gas industry. Membrane technologies can separate hydrogen/natural gas blends into hydrogen and natural gas and thus create an opportunity for using the existing gas infrastructure for sensitive end-use applications, such as e. g. industrial processes or fuel cells, simply by removing the undesired constituent.

### APPROACH

- Construction and commissioning of a demonstration plant in Prenzlau to test the capability of membranes to recover hydrogen from natural gas blends
- Testing the (long-term) stability, separation properties, attainable purity, cost, time to market, scalability and availability together with membrane manufacturers

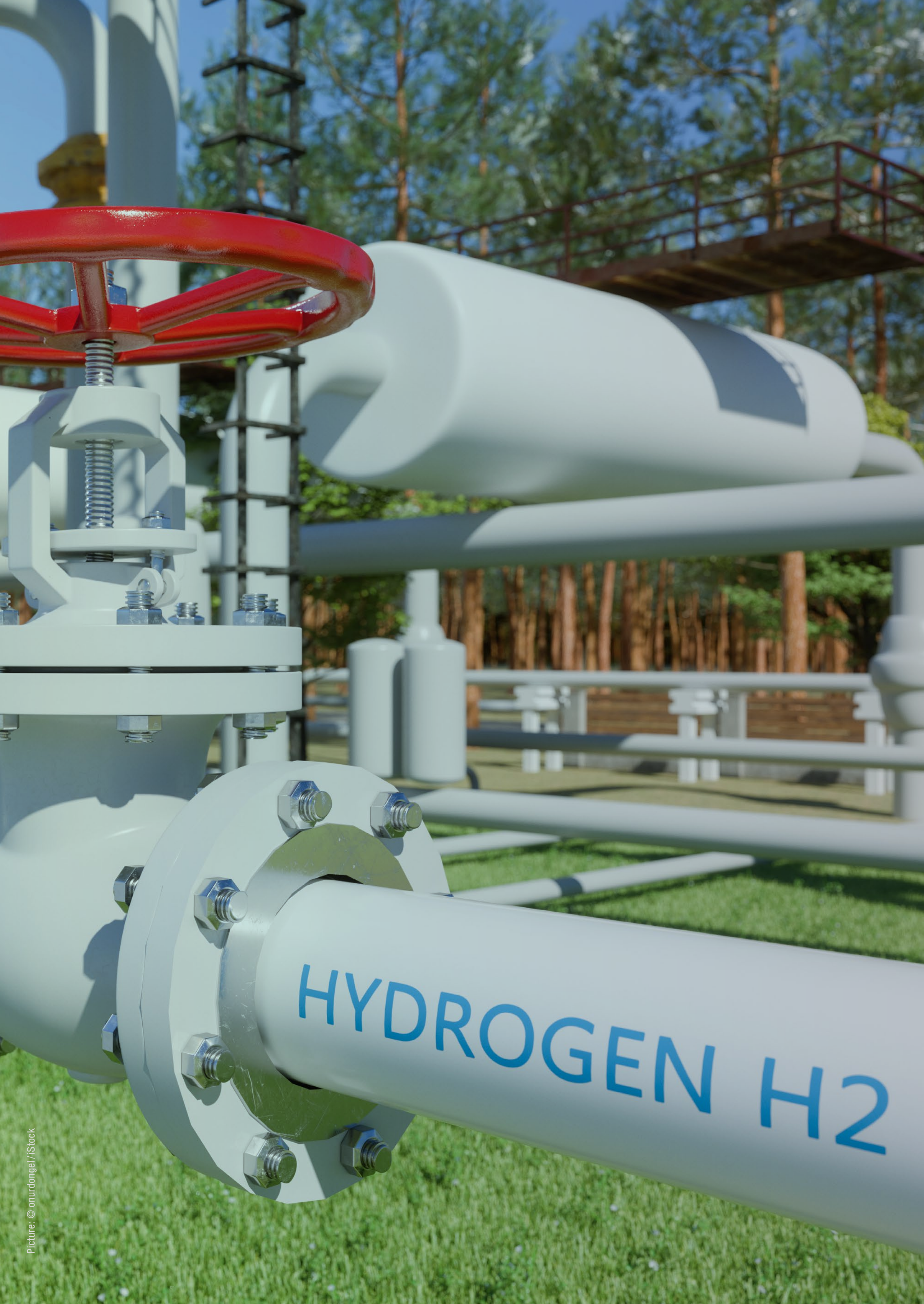
### PROJECT PARTNERS

ONTRAS Gastransport • GRTgaz Deutschland • Mitteldeutsche Netzgesellschaft Gas • ENERTRAG

### PROJECT COORDINATORS

DVGW

DBI GUT Gas- und Umwelttechnik


HYDROGEN H2

INFRASTRUCTURE

# TrafoHyVe

## Transformative pathways for distribution networks

**Completion: 12/2024**

H2-dvgw.de

### PROJECT NAME

Transformative pathways to integrate hydrogen into distribution networks

### OBJECTIVE

Development of an innovative planning methodology for efficiently retrofitting distribution networks to create a basis for the use of hydrogen

### BACKGROUND

The tolerance of existing gas infrastructures and local end-use applications to hydrogen is key to its successful use. Using an innovative planning method, this project aims to create a basis for the repurposing of distribution networks for the use of hydrogen.

### APPROACH

- Evaluation of technological, infrastructure and business economic aspects based on both the as-built status and real grid data provided by municipal and rural utilities and grid operators
- Development of a simple method to estimate the effort required to retrofit an existing network to use hydrogen
- Derivation of strategies to implement the energy transition at distribution network level and devise a safe and well-structured plan to retrofit an existing network to use hydrogen

### PROJECT PARTNERS

Stadtwerke Karlsruhe • DBI Gastechnologisches Institut • DVGW CERT • Energieversorgung Filstal • keep it green Partner der Energiewirtschaft

### PROJECT COORDINATORS

DVGW Forschungsstelle • ebi

### SPONSOR

Supported by

Federal Ministry for Economic Affairs and Climate Action

on the basis of a desicion by the German Bundestag


Picture: © mitnetz

INFRASTRUCTURE

# $H_2$Infra

## Operation of hydrogen distribution networks

**Completion: 12/2024**

### PROJECT NAME

$H_2$ infrastructure – Safe and efficient operation of hydrogen distribution networks

### OBJECTIVE

Ensuring the functionality of an $H_2$ distribution network and its components under dynamic operating conditions, especially when supplying gas of extremely high quality, as well as safe and secure supply to future end-use applications..

### BACKGROUND

The consortium that comprises DBI Gas- und Umwelttechnik, MITNETZ Gas and HTWK Leipzig continues working on the "$H_2$-Netz" and "$H_2$-Home" research projects sponsored by the Federal Ministry of Education and Research (Bundesministeriums für Bildung und Forschung, BMBF) in the framework of the incentive programme "Zwanzig20 – Partnerschaft für Innovation" that forms part of the HYPOS initiative. The unique, dedicated hydrogen distribution network research infrastructure that has been created in Bitterfeld-Wolfen as part of the projects will continue to be used and developed further to clarify many unanswered questions.

### APPROACH

- Identification of residual substances and their origins (pipe base materials, manufacturing processes) that currently impair the quality of hydrogen gas
- Examination of infrastructure components

### PROJECT PARTNERS

DBI Gas- und Umwelttechnik • Mitteldeutsche Netzgesellschaft Gas (MITNETZ Gas) • Leipzig University of Applied Sciences (HTWK)

### PROJECT LOGO

### SPONSOR

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Federal Ministry for Economic Affairs and Climate Action

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INFRASTRUCTURE

# HIGGS

## Hydrogen in gas grids

**Completion: 12/2023**

H2-
dvgw.de

### PROJECT NAME

Hydrogen in Gas Grids

### OBJECTIVE

Determination of the hydrogen tolerance of the high-pressure gas transmission network, compilation of a database of European rules, standards and certifications relating to gas / hydrogen blends of up to 100% hydrogen by volume

### BACKGROUND

The EU Directives on energy and the environment stipulate that greenhouse gas emissions must be reduced by 45 percent by 2030. Hydrogen from renewable sources can help reach these goals. The existing natural gas grid is capable of transporting hydrogen. The aim of the HIGGS project is to investigate the implications of hydrogen injection into and hydrogen transport through the natural gas grid.

### APPROACH

- Identification of technical, legal and regulatory barriers as well as remaining weaknesses of “$H_2$ readiness” in order to close knowledge gaps relating to the impact of large quantities of hydrogen on the gas infrastructure
- Testing of engineering solutions and development of strategies designed to retain components that are either not compatible with hydrogen or have a low tolerance of hydrogen (e. g. membrane separation technology, etc.)
- Preparation of harmonised European testing protocols for hydrogen compatibility certification

### PROJECT PARTNERS

Fundación para el Desarollo de las Nuevas Tecnologías del Hidrógeno en Aragón • TECNALIA • Eastern Switzerland University of Applied Sciences • European Research Institute for Gas and Energy Innovation • Redexis Gas • DVGW

### PROJECT LOGO

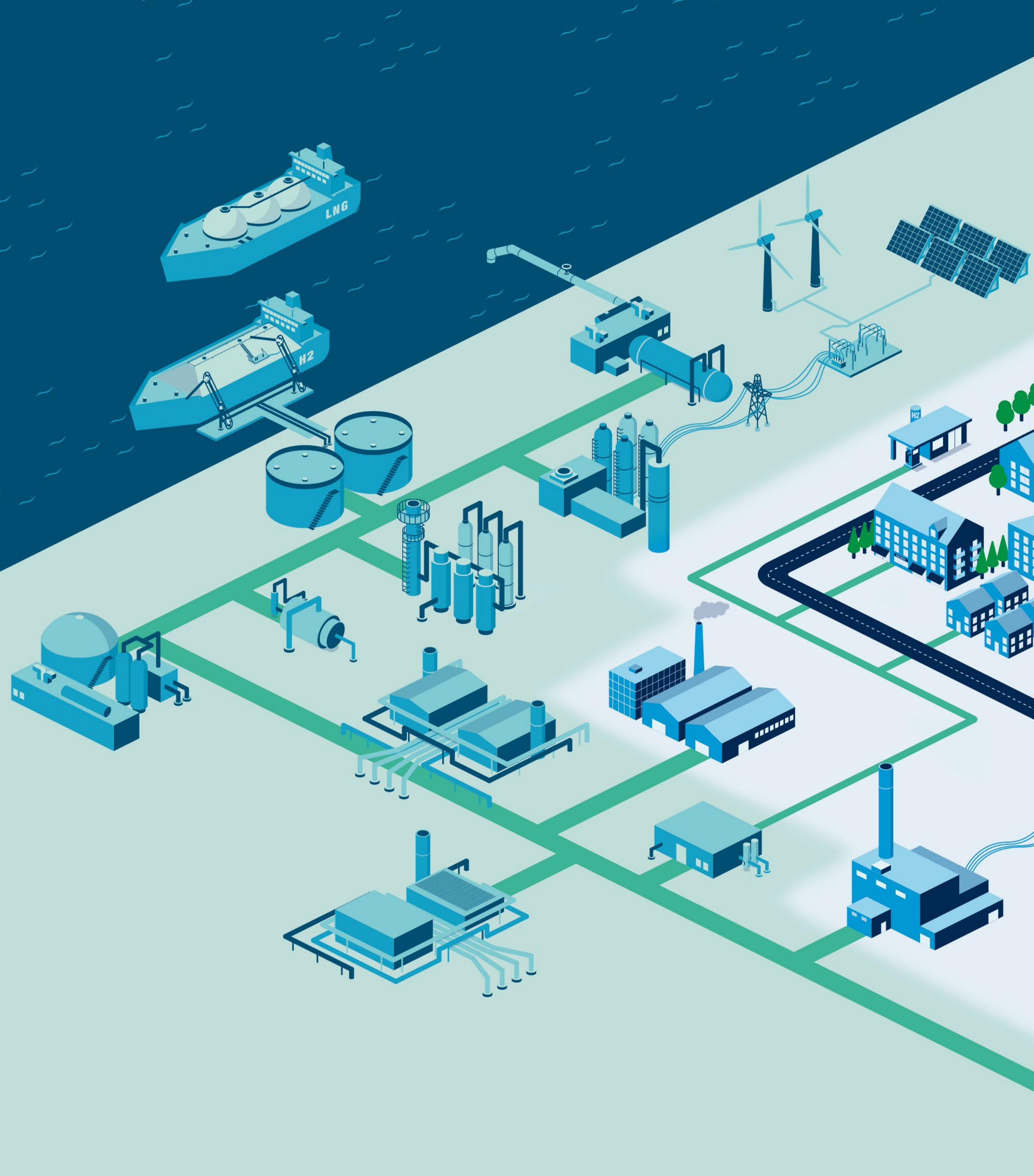
HIGGS
Hydrogen in Gas Grids

### SPONSOR

Clean Hydrogen Partnership

This project has received funding from the Fuel Cells and Hydrogen 2 Undertaking under Grant Agreement No. 875091. This Joint Undertaking receives support from the European Union’s Horizon 2020 research and innovation programme and Hydrogen Europe and Hydrogen Europe Research.

# End-use applications



# Hydrogen, an all-rounder

Hydrogen is the all-rounder among energy carriers, not least thanks to its versatility across all sectors. Hydrogen that is blended with natural gas and distributed via the gas infrastructure can heat residential buildings, for example, and thus gradually reduce emissions from domestic heating systems to net zero.

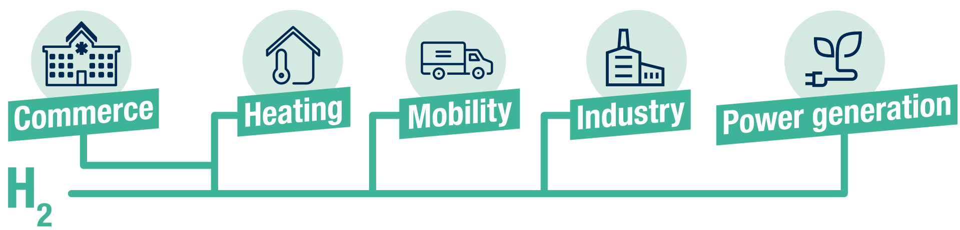
Environmentally-friendly hydrogen is also key for decarbonising numerous industrial processes, for it can be used wherever extremely high temperatures are required. However, retrofitting individual production processes to use hydrogen and decarbonising process applications that emit large amounts of $CO_2$ still requires investment in many areas.

In the transport sector, hydrogen fuel cells can power all types of road and rail vehicles, and it is also a key factor in achieving net-zero mobility in air and sea transport.

Hydrogen can be easily stored in existing gas storage facilities. If and when necessary, it can be used for electricity generation in power plants, or for decentralised power generation in fuel cells, thus supplying electricity without the need to resort to fossil energy carriers when only small amounts of solar or wind power are available.

**The existing gas infrastructure can be used to supply hydrogen to most industrial and commercial energy consumers as well as to the heating and power generation sectors.**

The DVGW research projects cover all fields of application and the associated requirements on gas quality in the context of the transition to hydrogen. Among other things, they study the tolerance of domestic end-use appliances and industrial applications to $H_2$ and assess the construction of an $H_2$ infrastructure for the logistics sector.



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Magdeburg
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Beelitz
Dessau-Roßlau

# H2-20

## Field test involving the injection of a 20% hydrogen gas mix into the distribution grid

**Completion: 07/2023**

H2-
dvgw.de

### PROJECT NAME

Hydrogen in the gas infrastructure: The DVGW/Avacon pilot project – injecting up to 20% hydrogen by volume into the natural gas grid

### OBJECTIVE

Demonstration of the injection of up to 20% hydrogen by volume into an existing network supplying approximately 400 domestic and commercial customers and derivation of recommendations for action

### BACKGROUND AND PURPOSE

Laboratory studies have shown that domestic gas appliances can safely run on a blend of up to 20% hydrogen by volume. This project intends to test and validate these findings under real-life conditions by conducting field trials on a gas distribution network. The results are intended to form the basis for the future use of hydrogen in gas networks and to be incorporated into the DVGW Set of Rules.

### APPROACH AND RESULTS

- Collection of system and installation data, including maintenance and adjustment requirements, in the relevant network area
- Field trials of the functioning and safe operation of gas appliances
- Incremental injection of up to 20% hydrogen by volume into a part of the Avacon network in the Jerichower Land in Saxony-Anhalt during two heating seasons, i. e. in 2021/22 and 2022/23

### PROJECT COORDINATOR

DVGW Forschungsstelle ebi

### PROJECT PARTNER & CO-SPONSOR

avacon

### RESEARCH PARTNER

gwi Gas- und Wärme-Institut Essen e.V.

Picture: © Roland Horn / DVGW

# $H_2$ tightness of installed valves and fittings

**Completion: 06/2023**

## PROJECT NAME

Leak rate detection and hydrogen tightness of installed valves/fittings and sealing systems

## OBJECTIVE

Investigation of the application options and limits of shut-off valves in terms of $H_2$ tightness, and extension of the Set of Rules

## APPROACH

- Detection of direct leak rates and long-term hydrogen tightness testing of valves and fittings
- Leak testing of glands and spindle seals
- Identification of possible interactions with hydrogen

## RESEARCH INSTITUTES

DVGW DBI GUT Gas- und Umwelttechnik

gwi Gas- und Wärme-Institut Essen e.V.

# $H_2$, valves and fittings

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**BACKGROUND**

The gas network can transport and distribute hydrogen, either as a blend with natural gas (up to 20% of hydrogen by volume in a first step) or as pure hydrogen. What is necessary now is a more detailed description of technical framework conditions; in other words, the DVGW Set of Rules needs to be amended to ensure the safe introduction of hydrogen. The safe handling of this gas is another big challenge, as the specific physical properties of hydrogen and their impact on the strength and hardiness of the materials used in existing gas infrastructure systems, most notably valves and fittings, play an especially important role.

## Shut-off valves

**Completion: 02/2023**

**PROJECT NAME**

Study of the long-term behaviour of the surface coatings, the ball valve coatings and the spring packages of shut-off valves in a hydrogen atmosphere

**OBJECTIVE**

Monitoring the long-term behaviour of surface coatings and spring energised seals for conformance with the tightness specifications for ball valves

**APPROACH**

- Study of the long-term behaviour of the surface coatings of ball valve coatings in response to cyclical pressure changes and of the service life of statically loaded seat ring package springs of ball valves in response to a cyclical load on the spring

**RESEARCH INSTITUTES**

DVGW | DBI GUT Gas- und Umwelttechnik

## Installed valves and fittings

**Completion: 11/2023**

**PROJECT NAME**

Study of the hydrogen tolerance of installed valves and fittings

**OBJECTIVE**

Creation of a basis for the qualification of installed valves and fittings for hydrogen transport

**APPROACH**

- Fracture-mechanical calculations based on existing and/or postulated defects with the intention being to prevent the failure of installed valves and fittings
- Finite-element simulations on and elastic stress analyses of representative valve designs

**PROJECT COORDINATOR**

DNV – Germanischer Lloyd Industrial Services GmbH

**RESEARCH INSTITUTE**

Fraunhofer Institute for Mechanics of Materials IWM


# $H_2$ Fronten

**Completion: 12/2022**

## OBJECTIVE

Suitability analysis and further development of existing substitute processes for the determination of the calorific value of hydrogen-containing gas blends as a basis for correct gas billing

## APPROACH

- Suitability analysis of calorific value allocation processes and quantitative balancing and determination of their application limits in different predicted feed-in scenarios
- Establishing contact with software and hardware engineers as well as manufacturers and grid operators to advance the further development of processes and technologies in theory and practice

## PROJECT PARTNER

Munich University of Applied Sciences

## PROJECT COORDINATOR

PTB
Physikalisch-Technische Bundesanstalt
Braunschweig und Berlin

# Measurement techniques and measurement accuracy

H2-dvgw.de

**BACKGROUND**

Hydrogen and natural gas have different thermophysical properties in terms of density and calorific value. In view of the fact that not enough measurement and test results are available for established meter technologies in conjunction with mixed gases, the DVGW has commissioned the National Metrology Institute of Germany (Physikalisch-Technische Bundesanstalt, PTB) to research different aspects of measurement technology and measurement accuracy and to study how to determine calorific values and ensure correct gas billing.

## Domestic gas meters

**Completed**

**OBJECTIVE**

Determination of the measurement errors of diaphragm gas meters in combination with the registration of the nominal output pressure of domestic pressure regulators

**APPROACH**

- Measurements with nitrogen and hydrogen and tests involving methane
- Determination of the pressure stability of domestic pressure regulators at different flow rates and with different types of gas

## Low pressure range

**Completion: 07/2024**

**OBJECTIVE**

Determination and alignment of the adjustments and error limits of mechanical gas meters during testing with air and operation with gases containing $H_2$

**APPROACH**

- Comparison of measurements of different gas meters with air, natural gas/hydrogen blends and pure hydrogen
- Development of a testing technique and procedure for measurements in the low pressure range

## Commercial and industrial meters

**Completion: 02/2024**

**OBJECTIVE**

Evaluation of the measurement accuracy and measurement stability of gas meters for commercial and light industrial applications in networks carrying hydrogen

**APPROACH**

- Verification of different measurement techniques involving orifice-measurement technology
- Evaluation of measurement and calibration results, taking into account thermodynamic factors

Picture: © RuslanDashinsky_KOM | iStock

# Transitioning to $H_2$ and CHP heating systems

**PROJECT NAME**

A sustainable heating transition based on decentralised CHP (combined heat and power) and environmentally-friendly gases

**APPROACH**

- Simulation of the combined operation of decentralised combined heat and power (CHP) plants and heat pumps in a typical German neighbourhood

**RESULTS**

The combined operation of decentralised combined heat and power (CHP) plants and heat pumps could significantly reduce demand for power in the neighbourhood, which could even become self-sufficient if large thermal storage capacities such as e. g. relief holders are provided. This would guarantee a sustainable power supply and relieve the power grid at all levels.

**RESEARCH INSTITUTE**

RWTH Aachen – Institute for High Voltage Equipment and Grids, Digitalization and Energy Economics

# A sustainable heating sector

Completed

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**OBJECTIVE**

Study of the contribution of hydrogen to a net-zero building sector and calculation of the extent to which a combination of decentralised combined heat and power (CHP) and net-zero gases can stabilise the power grid

**BACKGROUND**

Germany wants to become net zero by 2045. The heating market plays a major role in reaching this goal thanks to its sheer size. Renovating buildings and using renewable energies and power-based technologies alone are not sufficient to achieve sustainability, however – the use of environmentally-friendly gases is also necessary.

## Towards a sustainable heating transition

**PROJECT NAME**

Resilient strategies for a sustainable heating transition based on environmentally-friendly gases

**APPROACH**

- Analysis of the impact of electrified heating on the power grid
- Calculation of the seasonal and geographical performance gap in terms of renewable electricity potential and demand

**RESULTS**

Almost 23 million households are heated by mains gas and district heating, but only 5% are heated by electricity. What is more, gas demand during the winter is almost three times as high as during the summer. Geographical differences – a high potential for renewable electricity in the north and a high demand for energy in the south – further complicate the situation.

**RESEARCH INSTITUTE**

frontier economics

END-USE APPLICATIONS

# THyGA

## Hydrogen blending in natural gas applications

**Completion: 12/2022**

H2-dvgw.de

### PROJECT NAME

Testing Hydrogen Admixtures for Gas Applications

### OBJECTIVE

Pan-European acceptance of hydrogen/natural gas blends and identification of the technical impact of hydrogen admixtures on gas applications in the building sector

### BACKGROUND

Hydrogen and hydrogen blends can be used as an alternative to natural gas for heating buildings when fed through the existing infrastructure. THyGA aims to obtain and impart detailed information about the impact of natural gas and hydrogen blends on end uses, in particular in the domestic and commercial realms.

### APPROACH AND RESULTS

- Test scenarios involving about 100 domestic gas appliances running on hydrogen at different concentrations
- Development of a general-purpose testing protocol for gas appliances to certify their "$H_2$ readiness"
- Preparation of recommendations for action aimed at appliance manufacturers, end users and decision-makers regarding the design, production and certification of appliances

### PROJECT PARTNERS

ENGIE SA (project coordinator) • BDR Thermea Group • Commissariat à l'Energie Atomique et aux Energies Renouvelables • Dansk Gasteknisk Center • GERG – The European Gas Research Group • Electrolux AB • GAS.BE • DVGW Research Center at Engler-Bunte-Institut of KIT • Gas- und Wärme-Institut Essen

### PROJECT LOGO

THyGA

### SPONSOR

Clean Hydrogen Partnership

This project has received funding from the Fuel Cells and Hydrogen 2 Undertaking under Grant Agreement No. 875091. This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme and Hydrogen Europe and Hydrogen Europe Research.


Picture: © Gerd / AdobeStock

# LivingH2

## Demonstration of a hydrogen / fuel cell CHP

**Completion: 03/2023**

H2-dvgw.de

### PROJECT NAME

Living Laboratory Demonstration of Complete Pure Hydrogen Fuel Cell Cogeneration System

### OBJECTIVE

Demonstration of a complete solution based on power supply made from renewable sources in a living laboratory using a hydrogen fuel cell CHP ($H_2$ FC CHP).

### BACKGROUND

Fuel cell cogeneration systems running on green hydrogen could gradually replace existing conventional cogeneration systems and supply buildings with carbon-free energy. The project focuses on the technological development of such fuel cell CHPs.

### APPROACH

- Optimisation of fuel cell CHPs for pure hydrogen operation through technological innovation
- Installation and testing of a complete, pipeline-based hydrogen supply system in a typical domestic environment, i. e. a "living lab", including the production of hydrogen from renewable sources, the pipework installation in a building, odorisation and a fuel cell CHP
- Evaluation of the technological, economic, ecological and social potential of this technical solution

### PROJECT PARTNERS

inhouse engineering (project coordinator) • ENGIE (project coordinator) • Commissariat à l'Énergie Atomique et aux Énergies Renouvelables • DBI Gastechnologisches Institut • Ostbayerische Technische Hochschule Regensburg • European Research Institute for Gas and Energy Innovation

### PROJECT LOGO

### SPONSOR

Sponsored by

Federal Ministry of Education and Research

Funding reference number: 03SF0587B

# GreCoCon – Green Combustion Control

**PROJECT NAME**

Combustion control of high volatile amounts of hydrogen for industrial applications, based on flame signals

**APPROACH**

- Studies of changes in the radiation properties of flames and flame geometries due to increasing, fluctuating and high hydrogen concentrations in natural gas
- Development of models for the adaptive control of the gas / air mixture to compensate fluctuations in fuel gas and oxidiser composition

**PROJECT PARTNERS**

DBI Gastechnologisches Institut (project coordinator) • Gas- und Wärme-Institut Essen • Universität Duisburg-Essen

**SPONSOR**

Sponsored by

Federal Ministry of Education and Research

Based on a resolution of the German Bundestag

# TTgoesH2

## Hydrogen in thermal engineering

**Completion: 06/2023**

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### PROJECT NAME

Integration of hydrogen as a net-zero energy carrier into industrial and commercial thermal engineering applications

### OBJECTIVE

Elaboration and validation of concepts and recommendations designed to ensure the safe and economical operation of thermal engineering plants with hydrogen in the fuel gas.

### BACKGROUND

Germany intends to inject more hydrogen from renewable sources into the gas transmission networks as part of the energy transition. A higher hydrogen content in the grid affects the gas quality, however. This presents particular challenges to the thermal engineering industry, which mainly uses gaseous fuels.

# ULoBurn – Ultra Low Emission Burners

### PROJECT NAME

Development of ultra-low emission burners for thermal engineering plants using hydrogen

### APPROACH

- Development of concepts for burners that guarantee a low emission of pollutants when burning fuel of varying quality and pure hydrogen

### PROJECT PARTNERS

TU Bergakademie Freiberg (project coordinator) • RWTH Aachen • DBI Gastechnologisches Institut

### SPONSOR

Supported by

Federal Ministry
for Economic Affairs
and Climate Action

on the basis of a desicion by the German Bundestag

# $H_2$net&Logistics

**Completion: 06/2023**

## PROJECT NAME

Use of gas pipelines for the supply of heavy-duty trucks and trains with hydrogen through an optimally designed pipeline network for filling stations

## OBJECTIVE

Evaluating the technical options and economic and ecological potentials of a supply of filling stations with renewable hydrogen for heavy vehicles based on the gas network, heavy vehicles on the road and, in addition, on railways and in inland ports

## APPROACH

- Study of the ramp-up over time of the vehicles and the infrastructure
- Assessment of flexible supply concepts for filling stations as an interim solution for pipeline-bound supply
- Identification of sites for $H_2$ filling stations depending on logistics demand and the pipeline-bound supply of hydrogen

## PROJECT PARTNER

KNT Consult

## CO-COMMISSIONED BY

Research Association for Combustion Engines (FVV)

## DVGW RESEARCH INSTITUTES

DVGW DBI GUT Gas- und Umwelttechnik | DVGW Forschungsstelle ebi | gwi Gas- und Wärme-Institut Essen e.V.

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## $H_2$Net&Engines

**Completed**

### PROJECT NAME

$H_2$ in the gas network and interaction with gas engines

### OBJECTIVE

Determination of the hydrogen tolerance of conventional gas engines and research into technological retrofit

### APPROACH

- Determination of the hydrogen tolerance of gas engines in passenger cars and cogeneration plants
- Research into the possibility of building "multi fuel" filling stations and technologies for separating hydrogen from gas mixtures
- Determination of the most practical and, at the same time, most cost-effective solution

### RESULTS

- Macro-economic studies have found that higher hydrogen concentrations in the gas grid entail higher retrofitting costs for vehicles and gas engines.
- The methanation of hydrogen or the membrane separation of multicomponent gas mixtures suggest themselves as alternatives. These, however, entail higher ancillary costs for the gas infrastructure.

### PROJECT PARTNERS

KIT Institute for Thermal Energy Technology and Safety (ITES) • Institute of Solid Mechanics (IFKM) • Frontier Economics

### CO-COMMISSIONED BY

Research Association for Combustion Engines (FVV)

### DVGW RESEARCH INSTITUTES

DVGW DBI GTI Gastechnologisches Institut

DVGW Forschungsstelle ebi

## HyGlass

**Completed**

### PROJECT NAME

Use of hydrogen in the glass industry – An option to reduce $CO_2$ emissions and utilise renewable gases

### OBJECTIVE

Investigation of the impact of different hydrogen concentrations, up to 100 %, on the various firing schedules within the glass production chain and on product quality, service life and mode of plant operation

### APPROACH

- Characterisation of the glass production process steps and outlining of options
- GIS analyses and grid studies of different $H_2$ blending scenarios
- Characterisation of the burning behaviour after blending with $H_2$ and presentation of $CO_2$ savings
- Application of findings to the real world by means of CFD simulation and demonstration of implementation in a semi-industrial test plant

### RESULTS

- Almost all industrial applications allow up to 20% hydrogen.
- Higher concentrations or pure hydrogen may entail changes in the fuel properties which, however, are controllable by suitable technical precautions.
- More research is required into the implications for product quality, refractories, compensation strategies, etc.

### PROJECT PARTNER

Federal Association of the German Glass Industry (BV Glas)

### LEAD MANAGEMENT

gwi Gas- und Wärme-Institut Essen e.V.

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# $H_2$ in the glass industry

**BACKGROUND**

The glass industry is extremely energy-intensive, which is mainly due to the high heat requirement during processes such as glass melting. Currently, more than 70% of the energy is supplied by fossil fuels such as, for instance, natural gas, which release $CO_2$ emissions during the melting process of raw materials. Green hydrogen could help reduce the amount of emissions from harmful pollutants. The impact of hydrogen on the glass melting process, the product quality and the emission of pollutants requires further investigation.

## COSIMa

**Completion: 12/2025**

**PROJECT NAME**

Carbon-neutral industrial site of Saint-Gobain at Herzogenrath – Feasibility studies

**OBJECTIVE**

Reaching carbon neutrality by 2030 by retrofitting natural gas/air-fired furnaces for the production of float (sheet) glass production and the further processing of float glass for the automotive industry to run on hydrogen / oxygen with the maximum technically feasible auxiliary electric booster heater at the Herzogenrath site of Saint-Gobain

**APPROACH**

- F asibility study for the transition of conventional glass production to hydrogen and auxiliary electric booster heater (hybrid furnace)
- Energetic modelling of all energy and material flows using smart infrastructure
- Determination of the energetic optimisation potential of the production process

**PROJECT PARTNERS**

Saint-Gobain Sekurit Deutschland (consortium management) • RWTH Aachen – Institutes for Industrial Furnaces and Heat Engineering and for Power Generation and Storage Systems

**PROJECT PARTNERS OF THE DVGW GROUP**

gwi Gas- und Wärme-Institut Essen e.V.

**SPONSOR**

Ministerium für Wirtschaft, Innovation, Digitalisierung und Energie des Landes Nordrhein-Westfalen


320 M.T.

# OptiLBO
## Carbon-neutral steel production

Completion: 01/2025

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### PROJECT NAME
Energy-efficient, carbon-neutral steel production in an electric arc furnace using additive manufacturing processes and smart controls

### OBJECTIVE
Increasing the energy efficiency of an electric arc furnace (EAF) for melting scrap steel by reducing the use of natural gas and substituting natural gas with hydrogen in the process.

### BACKGROUND
Although electric energy is the main source of energy for steel produced by the secondary steel route, fossil carbon-based fuels are additionally used to optimise the melting process. The total $CO_2$ emitted by the process can be significantly reduced by the direct reduction of natural gas and oxygen that are used in the process. This is achieved by a flexible, innovative furnace system and more efficient process control. The newly developed, additively manufactured furnace system can also be progressively fired with $H_2$.

### APPROACH
- Optimisation of the energy efficiency of the arc furnace at the Bous steel mill
- Pollutant reduction through a novel, additively manufactured mixer in the furnace
- Development of AI-based, optimised furnace control
- Possibility to substitute natural gas with hydrogen in the process
- Analysis of the substitution of PCI coal with environmentally-friendly alternatives in the metallurgical process

### PROJECT PARTNERS
Küttner Automation • Kueppers Solutions • Stahlwerk Bou GMH Gruppe

### LEAD MANAGEMENT
gwi Gas- und Wärme-Institut Essen e.V.

### SPONSOR
Supported by

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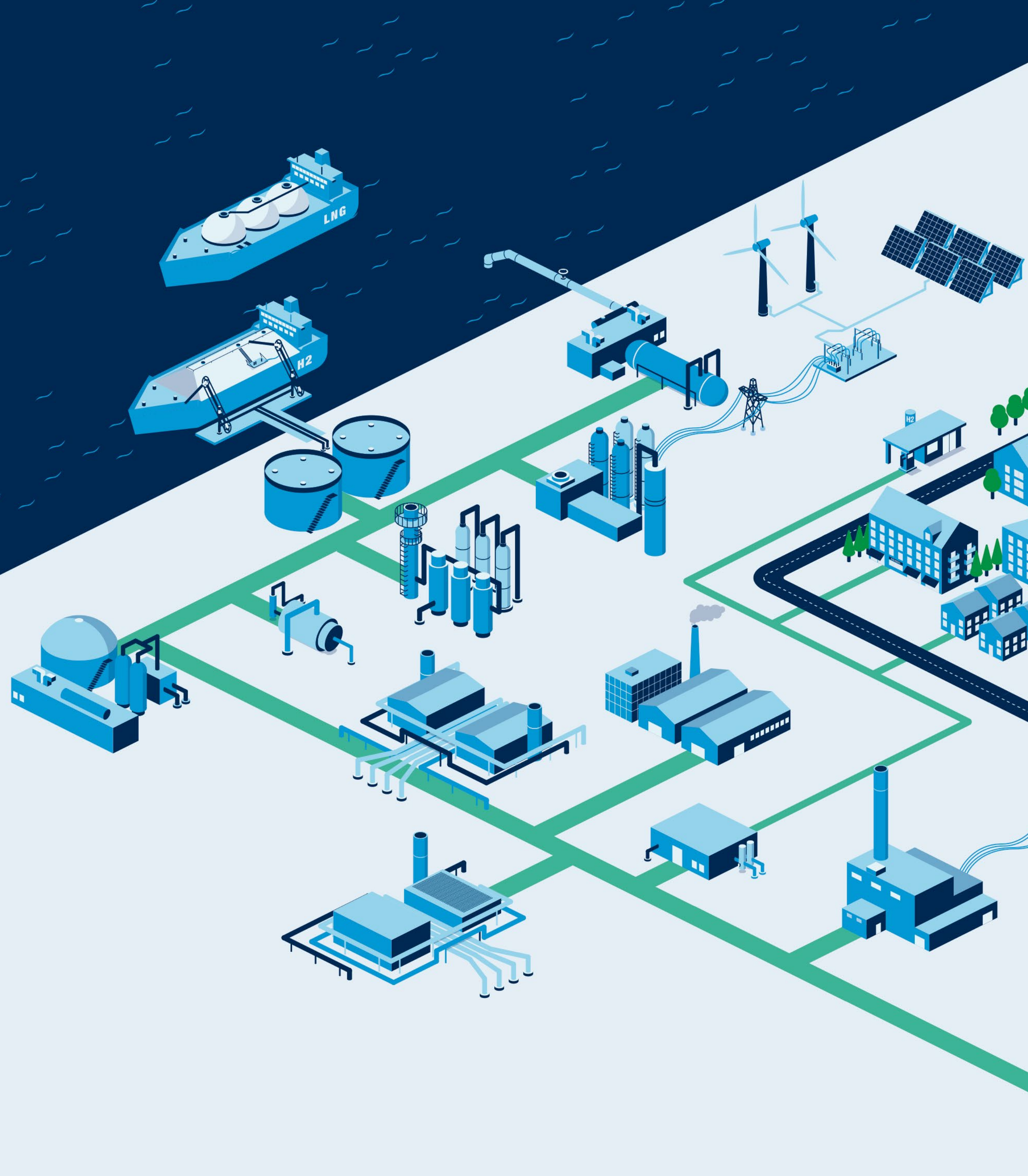
# Energy system



# Electrons and molecules – A powerful team that enables the energy transition

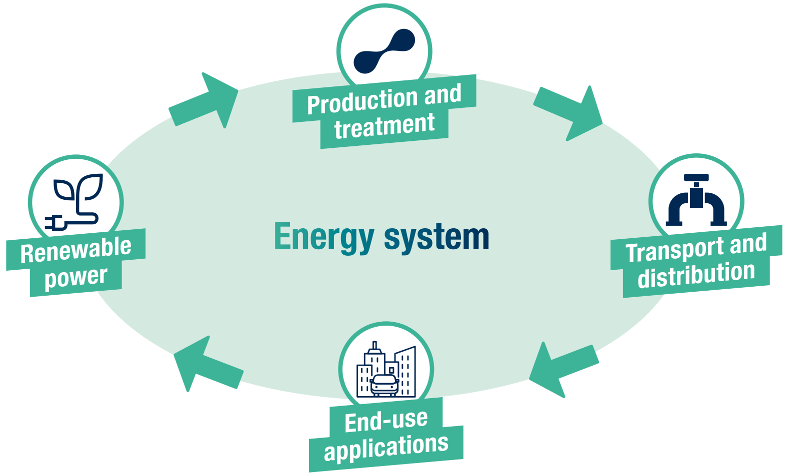
The energy transition necessitates the further development of wind power and solar photovoltaics. Renewable energies produce clean electricity; however, yield fluctuations through changing weather can significantly impact production. Another important point to consider is the fact that while it is true that in 2021, slightly more than 40% of the power generated in Germany came from renewable sources, electric energy meets only one quarter of the total annual demand of approximately 1,000 Terawatt hours, with another quarter of the demand currently being met by natural gas. The energy system will therefore continue to depend on gaseous energy carriers, for reasons of both supply security and climate protection.

Synergies can be used efficiently through coupling the three sectors of power, heating and transport. The ultimate goal is to use energy at the right place and at the right time, and to compensate fluctuations in renewable power.

**The successful implementation of the energy transition towards net zero is based on the combination of electrons and molecules.**

A true understanding of the significance of hydrogen for future energy systems requires taking a look at the entire value chain – from production and transport to distribution through to end-use applications. In this context, it is important not to focus on individual energy carriers alone, but to consider the energy system as a whole, for there are no clearly defined boundaries between electrons, i. e., electric current, and molecules in liquid or gaseous energy carriers.

This is precisely what the DVGW and its network demonstrate with their integrated research projects, where researchers collaborate to design solutions and concepts for the transition to a future net zero energy system.




## FIRST RESULTS

### Supply

- Tapping domestic potential and setting up an import scheme will provide sufficient quantities of environmentally-friendly gases as early as in 2030.

### Infrastructure

- The German gas infrastructure can be enabled and extended for the future transport of hydrogen at reasonable cost.

### End-use applications

- Current household appliances run on a 20% hydrogen blend – or higher – even now, and numerous compensation options exist for industrial and commercial end-use applications.

### Vision for the future

- Even a scenario that envisages electric current as the main energy supply will require gaseous energy carriers to guarantee a safe and reliable energy supply.

## PROJECT COORDINATORS

DVGW Forschungsstelle | ebi

## RESEARCH INSTITUTES

DVGW | DBI GUT Gas- und Umwelttechnik | gwi Gas- und Wärme-Institut Essen e.V.

Fraunhofer ISI

Picture: © OGE

ENERGY SYSTEM

# Roadmap Gas 2050

## Towards net-zero gas supply

**Completion: 10/2022**

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### PROJECT NAME

Development of a roadmap for the implementation of the DVGW Energy Impulse by 2050

### OBJECTIVE

Development of a holistic concept, based on facts and figures, for the provision of net zero gases, their integration into the existing gas infrastructure, and the repurposing of gas-using technologies

### BACKGROUND

Studies conducted within the DVGW research projects show that gas-based concepts make sense and can be implemented as part of the future energy system. The Roadmap Gas 2050 aims to develop a holistic concept by interconnecting the benefits – identified by previous studies – of using the gas infrastructure and gas applications, and by providing a quantitative description of the possible synergy effects.

### APPROACHES PURSUED BY THE PARTICIPATING PROJECTS

#### Supply

- Determination of future demand and production potentials for renewable gases
- Analysis of $H_2$ production methods, supply pathways and logistics chains

#### End-use applications

- Determination of the optimal hydrogen / natural gas blend and systematic testing of gas appliances
- Determination of the retrofit needed to run on different $H_2$ concentrations

#### Infrastructure

- Identification of preferred regions for the implementation of distribution networks for renewable gases
- Modelling of options for retrofitting the existing gas infrastructure, including gas applications, to integrate hydrogen and gas blends

#### Vision for the future

- Appraisal of the future role of gas on the basis of holistic energy system models
- Development and modelling of scenarios focussing on electric current, renewable methane and hydrogen


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# TransNetz
## Repurposing distribution networks

Completion: 08/2023

H2-dvgw.de

### PROJECT NAME
Development of robust transformative pathways for the implementation of climate goals at distribution network level – Phase I

### OBJECTIVE
- Realistic outline of a transition scenario for energy distribution networks in a technologically open policy setting
- Appraisal of the future roles of gaseous energy carriers and gas distribution networks
- Development of sustainable concepts for a future energy supply

### BACKGROUND
Gas distribution networks are indispensable for a successful energy transition, for the majority of users rely on the gas infrastructure for their energy supply. The speed and effort required for retrofitting energy infrastructures and end-use applications to match the new framework conditions is crucial in this context. Important aspects include supply security considerations as well as public acceptance and an affordable, environmentally-friendly transition of the energy supply system.

### APPROACH
- Update of existing analyses of the production and supply of environmentally-friendly gases produced in Germany, Europe and outside of Europe
- Evaluation of concepts for central and decentral production, and development of scenarios for the market ramp-up of environmentally-friendly gases
- Ascertainment and comparison of changes caused by switching from methane to hydrogen – including the power and heating sectors – and of the impact on gas distribution networks

### PROJECT PARTNER
University of Wuppertal

### RESEARCH INSTITUTES OF THE DVGW GROUP
DVGW DBI GUT Gas- und Umwelttechnik | DVGW Forschungsstelle ebi | gwi Gas- und Wärme-Institut Essen e.V.


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# Bad Lauchstädt Energy Park

Completion: 08/2026

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## PROJECT NAME

'Living labs' for energy transition – Sector coupling and hydrogen technologies: Bad Lauchstädt Energy Park

## OBJECTIVE

Production, transport, storage (in a salt cavern) and commercial use of green hydrogen on an industrial scale to decarbonise the chemical industry in the central German "chemistry triangle".

## BACKGROUND

Green hydrogen plays a key role in the successful implementation of the energy transition, for it can be produced in environmentally-friendly ways and is easy to store. Green hydrogen can counterbalance fluctuations in power from solar PV and wind, caused by changing weather, and thus enable the efficient coupling of sectors. The Federal Ministry of Economy (Bundeswirtschaftsministerium) is currently investigating the use of green hydrogen across the entire value chain in "Living Labs for Energy Transition", developing and testing technical and non-technical ideas and innovations under real-life conditions and on an industrial scale.

## APPROACH

- Construction of a large-scale electrolysis plant with a capacity of up to 35 MW of green $H_2$ production from renewable power from a nearby wind farm
- Further development and testing of $H_2$ production, $H_2$ transport and essential storage components

## PROJECT PARTNERS

Terrawatt Planungsgesellschaft • Uniper • VNG Gasspeicher • ONTRAS Gastransport • DBI Gastechnologisches Institut

## PROJECT LOGO

ENERGIEPARK BAD LAUCHSTÄDT

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# HyBEST – EnEff:Stadt

**Completion: 11/2024**

## PROJECT NAME

Innovative hydrogen concepts in existing clusters

## OBJECTIVE

Development and implementation of concepts for a hydrogen-based energy supply to existing industrial estates in the cities of Gifhorn, Herten and Karlsruhe

## BACKGROUND

Optimal use of renewable energies requires a smart energy concept based on e. g. hydrogen and enough storage capacity. For this reason, endeavours are made to establish integrated energy supply concepts at neighbourhood level that combine the direct use of renewable power with green hydrogen.

## APPROACH

- Study of different concepts for a hydrogen-based energy supply at three sites: Gewerbecluster (industrial cluster) Gifhorn, Technikum Herten and Gewerbecluster (industrial cluster) Karlsruhe (port area)
- Modelling of the plant to study options for energy management control optimisation
- Technical, economic and ecological analyses to investigate additional options for use (e. g., $H_2$ mobility, etc.) in the adjacent region
- Development of a blueprint based on these findings to motivate other players to endorse net zero energy supply

## PROJECT PARTNERS

DVGW Research Center at Engler-Bunte-Institut of KIT • Stadtwerke Karlsruhe • Gas- und Wärme-Institut Essen • Landkreis Gifhorn • HYCON

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# Model regions and innovative $H_2$ concepts

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## RegioTrans$H_2O$

Completion: 12/2024

### PROJECT NAME
Regional zero GHG strategies illustrated by the Oberschwaben model region

### OBJECTIVE
Study of a technology-based transition from a fossil to a net-zero energy system for the regional distribution of power, gas and heat, including the preparation of implementable business models for enterprises

### BACKGROUND
The use of hydrogen here and there can inspire and incentivise value creation in a region, for the coupling of different renewable energies enables the integration of efficiency and synergy measures which, in turn, pave the way for the successful implementation of the energy transition and attaining net zero. It is indispensable, however, to take into account – as this project does – local conditions, infrastructures and user behaviour / user wishes in order to reach these goals.

### APPROACH
- Development of a regional energy system based on the general technical conditions and stakeholder requests
- Ongoing use and development of existing infrastructures and regional integration and / or use of biogas and hydrogen
- Identification of options for the creation of local synergies, sector coupling and realistic business models, and development of transition strategies for utilities and energy providers

### PROJECT PARTNERS
Erdgas Südwest • EnBW • Netze BW

### PROJECT COORDINATOR
DVGW Forschungsstelle ebi

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ENERGY SYSTEM

# SuperP2G

## Integrating European power-to-gas initiatives

**Completion: 10/2022**

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### PROJECT NAME

Synergies utilising renewable power regionally by means of power to gas

### OBJECTIVE

Lowering the entry threshold for parties interested in using power-to-gas for smart energy systems, local and regional developments and sector integration

### BACKGROUND

The increasing use of renewable energies requires sector coupling with storage options such as power-to-gas. The SuperP2G project aims to develop internationally applicable evaluation tools and to indicate potential fields of application or case examples in Europe, integrating leading power-to-gas initiatives from five European countries for this purpose.

### APPROACH

- Integration of leading national projects and regions with interested parties within the EU in order to create synergies for developing evaluation tools and methods
- Identification of the potential in each of the participating countries and elaboration of a joint European conclusion on market conditions and stakeholders' needs

### PROJECT PARTNERS

Technical University of Denmark (project coordinator) • Energifonden Skive – GreenLab • National Research Council of Italy, CNR-ITAE • University of Bologna, Department of Industrial Engineering • University of Groningen, Faculty of Economics and Business • Energy Institute at the Johannes Kepler University Linz • DBI Gastechnologisches Institut • DVGW Research Center at Engler-Bunte-Institut of KIT • European Research Institute for Gas and Energy Innovation

### PROJECT LOGO

SUPER P2G

### SPONSOR

Smart Energy Systems ERA-Net

This project has received funding in the framework of the joint programming initiative ERA-Net Smart Energy Systems' focus initiative Integrated, Regional Energy Systems, with support from the European Union's Horizon 2020 research and innovation programme under grant agreement No 775970.

# The DVGW

## Provider of Innovation and Regulator for the Gas and Water Sectors

The German Technical and Scientific Association for Gas and Water (Deutscher Verein des Gas- und Wasserfaches e. V., DVGW) is a state-recognised regulator, provider of technical and scientific knowledge and promoter of technical innovations. In other words, the DVGW doubles as a network of excellence connecting all expertise relating to the supply of gas and drinking water. The DVGW inspires and supports the gas and water sectors in all technical and scientific matters.
The core focus of its work is on safety and hygiene, environmental and consumer protection and on preparing the technical rules that enable the German gas and water industry to self-manage all technical issues, ensuring the safe and secure supply of gas and water in line with the strictest international standards.

Research activities form another important part of the DVGW's work as they provide the basis for technical innovations. The DVGW promotes not only research projects pursued by different research institutes but also conducts its own research activities.

The Association was founded in 1859 and has approximately 14,000 members. Being a not-for-profit organisation, the DVGW is economically independent and without political bias. At the local level the DVGW is represented by district groups, whereas at the federal Land level regional groups act as the first point of contact for members. Matters of pan-German or European interest are dealt with at the Bonn Headquarters and the DVGW offices in Berlin and Brussels.

# The DVGW – Research and Development

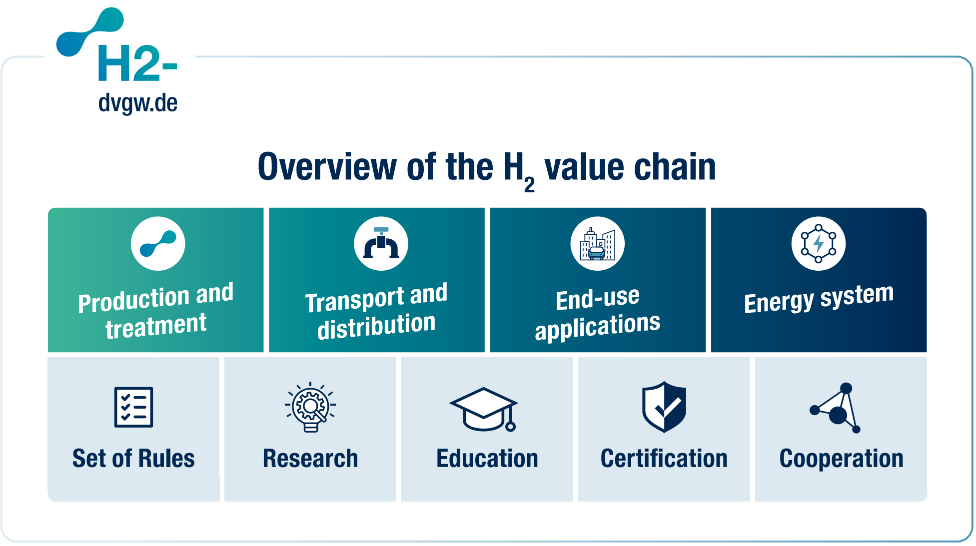
The German energy and water industries are constantly facing new challenges. The energy transition, in particular, necessitates the development of pioneering and sustainable concepts for gas as an energy source while staying focused on climate and environmental goals as well as on system, economic and technical safety aspects.

The DVGW's research activities span from regional and national studies to European research cooperations. They provide a basis for ongoing technical development in the gas industry, inspire regulation and standardisation processes and ensure the high quality of the DVGW's scientific expertise.

Based on a decentralised organisational structure, DVGW research activities into energy are conducted by five institutes that bring together scientific know-how and university partnerships and the hands-on experience of the gas industry. The individual institutes' competences complement each other and have developed into an extensive network that covers everything related to gas and energy.

# The DVGW Hydrogen Innovation Programme

The **DVGW Hydrogen Innovation Programme** encompasses individual research projects that explore how to achieve a net zero energy system with the help of hydrogen, with a focus on the entire hydrogen value chain, from production and treatment to transport and distribution through to storage and end-use applications. Additionally, the projects investigate how to integrate hydrogen within the energy system of the future – after all, combining all energy sources and technologies will help achieve net zero quickly and in a socially compatible way.



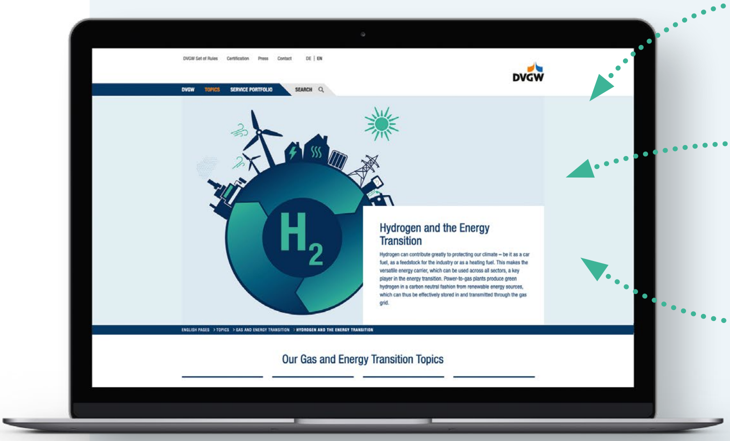
H2-Kompetenzverbund der deutschen Energiewirtschaft

Hydrogen plays an important role in the future energy system because it is an environmentally-friendly energy source. Innovative solutions are needed to promote its use and accelerate the market ramp-up of a hydrogen economy. The DVGW recognised this early on and has constantly expanded its expertise in this field.

In April 2022, the DVGW founded the **H2-Kompetenzverbund der Deutschen Energiewirtschaft** (H2 Network of Excellence of the German Energy Business) to pool the wide-ranging expertise in hydrogen of its research network, intensify existing collaborations within individual research projects, and achieve a closer integration of the renowned research institutes.

## For more information about hydrogen, please go to:

**www.h2-dvgw.de**





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Events


Research

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# Overview of the H2 Network of Excellence of the German Energy Industry