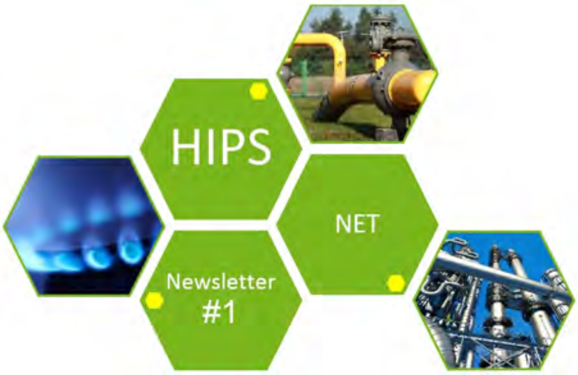


HIPS-NET

"Establishing a pan-European understanding of admissible hydrogen concentration in the natural gas grid"

Newsletter #1 — **January 2014**

Content Newsletter #1

Power-to-gas - the merging of two grids

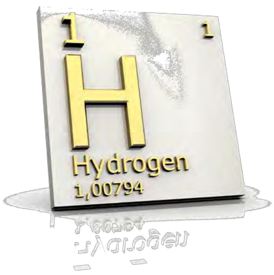
"A network leads to co-operation, cooperation leads to creativity and innovation - this changes the world."

- Marissa Mayer (CEO Yahoo)

HIPS-NET history and presence

First of all

Dear HIPS-NET partners,



We are pleased to welcome you as partner in the "H_2 Tolerance Network" (also called "HIPS-NET").

The HIPS-NET newsletter aims to gain a collective understanding of the H_2 tolerance of the gas infrastructure. This first newsletter is focusing on Germany, by recording open research topics and portraying current research projects and as far as possible, indicating the results.

The second newsletter will focus on activities among the partner countries. Therefore, your assistance is requested and needed.

Please support the successful network operation and let us know about H_2 projects (mixture of CH_4 and H_2) you perform or you might know. We would appreciate if you could name the references, how to find detailed project information in case they are accessible (e.g. internet links). We are looking forward to working together with you on gaining and sharing knowledge.

Information GERG HIPS final report

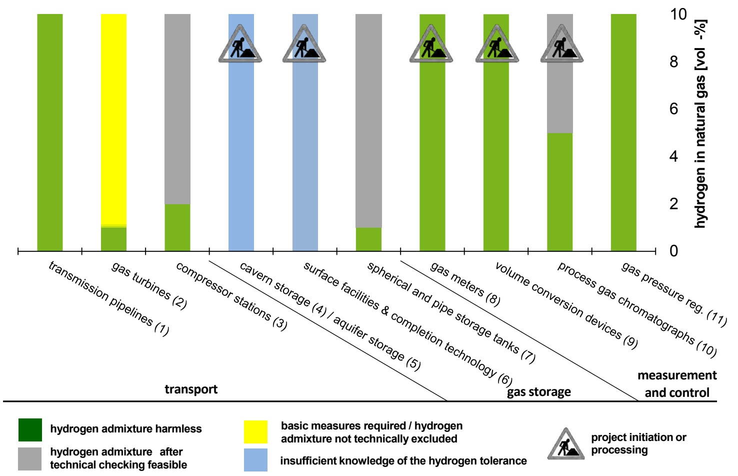
The GERG hydrogen project: "Admissible Hydrogen Concentrations in Natural Gas Systems", also known as "Hydrogen in Pipeline Systems" or "HIPS" has now been published. The report is confidential to project members, but copies can be purchased by contacting the GERG Secretary General: robertjudd@gerg.eu for €500 each (€200 for universities.)

The related paper, "Admissible hydrogen concentrations in natural gas systems", Altfeld, K. and Pinchbeck D., which is not confidential, has already been published in "Gas for Energy", No. 3 (2013), pp. 36-47. Copies can be downloaded free of charge.

Hydrogen tolerance state of the art

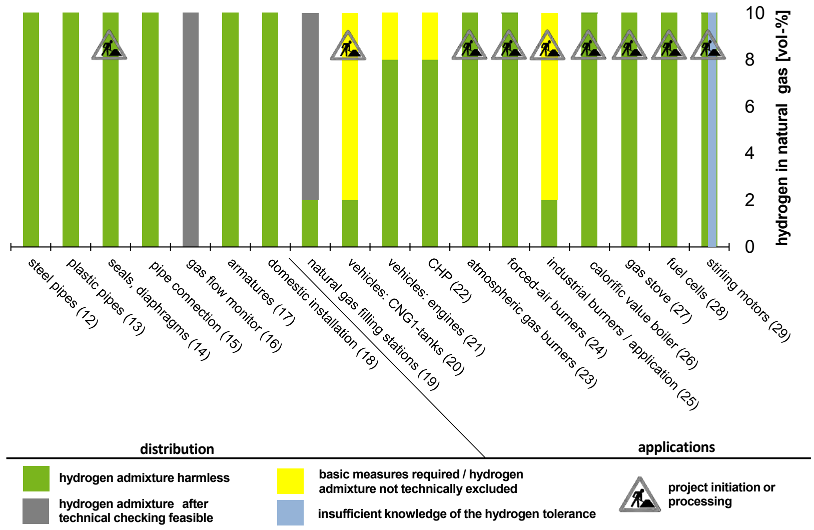
Introduction

The direct feed-in of hydrogen (H_2) in the existing natural gas grid is limited due to technical restrictions and limitations of technical standards. Ongoing R&D projects (e.g. DVGW [German Association for Gas and Water] project G1-07-10 "Development of modular concepts for production, storage and feed-in of hydrogen and methane in the natural gas grid" and the GERG HIPS project „Admissible Hydrogen Concentrations in Natural Gas Systems") summarised the current knowledge about hydrogen tolerance of the natural gas grid. The results show that the natural gas infrastructure is in general compatible for a concentration up to 10 vol.-% H_2 in the natural gas (shown in overview 1 and 2). The results are promising but further need for research has been identified concerning **porous underground gas storage, steel CNG1 vehicle tanks, gas turbines and engines**. The „DVGW Innovationsoffensive" aims to find answers to the open issues of hydrogen tolerance.



Matrix hydrogen tolerance - overview 1 (DVGW / DBI)

The results show that the natural gas infrastructure is in general compatible with a concentration up to 10 vol.-%



Matrix hydrogen tolerance - overview 2 (DVGW / DBI)

Therefore, a project was initiated, called DVGW project G1-02-12, „Information and data collection sheet for hydrogen tolerance of the gas grid" within the cluster „Power-to-Gas". Main project goals are the efficient national information exchange on results available so far on H_2 tolerance of the gas infrastructure, gaining further knowledge, and unanswered questions on H_2 tolerance.

Required actions for constraining elements and currently undertaken research projects will be described on the following pages. The main focus is on results gained in Germany; the international focus will be added in the HIPS Newsletter #2.

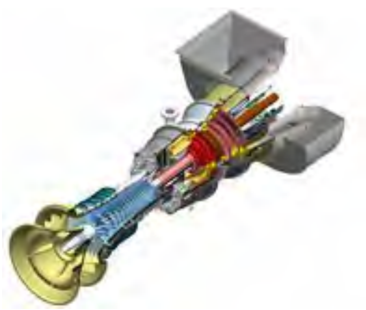
Overview of the core topics // 1

- ***+ Gas turbines and engines***
- ***+ Porous underground gas storage***
- ***+ Steel CNG1 vehicle tanks***
- ***+ Natural gas as working medium***
- ***+ Cross border transmission***

Gas turbines and engines

Research programs should be initiated to define the restrictions of gas turbines and to identify possible counteractions. The impact of high temperature/thermal stress/temperature load, flash-back, emissions and thermo-acoustic oscillations up to 10 vol.-% H_2 on existing gas turbines needs to be quantified and assessed. Furthermore, an inventory of the sensitivity and the age of turbines should be set up. The results provide a base to estimate costs for adjusting the operating machinery.

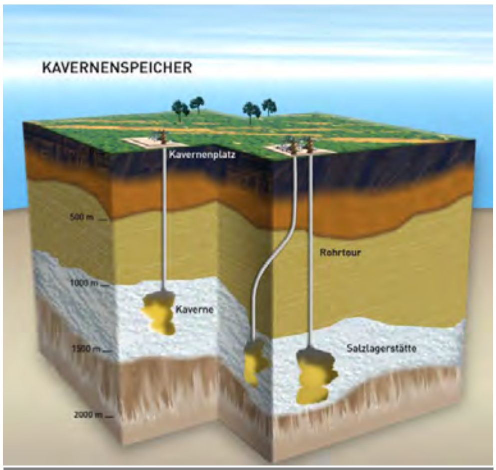
Neither known current projects nor projects in preparation in Germany address these research questions.



Solar Turbines (Titan 250)

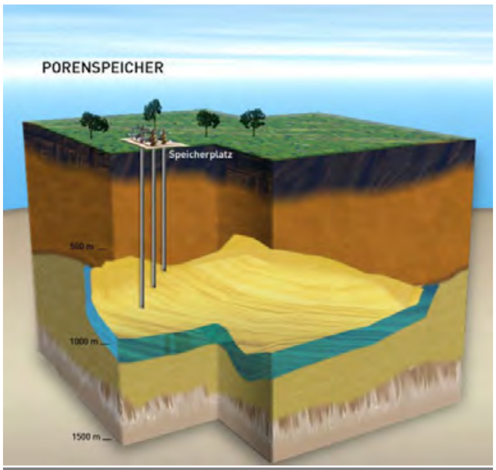
CAVERN UNDERGROUND GAS STORAGE / POROUS UNDERGROUND GAS STORAGE

Each underground gas storage is individual and should be site-specifically analysed for H_2 tolerance. Research has to be conducted to identify the effect of permeability and interaction of the micro-organisms. The H_2 tolerance of materials, components, cement, well completion as well as potential interactions between storage gas and rock salt or surrounding rock needs to be examined.



CAVERN UNDERGROUND GAS STORAGE (KGE-GASSPEICHERGESELLSCHAFT)

Main topics have been roughly examined in 2013 in two DGMK literature enquiries. An uncritical threshold of hydrogen concentration in natural gas can currently not be defined. Another project „Underground Sun Storage" (RAG, Rohöl-Aufsuchungs AG) has started in October 2013 to determine the compatibility of a porous underground storage. The central task of the project is the analysis of geochemical alterations of reservoir rocks or reservoir fluids. Laboratory tests with original drilling cores shall reproduce the interactions of micro-organisms. Furthermore, corrosion and changes in cementation will be assessed under typical storage operating conditions. Another work package contains an in-situ experiment for the storage of methane-hydrogen-mixtures and hence the demonstration of aspects of energy storage. Upon completion of the projects, the state of knowledge on hydrogen tolerance will have to be reassessed.



POROUS UNDERGROUND GAS STORAGE (KGE-GASSPEICHERGESELLSCHAFT)

NATURAL GAS VEHICLES: STEEL CNG1 TANKS

The H_2 threshold for currently used vehicle tanks as well as for new vehicles needs to be reviewed in technical and regulatory terms. Within the DVGW a project "Strategy development and building of a consortium for target-orientated extension of the admixture threshold of hydrogen in CNG tanks of new natural gas vehicles", is in preparation. Interested industrial companies are invited to become involved. Regulatory and contractual guarantees may be addressed in the proposed project. The project is scheduled to start in the beginning of 2014.

STEEL CNG1 TANKS (OZ-ONLINE)

CORE TOPIC FACTS //1

GAS TURBINES:
for currently installed gas turbines is the max. admissible H_2 concentration in the range of 1 and 5 vol.-% or even lower. Some new types accept H_2 concentrations up to 15 vol.-%.

UNDERGROUND GAS STORAGE:
a limit value for the max. H_2 concentration is not defined.

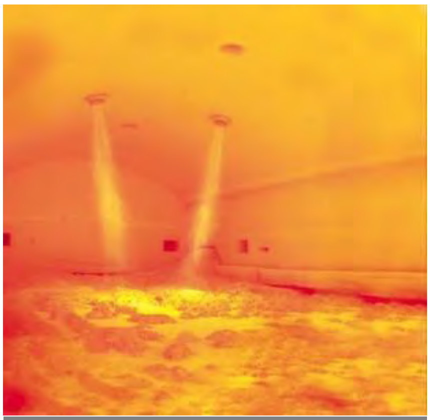
STEEL CNG1 TANKS:
UN ECE R110 limits the value for H_2 to 2 vol.-%.

NATURAL GAS AS WORKING MEDIUM

There is a need for action to record and analyse the impact of H_2 in working and process applications (analysis of the entire spectrum e.g. measuring methods, integration in the SCADA systems, impact on refractory materials, product quality, and appearance of NOx-data). Mitigation actions to compensate or avoid unwanted influence on the processes in place by H_2 are partly known. Results from the DVGW research project G1-06-10 "Analysis of the impact of changes in gas quality on industrial and commercial applications" on industrial applications, that has started in May 2011, showed that appropriate processes, appliances (O_2 measuring probes) and methods (verification by chromatographs for gas) are required for detection and compensation of variations of gas quality.

The main focus lay upon the variations of gas quality of potentially distributed gases in the gas grid (H + L natural gas, biogas, etc.) as well as the sensitivity of processes (burner-, installation and control devices) of industrial gas applications. The potential impact of H_2 has been assessed on a basic level.

The VCI (Association of the Chemical Industry), is currently recording potential impacts to processes by H_2. The results should be discussed and revised by the gas industry to achieve a common understanding on the opportunities as well as on the open issues that still need to be solved.



FIRING OF A GLASS BATH (ENERGY20.NET)

CORE TOPIC FACTS //2

NATURAL GAS AS WORKING MEDIUM:

a limit value is still not defined — there is a huge range of industrial applications.

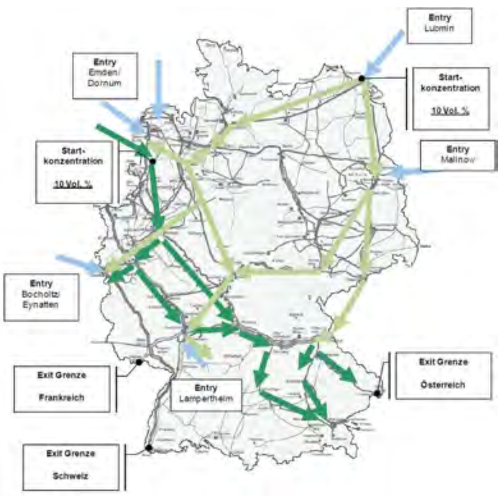
CROSS BORDER TRANSMISSION:

the limit value is defined by the different national standards and needs harmonisation as well as updating concerning the progress of technical knowledge (outlook newsletter # 2).

CROSS BORDER TRANSMISSION

In the case of H_2 feed-in in the transmission network, the distribution within the gas grid incl. potential cross border transmission has to be analysed and assessed. This requires in particular an analysis of the international standards. This problem has partly been addressed in the „Netzentwicklungsplan Gas 2012" (www.fnb-gas.de).

Neither the current project nor a project in preparation that addresses this research question is known at the moment.



THE POSSIBLE DISTRIBUTION OF H_2 IN THE GERMAN TRANSMISSION NETWORK (FNB-GAS)

INFORMATION FROM THE PARTNERS

CURRENTLY IDENTIFIED PROJECTS

France:
GRHYD

Austria:
Fronius International Research Facility

Underground Sun Storage

Netherlands:
Rozenburg

Italy:
INGRID

Belgium:
Don Quichote

CORE TOPICS COVERED BY KNOWN PROJECTS

The figure below show the core topics covered by running projects. We hope to further develop the table in the course of our network cooperation.

With YOUR commitment, your support – support from the HIPS NET partners, we intend to find and share the answers to hydrogen core topics. Our HIPS NET cooperation needs your information about research, findings, expertise — we summarize the research, prepare the main findings and publish them in upcoming newsletters. Further discussion will be done in our workshops.

Our aim is to establish a single (European) understanding for the transport of hydrogen in the natural gas grid and avoid double research. Please contact us.

CURRENT PARTNERS

Alliander ++ DGC ++ E.ON New Build & Technology ++ Enagas ++ ETIC ++ EWE ++ Fluxys ++ Gasnatural ++ Gasum OY ++ GRTgaz ++ grzi ++ Infraserv GmbH & Co. Höchst KG ++ ITM-Power ++ KOGAS ++ nPlan GmbH ++ OGE ++ ÖVGW ++ RAG Rohöl-Aufsuchungs Aktiengesellschaft ++ RWE Dea ++ RWE Deutschland ++ SGC ++ Shell ++ Solar Turbines Europe S.A. ++ SVGW ++ Synergrid ++ Volkswagen AG

INFORMATION OVERVIEW

IMPORTANT NOTES

SELECTION OF APPOINTMENTS

(FOCUS ON THE COMBINATION OF HYDROGEN AND NATURAL GAS)

- ++ „Wasserstoffspeicherung“ (6. Feb. / Hamburg, Germany)
- ++ „European Hydrogen Energy Conference“ (12. Mar. / Seville, Spain)
- ++ „DVGW/VDE 2. Münchener Energietage“ (17. Mar. / München, Germany)
- ++ „Energy Storage International Conference for Storage of Renewable Energies“ (25. Mar. / Düsseldorf, Germany)
- ++ „3rd Conference Power to Gas Projects for Europe's Energy Industry“ (27. Mar. / Düsseldorf, Germany)
- ++ „7. Energy Storage World Forum“ (1. Apr. / London, Great Britain)
- ++ „EES 2014“ (4. Jun. / München, Germany)
- ++ „BDEW Kongress 2014“ (24. Jun. / Berlin, Germany)
- ++ „11th EUROPEAN SOFC & SOE FORUM“ (1. Jul. / Lucerne, Switzerland)
- ++ „Fachforum Energiespeicherkonzepte“ DBI GUT (9./10. Sept. / Berlin, Germany)
- ++ „H2Expo 2014“ (23. Sept. / Hamburg, Germany)
- ++ „Performing Energy“ alliance for wind hydrogen (Germany)
- ++ „Strategieplattform Power to Gas — dena“ a strategy platform of dena (Germany)

NATURAL GAS TRANSMISSION PLANT

Outlook Newsletter #2

Content Newsletter #2

++ Overview of core topic projects — information from the partners

++ Detailed information on selected core topics

++ Analysis of legal aspects: restrictions for H_2 feed-in in the gas infrastructure. Overview of national technical standards on gas quality within Europe.

++ Final results of the DVGW project G1-02-12, „Information and data collection sheet for hydrogen tolerance of the gas grid"

++ New HIPS-NET partners

++ News // important appointments

Interests and Wishes

Please let us know if you have special interests/wishes for the next newsletters. This is the first newsletter of HIPS-NET —requests for change in the upcoming newsletters are always welcome. We would appreciate feedback especially since this is the first newsletter and we aim to provide quality information that is actually needed and wanted to answer the hydrogen core topics.

Enrich the hydrogen in the natural gas grid and our knowledge for hydrogen.

Contact and Privacy Notes

Questions, Notes and Criticism to

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HIPS-NET

"Establishing a pan-European understanding of admissible hydrogen concentration in the natural gas grid"

Newsletter #2 | **April 2014**

Content Newsletter #2

Power-to-gas - the invisibility of the natural gas grid (Uschi Dreiucker - pixelio.de)

"A network leads to cooperation, cooperation leads to creativity and innovation - this changes the world."

- Marissa Mayer (CEO Yahoo)

HIPS-NET Workshop in Brussels

Dear Partners,

As already announced, it is a pleasure for us to let you know that the HIPS-NET workshop will take place on the 25th/26th June in Brussels. We kindly invite you for dinner on the 25th June and hope that you can use the opportunity to exchange experiences and information on the latest developments on hydrogen in gas grids.

The workshop itself will be held on the 26th June on kind invitation of Robert Judd in the GERG office. Please note the preliminary agenda.

If you have not already done so, please let us (gert.mueller-syring@dbi-gut.de, stefan.schuetz@dbi-gut.de) know if you will attend before May 16th. Thank you in advance.

Envisaged next HIPS-NET dates:

- 25th / 26th June (HIPS-NET-Workshop)
- 7th July 2014 (3. Newsletter)
- 29th September 2014 (4. Newsletter)
- 16th December 2014 (5. Newsletter - year 2 of HIPS-Net)

No.	Start	End	Topic
1	09:30	10:00	Welcome coffee
2	10:00	10:15	Introduction - Gert Müller-Syring (DBI), Robert Judd (GERG)
Presentation on core topics			
3	10:15	10:45	„Sun Storage Lehen" - Stephan Bauer (RAG)
4	10:45	11:15	"Effect of H_2 on chemical industry applications – a first screening" Dr. Andreas Kronimus (VCI)
5	11:15	11:45	"Gas turbines - New findings on turbines in operation and current developments" - Christophe Huth (Solar Turbines)
6	11:45	12:15	„H_2 in CNG-tanks-state of the investigations" - Gert Müller-Syring (DBI)
Lunch			
7	12:15	13:30	Lunch in the GERG office
Pilot Projects			
8	13:30	14:00	"Injection of Hydrogen into Germany's Gas Distribution Grid" - Dr. Simon Bourne (ITM)
9	14:00	14:30	„Power-to-Gas in France and GRHYD project" - Jacques Dubost (GDF SUEZ)
10	14:30	15:00	Feedback from the auditorium (discussion, new projects aware, new findings)
11	15:00	15:15	HIPS NET next steps and organisational aspects - Gert Müller-Syring
12	15:15	15:30	Conclusions - Robert Judd/Gert Müller-Syring

In preparation of the workshop, we have gathered relevant topics that require further exchange and are therefore suggested for discussion:

- Specification of the ignition group for different gas mixtures (natural gas plus hydrogen)
- Verification of the specific ignition temperature for different gas mixtures (natural gas plus hydrogen)
- Thermodynamic properties / chemical reaction kinetics of H_2 and compatibility for reservoirs
- H_2 associated material requirements of well completion
- Changes in gas quality (chemical/biogenic) and their effects on reservoirs

Please let us know if you have additional relevant topics we could discuss at the workshop.

Simulation of a cellar room explosion — natural gas (DBI demonstration plant)

Latest news on DVGW project G1-02-12 „Information and data collection for hydrogen tolerance of the gas grid"

The DVGW project "Information and data collection for hydrogen tolerance of the gas grid" has been finalised. The project was introduced in the 1st HIPS Newsletter. The project report is scheduled to be published by the DVGW shortly and key results will be published in the HIPS-NET. The general conclusion is that in the course of the project the available findings on the hydrogen tolerance of the gas infrastructure has been verified by the industry, natural gas consumers as well as technical committees of DVGW.

It was verified by the industrie that the main issues are:

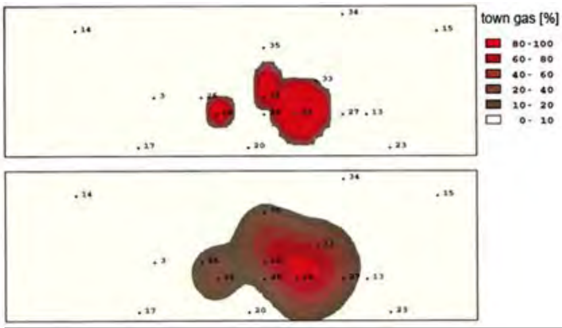
- Gas turbines,
- Cavern storages / porous rock storages,
- Well completion technology, above ground installation of natural gas storages,
- CNG vehicle tanks type 1 (steel tanks),
- Large scale burners.

Apart from CNG petrol stations and complex industrial consumers, the natural gas distribution network would tolerate 10 vol% hydrogen concentration. Open issues concerning uncritical topics (e.g. burners, EX-protection) are expected to be clarified by 2017. Upon finalisation of research projects on the hydrogen tolerance of natural gas underground storages in 2019, findings need to be assessed and may determine the scope of follow-up projects. Furthermore, it has been found that elements of the natural gas transmission network that cannot be adjusted to hydrogen admixtures cost-effectively, could be replaced after amortisation (approximately 25 years). A similar situation applies for CNG vehicle tanks type 1 for which a manufacturers` warranty of 20 years is given. Replacement after amortisation could cause low additional expenses.

Furthermore, it has been verified that the gas quality in the gas network will vary significantly more that in the past due to the feed-in of LNG or renewable gases. Consumers, especially industrial users, are therefore asked to implement measures to be prepared to work with varying gas compositions and a certain shares of hydrogen. Additionally it was recommended that future research projects should focus on estimating required expenses to establish a hydrogen tolerant natural gas infrastructure.

UNDERGROUND GAS STORAGE / INJECTION FLOW AND MISCIBILITY PROCESS

In Central Europe, the power supply of renewable energy sources (RES) does in general not correspond with the power demand. For balancing of daily and/or seasonal fluctuations, it is important that excess electricity can be stored and used, when the demand exceeds production. Fluctuation of power generation, and hence the spread between power generation and demand, will increase with the expansion of RES. For example in Germany, it is expected that a storage capacity of about 60 GW will be necessary (Fig.1) to balance energy production and consumption. In order to react to the strongly fluctuating power generation from renewable sources UGS must very quickly switch between injection and production to handle large gas transfer rates and large volumes. Within the R&D project WESPE (started 12/2013) the expected gas composition (H_2, H_2/CH_4-mixed gas), resulting gas properties and operating parameters are determined. Based on the H_2 concentration, tolerated by the natural gas grid, the relevant properties for injection/withdrawal in underground gas storage (UGS) - wells and reservoirs, will be determined for mixed gas and pure hydrogen (electrolysis). Thermodynamic properties will be evaluated (e.g. Joule-Thompson effect), similarly reservoir engineering (e.g. viscosity, H_2-CH_4 miscibility/displacement, convection-dispersion/diffusion-processes) for different storage types. The understanding of miscibility and/or displacement of different gas compositions among each other and with water is essential for safe and economic UGS operation and is therefore a significant scientific task. The experience of town gas storage, in the 1970s, with hydrogen contents up to 50%, will be integrated (Fig. 3). Another focus in the project plan is the investigation of H_2, H_2/CH_4-mixed gas effects on common reservoir and cap rocks, as well as on the reservoir operations.



TOWN GAS INJECTION IN THE RESERVOIR WITH RESIDUAL GAS N_2 50% (ABOVE: CONCENTRATION AFTER 4 MONTHS INJECTION, AND TOWN GAS-MIXING AFTER 6 YEARS OF REST)

ANALYSIS OF THE HYDROGEN TOLERANCE OF CNG VEHICLE TANKS

The technical standards ECE R110 and DIN 51624 are currently limiting the hydrogen concentration for CNG vehicle tanks to 2 vol%. The elements of the distribution gas grid would tolerate hydrogen concentrations up to 10 vol% or more. The technical standards for CNG vehicle tanks, therefore, impose a restriction on the capacity of the natural gas infrastructure for the renewable gas hydrogen.

It is generally belived that the 2% limit was an ad hoc ‚finger in the air' estimate to be ultra-safe and is therefore in need of review by the auto industry. A preliminary technical analysis suggests that the limitation to 2 vol% seems to be a rather conservative restriction. According to the current version of the ECE R110 standards, CNG tanks may be used for 100 vol% hydrogen if the tensile strength of steel does not exceed 950 MPa and if the inner surface has been inspected before commissioning. The permitted hydrogen concentration for steel with a tensile strength of more than 950 MPa drops to 2 vol%. The technical necessity of the reduction of the hydrogen concentration in the given amount is doubted. This assumption is supported by research results on steel pipelines that have been carried out in the fram of the Naturalhy Project (SES6/CT/2004/502661). The chosen research approach includes literature review; enquiry to steel tank producers, "problem owners" (vehicle manufacturers), representatives of the gas industry as well as DVGW institutes who have experience in the field of hydrogen tolerance of steel.

The analysis of the hydrogen tolerance of CNG vehicle tanks aims to establish an overview on the current knowledge and to identify open research questions. This project (DVGW G7-02-11), together with further possibly required research, might provide the scientific basis to raise the admissible hydrogen concentration in the technical standards ECE R110 and DIN 51624 and thus enable the transport of renewable hydrogen in the natural gas infrastructure.

CNG TANKS (OPEL AND MERCEDES BENZ)

Key project aims:

- Analysis of the basis of the currently valid limitation for hydrogen concentration in the technical standards.
- Analysis of available experience on hydrogen tolerance of steels.
- Analysis of the scientific basis of the corrosion mechanism for hydrogen including possible counteractions.

Natural Gas as working medium

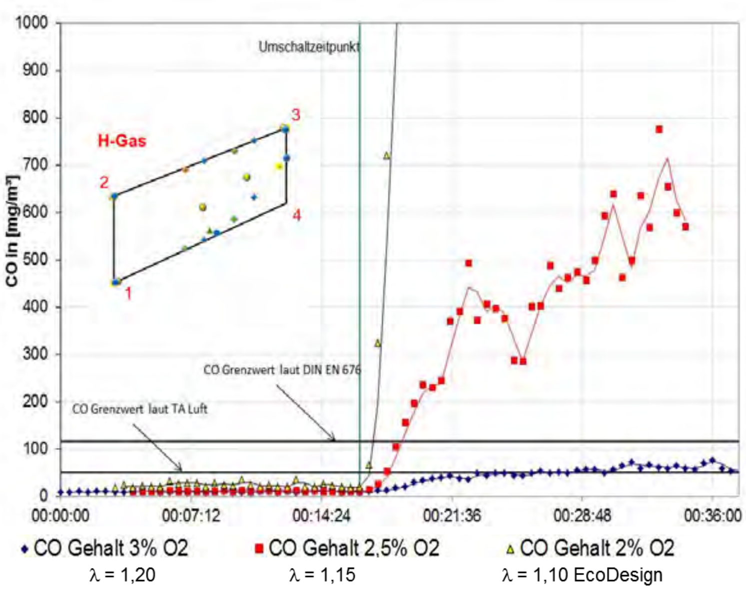
The natural gas market has been undergoing substantial changes recently. The gas supply situation has changed, leading to more diversified gas sources. Liquefied natural gas entered the market on a wider basis including, for example, Germany; the share of biogas is growing steadily and synthetic gases such as hydrogen or methane could play a role soon. The changes in the gas supply situation will inevitably cause increasing variations of the chemical composition characteristics of natural gas.

Such supply diversification offers economic and ecological benefits, but may result in challenges for operators of sensitive thermal processes, e.g. in the glass, ceramics, or metal industry. Small changes of the chemical composition of gas characteristics could have a direct impact on product quality, process efficiency and pollutant emissions in manufacturing processes.

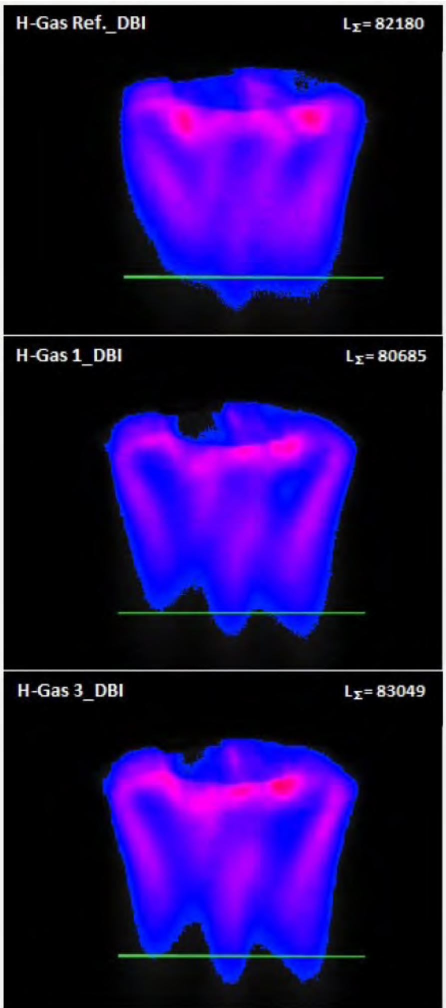
The DVGW research project "Gas quality changes: consequences for industrial combustion processes" (DVGW-Projekt G1-06-10) aims to address potential consequences of gas quality variations. By observation of industrial combustion processes, critical aspects will be identified and potential solutions suggested.

In the following an extract of the scope and aim is given:

- Feed-in of hydrogen in the natural gas (H gas) distribution grid (endpoint before a customer) in the region Freiberg/Germany up to a concentration of 16 vol% hydrogen.
- Identification of the possible influence of hydrogen on industrial boilers with varying burner systems up to 100 kW.
- Assessment of the effect on flame formation, radiation characteristics, power, efficiency, and exhaust gas temperature.
- The 100 kW burner systems were adjusted to a reference gas (λ = 1.135 and residual O2 = 2,5 vol%).Gradual hydrogen admixture with 4, 6, 10, and 16 vol% hydrogen estimated.



Influence of CO-emission and flame shape at different air ratios (DBI)



Optical flame rating in the UV range for the determination of OH radicals combustion of gas mixtures in the G 260 map for H- gases. L = total intensities. Red indicates "hot spots". (DBI)

Main findings:

- Technical problems during combustion could not be observed under the experimental conditions (field test "industrial boiler").
- Surprisingly, the power of the burner increased although the calorific value of the gas gradually declined (due to the rising concentration of hydrogen). This may be explained by the lower viscosity and volumetric mass density of the hydrogen-natural gas mixture, which increases the volume flow rate of the fuel gas.
- Gradual change of the hydrogen concentration of the fuel gas had the following influence on flames:
  - ⇒ Influence on radiation characteristics.
  - ⇒ Influence on flame formation.
  - ⇒ Influence on location of the flame (distance to the burner nozzle).

ANALYSIS OF LEGAL ASPECTS: RESTRICTIONS FOR FEED-IN OF H_2 - IN THE NATURAL GAS INFRASTRUCTURE.

Feed-in of hydrogen in the natural gas infrastructure may result in cross-border transport of gas mixtures and hence affect the gas quality parameters. Up to now, the gas quality for use in the natural gas grid has neither been regulated by international nor by European standardisation bodies. The ISO 13686 "Natural gas – Quality designation" contains a general description of different parameters rather than concrete parameters in the sense of thresholds, limits, or ranges. The ISO 13686 standard refers for gas quality parameters on an informal basis to the Common Business Practice (CBP 2005-001/02), released by EASEE-gas (European Association for the Streamlining of Energy Exchange-gas) in 2005 [1]. The CBP has the title "Harmonisation of Gas Qualities" and recommends natural gas quality specifications, parameters and parameter ranges to streamline interoperability at cross border points in Europe. Hydrogen concentration limits are not mentioned in concrete figures but "insignificant levels of hydrogen" are tolerated. As the CBP has not been issued by an authorised body or organisation, it is not legally binding for the transportation of natural gas, unless agreed upon under private law agreements. It is therefore necessary to pay attention to the national standards and legislation for gas quality. An overview about applicable hydrogen concentration limits in Europe may be derived from research conducted by AFNOR on behalf of the European Committee for Standardization (CEN) in 2011 [2] or an investigation by GASQUAL in 2010 [3]. National standards for hydrogen concentration in the transmission network seem to exist in only a few European countries. That means feed-in of hydrogen is not prohibited although the concentration may be limited by other gas parameters, e.g. Wobbe index, methane number. We would suggest gathering current knowledge on hydrogen concentration limits within the HIPS-Network.

GAS TRADE FLOWS IN EUROPE (IEA)

If you are aware of the admissible hydrogen concentration in your country preferably, with indication of the applicable national standards or legislation regulations/ legal, we would appreciate if you would provide us with this information. With your support we would then prepare an up to date overview in a future newsletter.

References:

[1] CBP Common Business Practice 2005-01/02, 08.02.2005: Harmonisation of Natural Gas Quality.

[2] CEN Europäisches Komitee für Normung (Hg.) (2011): *Gases from non-conventional sources — Injection into natural gas grids — Requirements and recommendations (CEN/ TC 234 WG 9 N 54:201)*

[3] GASQUAL (Hg.) (2010): *Investigations on new acceptable EU limits for gas quality. Influence on the performance of new and installed gas appliances. dy Project. PHASE 1 of the Mandate M/400*.

INFLUENCE OF HYDROGEN ON THE ENERGY METERING AND BILLING //

Work packages of the DVGW-project G3-02-12:

- Possibility of reconstructing heating value in gas transmission grids.
- Billing in accordance to DVGW-Arbeitsblatt G 685 „Gasabrechnung" (German standard for gas billing).
- Reconstruction of heating value in gas distribution grids.
- Metering of gas quality (process gas chromatograph).
- Features of hydrogen metering by volume.
- Certification of hydrogen metering by volume.
- Compressibility coefficient.

PGC (ENCAL 3000 ELSTER INSTROMET)

Main content of the working package „Metering of gas quality "

- Description of the technical and regulatory basis for certified metering of hydrogen with process gas chromatographs (PGC - process gas chromatograph).
- Illustration of currently available PGC for certified metering contents of hydrogen (categories: certified, applied for certification, certification intended).
- Identification of the total number of PGC in the German natural gas grid.
- Determination of the expenses for replacement or modernisation of existing PGC.

Main content of the working package "Metering of hydrogen by volume"

- Description of current rules and standards on hydrogen limits for gas meters.
- Examination and assessment of the influence of hydrogen on metering principles.
- Summary of the ability of gas meters based on manufacturer's information.

DIAPHRAGM GAS METERS (ELSTER INSTROMET)

INTERNATIONAL ENERGY AGENCY (IEA) – TECHNOLOGY ROADMAPS ON HYDROGEN (INFORMATION PROVIDED BY DGC)

During 2013-14 IEA is preparing a Technology Roadmap on Hydrogen. Input to the roadmap are given at three workshops with participants of key stakeholders from industry, government, and academia, in order to discuss crucial technology, market and policy issues.

The 1st workshop was held in July 2013, at the IEA office in Paris, while the 2nd workshop was held in January, at the IEA-Hydrogen Implementing Agreement campus in Bethesda, US co-organized by the US Department of Energy and Industry Canada.

The 3rd and last IEA Hydrogen Roadmap Workshop will take place end of June in Japan and the final Hydrogen roadmap is expected in the beginning of 2015.

The aim of the "Technology Roadmap on Hydrogen" will be to clearly identify the potential of hydrogen in transport, buildings and industry as well as to outline technological challenges and institutional barriers which needs to be overcome if hydrogen is to be provided on a large scale in the future. A special focus will be put on hydrogen transmission and distribution infrastructure as well as on large scale energy storage and its linkages to the integration of variable renewables.

CURRENT PARTNERS

Alliander ++ DGC ++ E.ON Technologies (Ratcliffe) limited ++ Enagas ++ Energinet ++ ETIC ++ EWE Netz GmbH ++ Fluxys ++ Gasnatural ++ Gasum OY ++ GRTgaz ++ grzi ++ Infraserv GmbH & Co. Höchst KG ++ ITM-Power ++ KOGAS ++ nPlan GmbH ++ OGE ++ ÖVGW ++ RAG Rohöl-Aufsuchungs Aktiengesellschaft ++ RWE Dea ++ RWE Deutschland ++ SGC ++ Shell ++ Solar Turbines Europe S.A. ++ SVGW ++ Synergrid ++ Verband der Chemischen Industrie ++ Volkswagen AG

Further information to the 1st workshop | agenda and presentations (Paris, France: 9 July 2013 – 10 July 2013)

Further information to the 2nd workshop | agenda and presentations (Bethesda, Maryland, United States: 28 January 2014 – 29 January 2014)

Another **IEA's Technology Roadmap on Energy Storage** – with some relations to hydrogen - was released in March 2014

REPORT | GLOBAL SCREENING OF PROJECTS AND TECHNOLOGIES FOR POWER-TO-GAS AND BIO-SNG

"Selected Project results"

- hydrogen from an electrolyser with a CO2 source (typically from a biogas plant) is fed to a methanation unit prior to feeding the gas to the gas grid, or
- hydrogen from an electrolyser is fed directly to the natural gas grid. (In some countries 5 vol% hydrogen is already permitted in the gas grid, and some say that 15 vol% could be permitted without considerable modifications of the gas consuming appliances.) or,
- hydrogen from an electrolyser is stored and converted to electricity/heat via a CHP unit (fuel cell plant or gas engine), when electricity is needed.

The updated version of the "Global screening of projects and technologies for Power-to-Gas (P2G) and Bio-SNG" has been published in November 2013 by the Danish Gas Technology Centre (DGC).

The report introduces various P2G projects mainly in Europe and summarises them by the way they are integrated in the energy system.

Selected findings of the report are summarised in the following: Some P2G plants produce hydrogen and act as "storage" for a fluctuating electricity supply based on solar and wind. Demonstration plants of this type are found all over the world. The typical plant size is 5-100 kW_e.

Electrolysis plants used in systems connecting the electricity and natural gas systems have only been realised as demonstration plants in Germany and France during the last couple of years. More are on their way, though, in Denmark, Germany, France, The Netherlands and Italy.

The reason that Denmark and Germany are following the third path is that in these countries a heavy expansion of renewable energy plants is on the agenda. This requires increased balancing of the system, and the interest in energy storage is thus sky-high.

The report outlines key facts of P2G demonstration projects, e.g. project description, duration, further findings, partners and contact person. It may be downloaded from: this link.

SELECTION OF APPOINTMENTS

(FOCUS ON THE COMBINATION OF HYDROGEN AND NATURAL GAS)

++ Energy Storage 2014 - ACI's 4th Annual Energy Storage summit (14/15 May 2014, Luxembourg)

++ 6. Deutscher Wasserstoff-Congress - *Wasserstoff – Speicher und Kraftstoff* (22/23 May 2014, Berlin)

++ Carbon Expo - *Annual global leading interface between climate finance and carbon markets, industry and technology* (28/30 May 2014, Köln)

++ International Workshop on PEMFC Stack and Stack Component Testing (3/4 June 2014, Stuttgart)

++ „EES 2014" (4 June 2014, München)

++ „BDEW Kongress 2014" (24 June 2014, Berlin)

++ „11th EUROPEAN SOFC & SOE FORUM" (1 July 2014, Lucerne)

++ „Fachforum Energiespeicherkonzepte" DBI GUT (9/10 Sept. 2014, Berlin)

++ „H2Expo 2014" (23 Sept. 2014, Hamburg)

++ „Performing Energy" alliance for wind hydrogen (Germany)

++ „Strategieplattform Power to Gas — dena" a strategy platform of dena (Germany)

CONTENT NEWSLETTER #3

++ Long term exposure of pure hydrogen on PE-pipes for natural gas distribution. 10 years of testing

++ "Energy storage – hydrogen injected into the gas grid via electrolysis field test". Full scale testing on 80/40 barg meter/regulator station (nominal 18000 Nm3/h) with natural gas plus 0-20 vol% hydrogen.

++ "The future storage for renewable energy" A pre-study for a Danish field test of hydro gen injection in the gas grid with around ten residential end-users and light industrial users.

++ Power to gas in France and GRHYD project.

++ Project „Hydrogen in distribution and utilisation"

++ New HIPS-NET partners

++ News // important appointments

INTERESTS AND WISHES

Please let us know if you have special interests/wishes for the next newsletter. We look forward to get feedback and we aim to provide quality information that is actually needed and wanted to answer the hydrogen core topics.

CONTACT NOTES

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HIPS-NET

"Establishing a pan-European understanding of admissible hydrogen concentration in the natural gas grid"

Newsletter #3 — **October 2014**

Content Newsletter #3

Power-to-gas - the invisibility of the natural gas grid
(Uschi Dreiucker - pixelio.de)

"A network leads to cooperation, cooperation leads to creativity and innovation - this changes the world."

- Marissa Mayer (CEO Yahoo)

3rd HIPS-NET Newsletter - Introduction

Dear Partners,

We are pleased to issue this 3rd newsletter. It has been challenging to gather information as the summer was rather "quiet", because those of us that have interesting topics to share were on holiday and returned back to their desks with the typical pile of unsolved work leaving little time for additional tasks. We therefore thank the partners who nevertheless are keen to share information within the network and contribute to the newsletter, even though sometimes, specific constraints have prevented publication.

The newsletter includes various projects in Europe all of which are investigating the impact of H_2 on the gas network. We do hope, you find some interesting information for your company. Moreover, we would like to draw your attention to two initiatives aiming to standardize H_2 injection to the natural gas network and further aspects related to it.

Please note, that the HIPS-NET activities and the aim of our network was presented during the International Gas Union Research Conference (IGRC) Copenhagen, Denmark (17.-19. September 2014).

Influence of Hydrogen on Underground Gas Storage (DGMK 752)

A literature study on the influence of hydrogen on underground gas storage was recently performed by the Technical University Clausthal and was published in 2014 by DGMK (German Scientific Society for Oil, Gas, and Coal). Natural gas, stored underground, is typically free of hydrogen. The impact to the storage of the renewable gas hydrogen within the gas infrastructure therefore requires careful evaluation. The study compares, for example, the characteristics of natural gas and town gas, analyses the influence of diffusion on hydrogen losses, and considers the efficiency of gas storage in the event of hydrogen admixture. The two main chapters address the influence of hydrogen on the technical and geological integrity of different types of gas storage formations, followed by security considerations.

CRACK IN CASING BY HYDROGEN EMBRITTLEMENT (PETROLEUM RECOVERY RESEARCH CENTER, SOCORRO,NM)

As suggested, technical integrity can be secured by the usage of appropriate materials. This applies in particular to newly constructed facilities. Up to 800 MPa, the material strength of carbon steel with low and medium carbon content meets the integrity demands for use with high-pressure hydrogen. High-tensile steels with carbon content exceeding 0.3 percent, however, have considerably lower hydrogen resistance. At a temperature of 200 °C, which occurs at only few spots of the above ground installation, the hydrogen resistance of chromium molybdenum steel is necessary. The use of carbon steels at such elevated temperatures will increase the probability of high-temperature induced damages. The risk of corrosion by embrittlement, blistering and crack formation under low temperatures of corrosion resistant alloys (CRA) caused by hydrogen exposure results from the hydrogen permeability of the CRA. Steel alloys with little hydrogen permeability are less exposed to corrosion risks. Similar results were seen for the elastomer used for sealing elements of the packers and installation of storage drills. Upon sudden decompression, redundant hydrogen can be released and may cause inner cracks and blistering. Generally, decreasing hydrogen permeability leads to reducing risk of material defect in sealing elements.

BLISTERS ON THE METAL SURFACE UNDER HIGH T EMPERATURE HYDROGEN ATTACK (KAWANO, K 2004)

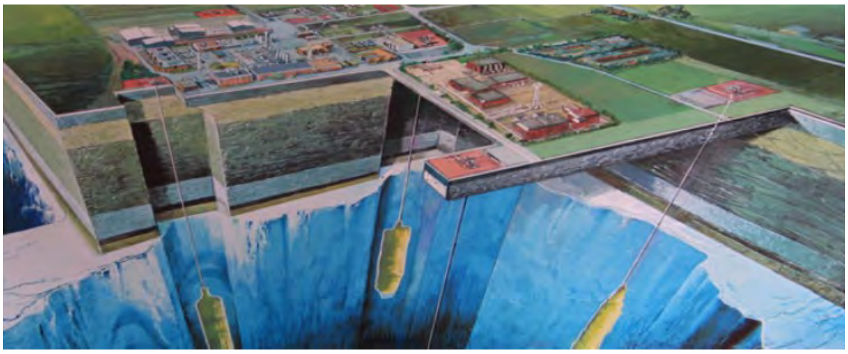
The risk of hydrogen losses due to inadequate geological integrity based on hydrogen diffusion needs to be further addressed by R&D. The same applies to the possible chemical reactions with minerals and reservoir fluids, especially microbiological initiated production of hydrogen sulphide and acetic acid. This may help ensure reduced losses of stored gas and secure operation of both the below and above ground facility.

DGMK 752:

The study identified the need for further R&D in various key points. The results are published in German and English. The study no. 752 can be obtained here for a price of € 70. (http://www.dgmk.de/berichte.htm)

Overview of the core topic „Underground Storage“

Public perception of hydrogen storage (HyUnder)



Hydrogen underground storage
(KBB Underground Technologies)

The HyUnder project has been finalised and published under hyunder.eu. The project partners addressed several subjects within eight work packages, one of which addressed the rather new field of public perception of hydrogen storage, in a more sociological approach. Although the study is not representative, as only 16 people participated, the results can nevertheless give an impression about possible public opinions and the tasks ahead before hydrogen may gain public acceptance as an energy carrier.

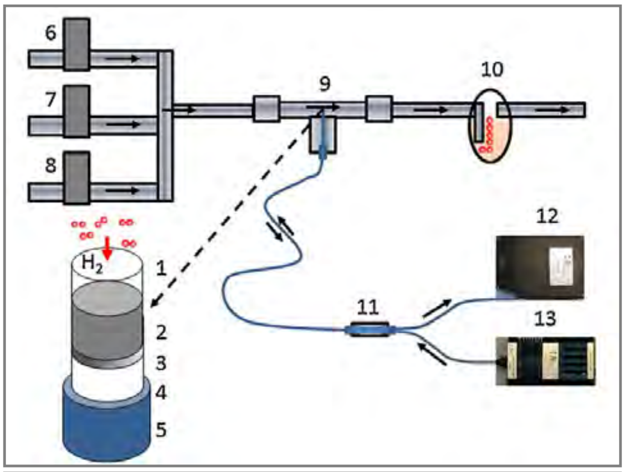
“Practically everyone lacked the knowledge to understand the whole chain of reasoning; from the need to increase use of renewables, to the problem of intermittent energy supply by renewables, to the need to store energy, to hydrogen being a possibility for this, to how to produce hydrogen, etcetera. After people were given information on this reasoning, they were mostly quite enthusiastic. However, this conclusion should be nuanced by the fact that most interviewees had a hard time envisioning any other options for our future energy system, and also by most interviewees’ perception of having too little information to form an opinion on hydrogen storage.”

HyUnder: The whole document may be found here.
(http://www.hyunder.eu)

Hydrogen measurement in natural gas

Fiber optic hydrogen sensor for continuous monitoring of the partial hydrogen pressure in the natural gas grid

The feed-in of hydrogen to the natural gas network, especially changing gas compositions as well as changing hydrogen concentrations require extra measures to guarantee the safety and performance of sensitive end use equipment (e.g. industrial applications).



Schematic representation of the optical fiber sensor layout (Westerwaal et al.)

The share of hydrogen in natural gas may be measured optically using a Pd-Au alloy thin film with a fiber optic sensor. The sensor provides precise knowledge of the hydrogen content and thereby enables, for example, control systems of industrial appliances to automatically adjust the fuel/air ratio to obtain optimal combustion. The experiments showed that the partial hydrogen pressure can be monitored quantitatively in CH_4+ H_2, H_2-C_2H_6 and H_2–C_3H_8 gas mixtures with H_2 partial pressure up to 200 mbar. The sensor response is independent of the carrier gas and the response time (hydrogenation kinetics) is typically 15-30 s for all tested gas mixtures. This has been found for gas mixtures at room temperature; for lower temperatures the optical response can be estimated by an inverse temperature behaviour. The sensor is described as a stable thin film based structure, which is cheap and reliable especially in an explosive environment. A detailed description of the experiments and findings can be found in the article: Westerwaal et al.: “Fiber optic hydrogen sensor for a continuously monitoring of the partial hydrogen pressure in the natural gas grid” in *Sensors and Actuators B: Chemical* vol 1999, August 2014, p 127-132.

HYPOS - HYDROGEN POWER STORAGE & SOLUTIONS EAST GERMANY "THE REVOLUTION OF THE HYDROGEN ECONOMY INITIATED IN EAST GERMANY"

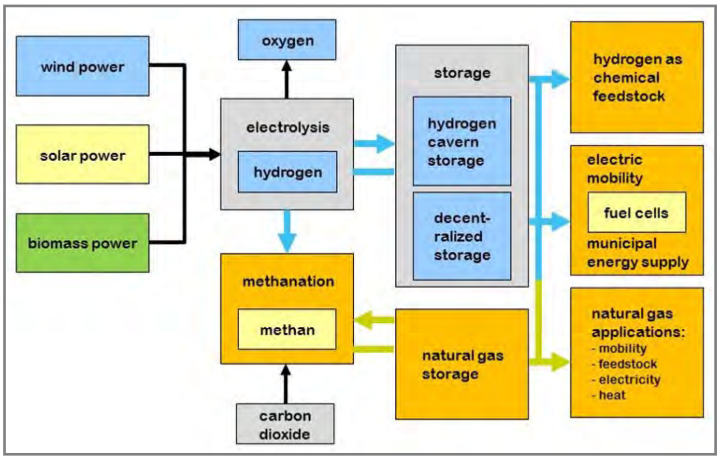
HYPOS aims to enhance technical and economic progress in system and network R&D for the integrated use of renewable hydrogen in the stand-alone industrial hydrogen network and the interlinking with both the electricity and natural gas networks, including nearby underground gas storage. The project is orientated in particular to use electricity generated by wind turbines and photovoltaic arrays, to convert the electricity to hydrogen, and store it in accordance with market supply and demand. The infrastructure of the region, especially the existing hydrogen network, and the on-site demand for hydrogen, is expected to stimulate the realisation of the technically-driven cost reduction potential (economy of scale).

The **HYPOS** project is aiming to tackle both challenges:

- the integration of volatile renew-able electricity sources by stor-age of hydrogen in the natural gas infrastructure using Power-to-Gas and
- the supply of renewable hydro-gen for applications as mobility, chemical industry, as well as municipal gas and electricity supply.

Further information on HYPOS can be found here: (http://www.hypos-eastgermany.de/)

During the currently conducted initial phase, the innovation strategy of the project is under development. This comprises, for example, gaining a more detailed understanding of the project strategy and aim, developing a roadmap for the entire initiative, as well as generating methods and criteria to benchmark future sub-projects.



HYPOS VALUE-ADDED CHAIN: PRODUCTION, TRANSPORT, STORAGE AS WELL AS UTILISATION OF HYDROGEN (HYPOS)

In preparation of the benchmark tool, value-added chains were defined and the pipeline-based connections for gaseous energy carrier were identified (see figure left). This applies to the chain from production of hydrogen and other gases using different technologies, over the storage of the gases, to the distribution in stand-alone grids or the natural gas network as well as the use as chemical feedstock, fuel, or the energetic use. Aided by the value-added chains, the project eventually aims to achieve economically viable production and utilisation of renewable hydrogen.

Up to now, more than 100 research project proposals have been submitted; a first set of accepted projects will be selected in September 2014, and are scheduled to commence in 2015.

The HYPOS consortium was founded in 2013 and has currently more than 80 members; it delivers know-how from small and medium-sized enterprises, from large companies (e.g. Linde, VNG, Air Liquide), as well as from various research institutions in East and West Germany. The German Federal Ministry for Education and Research (BMBF) intends to subsidise the consortium until the year 2020 with up to 45 million Euro in alignment with the program "Twenty20 – Partnership for Innovation".

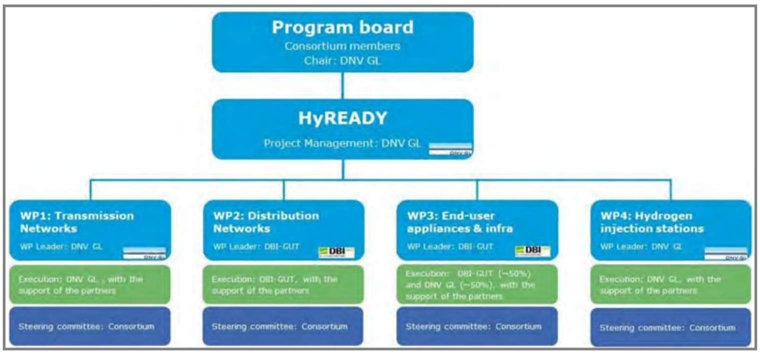
STANDARDISATION / RECOMMENDED PRACTICES

HYREADY INITIATIVE: DEVELOPING "RECOMMENDED PRACTICES FOR PREPARING NATURAL GAS NETWORKS FOR H_2 INJECTION"

On the 4th of September the Kick-Off-Meeting of the HYREADY-Initiative (a Joint Industry Project) has successfully taken place. The initiative aims to support TSO's and DSO's to prepare themselves for hydrogen addition to natural gas by developing "Recommended Practices for preparing natural gas networks for H_2 injection". These Recommended Practices will be based on existing knowledge and experiences: neither tests nor experiments are foreseen in the framework of this project. On a technical level and on a system level, the impact of hydrogen addition on the natural gas infrastructure will be mapped out as well as the consequences thereof and feasible counter measures. *(continue next page)*

(continue from previous page)

Four work packages focussing separately on transmission and distribution grids, end user, and hydrogen injection facilities will be launched. The aim of the single work packages is to develop recommended practices on each topic that will be covered by a general document. At the moment there are 27 parties that are interested in supporting HYREADY. The partners will support the project both financially and with their knowledge. The operational work including gathering additional information and developing drafts of the recommended practices will be jointly performed by DNV GL and for the "distribution" and "end use" work packages by DBI. The structure of the project as well as the responsibilities are shown in the figure at the right side. It's important to note that both DNV GL and DBI are impartial organisations, and have been involved in many projects on the accommodation of hydrogen/natural gas mixtures in the natural gas infrastructure.



HYREADY STRUCTURE (HYREADY)

If you require additional information please do not hesitate to contact Onno Florisson (onno.florisson@dnvgl.com) or the HIPS-NET editorial team.

The project is still in its initiation phase and welcomes interested parties. The execution of HYREADY is planned to take 2 years and will start in January 2015. It would be great if we could further extent the consortium!

STANDARDIZATION ACTIVITIES FOR HYDROGEN TECHNOLOGIES

Hydrogen can play an important role to integrate renewable electricity (large-scale storage) and may support establishing a renewable energy system (substitution of conventional energy sources). Within the initiative "Putting Science into Standards", scientific and standardization communities are invited to work closely together. The initiative has been launched by the Joint Research Centre (JRC) of the EC, together with the European Association of Research and Technology Organisations (EARTO), the European Standards Organisations CEN and CENELEC, as well as the EU Directorate-General Enterprise and Industry (ENTR).

The initiative has planned a workshop on the subject of "Power-to-Hydrogen and HCNG (hydrogen and compressed natural gas)" for the 21-22 October 2014 at the JRC's Petten (NL) site. The workshop aims to establish a consensus between research, industry and standardization communities on the relevant technical issues involved, on the scope and nature of standardization measures needed. Prior to the upcoming workshop, the European standardization bodies CEN and CENELEC have conducted a survey among interested stakeholders from different backgrounds coming from several European countries. The survey results, published in June 2014, confirm a potential of hydrogen technologies for different applications. Focus seems to be primarily the injection into the natural gas network and mobility induced applications. Most stakeholders support the need for standardization and the spectrum varies from a currently given need, especially for hydrogen as fuel, to future needs to safeguard the electricity production from fluctuating renewable sources, and feed-in of hydrogen in the gas network. The stakeholders recommended a whole set of issues that may require standardization and discussed which body should carry the responsibility to develop the standards. It has been suggested to adjust the gas quality standard for pipeline transport in order to list permissible hydrogen contents but to postpone activities until the research results from currently conducted projects are available.

Key European experts are invited to discuss industry's current and future standardization needs in **four identified aspects:**

1. Power-to-hydrogen by electrolysis,
2. Admixture of hydrogen to the natural gas grid,
3. Impact of HCNG (Hydrogen-enriched Compressed Natural Gas) blends on materials and on the performance in end-use applications,
4. Provision of ancillary services in support of the electricity grid.

DBI participates at the workshop in October 2014 and will share gained knowledge on future standardization issues within the HIPS-NET.

FIELD STUDY OF HYDROGEN FEED-IN TO A NATURAL GAS DISTRIBUTION NETWORK

This project explores the feasibility of up to 10 vol% h [illegible] stribution network. The focus is on the investigation of today's gas consumer [illegible] erating modes, weather conditions, installation conditions, levels of gas dem [illegible] ologies in collaboration with E.ON Hanse and Schleswig Holstein Netz AG c [illegible] Bunte-Institute (DVGW-EBI) in a field investigation of installed appliances. Th [illegible] ation Campaign, which includes additional tests carried out at the laboratories [illegible] (Essen).

Project preparations included selecting an appropria [illegible] e, the gas quality, gas flow rates and appliances used in the service area. [illegible] was built in 1997 and supplies, over a single gas pressure regulation statio [illegible] ominantly single-family houses and some commercial clients. The installed a [illegible] to the commencement of feed-in of hydrogen. As expected by the project partners, the most frequently installed appliances are condensing boilers. The second most widely used are low temperature boilers followed by a small group of cookers, jet burners, water heaters, one CHP, and others. The age of the appliances varies between 1 and 17 years.

GAS PRESSURE REGULATION STATION WITH HYDROGEN INJECTION (E.ON TECHNOLOGIES)

The hydrogen injection unit has been installed next to the gas pressure regulator station and was approved by TÜV (German technical inspection agency). Cylinder bundles provide the hydrogen supply and they need to be replaced every three weeks on average and every four days in the coldest winter days. Hydrogen injection has started and the control of the volumetric hydrogen flow rate has been tested and optimised. The pipe that injects the hydrogen has been configured to ensure the best possible mixture of natural gas and hydrogen. There are two downstream pipe bends for additional mixing to reach an evenly spread gas quality.

A measuring and billing concept was developed in close cooperation with the calibration authority. The volumetric gas flow and the relevant calorific value are determined separately for both, natural gas and hydrogen in one-minute intervals, and the respective values of the components of the distributed mixture are calculated. From this, a weighted monthly calorific value is derived and used for billing purposes. Thus, the expenditure for the installation of an additional process gas chromatograph for the metering of the distributed mixed gas was avoided.

HYDROGEN SUPPLY (E.ON TECHNOLOGIES)

So far, there have been tests with up to 4 vol% of hydrogen injected into the natural gas flow. None of the appliances have shown malfunctions.

The tests will continue in the upcoming heating season with the hydrogen concentration gradually being increased to nearly 10 vol%. The gas will always comply with the quality standards defined in DVGW G 260 (e.g. Wobbe number and relative density). Therefore, the control system will be closely monitored and adjustments made if necessary. Upon extension of the injection period, a series of measurements of representative appliances will be conducted.

A DANISH DEMONSTRATION PROJECT AIMING AT USING THE EXISTING GAS GRID WITH HYDROGEN

The possibility of adding hydrogen to the gas network is currently subject to much attention, since the natural gas network represents potentially very large energy storage for electricity produced by wind and solar power.

The project purpose is to define and demonstrate the extent to which the Danish gas distribution network infrastructure can be used as for energy storage in an energy system - fully or partly - based on hydrogen.

Both practical and theoretical considerations are included in the assessment. The economic expenses of the grid conversion from natural gas into hydrogen are compared to a shift from natural gas into renewable energy via electricity and biomass. There is moreover a scenario of a transition phase from fossils to a renewable based energy system included, with a fully developed supply by renewables safeguarded by minor shares of hydrogen.

The project started earlier in 2014 and phase III is planned to take place in 2015 (depending on the results of the first two phases.) It is executed in cooperation between DGC, the natural gas distribution companies HMN, DONG Energy and Naturgas Fyn as well as TSO Energinet.dk.

The project is divided in three phases:

Phase I: Gas system and gas appliance's suitability for hydrogen

Phase II: Design of demonstration project (small grid system)

Phase III: Demonstration of the operation of gas networks with gradually increased hydrogen concentrations.

For more information: dgc@dgc.dk

THE GRHYD DEMONSTRATION PROJECT | GDF SUEZ

Among the technical issues linked to Power-to-Gas development, several issues related to using hydrogen in natural gas grids have already been explored through a variety of research projects (NaturalHY (EU), Althytude (FR), HIPS (GERG)) in the last decade.

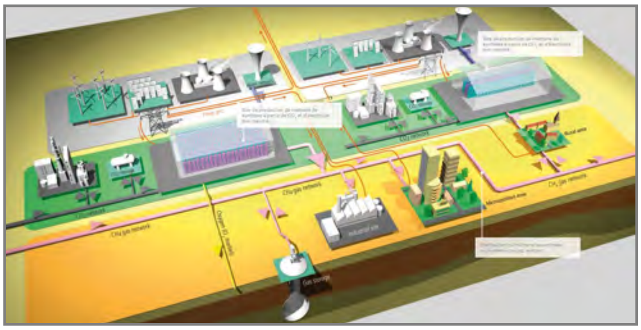
It is believed that injecting synthetic methane into existing natural gas networks raises fewer difficulties than having hydrogen directly injected into the grid which is still to be fully evaluated from a technical and economic point of view. As a consequence, GDF SUEZ Research and Technologies Division and its 12 partners will soon test in Dunkirk the effects of hydrogen injection into a new-built natural gas grid in the GRHYD project (Grid Management by Hydrogen Injection for Reducing Carbon Energies).

The GRHYD project started in the beginning of 2014 with a preliminary phase of about 2 years. The project comprises two demonstration projects:

An industry-size project of Hythane® fuel. A natural gas vehicle (NGV) bus station will be adapted to a hydrogen/natural gas mixture, starting with a 6 vol% hydrogen/natural gas (NG) ratio, rising up to 20 vol%, so as to fuel the 50 NGV city buses.

A project to inject hydrogen in a natural gas distribution network. A newly built area of around 200 dwellings will be supplied by a mixture of hydrogen and natural gas, with hydrogen/natural gas ratio varying up to 20 vol%.

These two pilots have a five year duration. They will allow the evaluation of this new technology, from various outlooks (technical, economical and environmental). Experience gained in the relationship with local communities and inhabitants will also be a plus for the future. Industrial developments of the power to gas technology are expected within the next 5 to 10 years.



POWER TO GAS (GDF SUEZ)

SELECTION OF APPOINTMENTS

(FOCUS ON THE COMBINATION OF HYDROGEN AND NATURAL GAS)

++ H2Expo2014 e-mobility, fuel cells, hydrogen & storage solutions // WindEnergy (23./26. September 2014, Hamburg)

++ wat 2014 + gat 2014 - gasfachliche Aussprachetagung (30. Sep./ 1. Okt. 2014, Karlsruhe)

++ World of Energy Solutions 2014 f-cell, Battery+Storage, e-mobil BW conference (6./8. Oktober 2014, Stuttgart)

++ zukunfts technologie tage „Technologische Herausforderungen der Energiewende" (5./6. November 2014, Cottbus)

++ Energiesymposium Nutzung regenerativer Energiequellen und Wasserstofftechnik (6./8. November 2014, Stralsund)

CURRENT PARTNERS

Alliander ++ DGC ++ DNV·GL Oil & Gas ++ E.ON Technologies (Ratcliffe) limited ++ Enagas ++ Energinet ++ ETIC ++ EWE Netz GmbH ++ Fluxys ++ Gasnatural ++ Gasum OY ++ GRTgaz ++ grzi ++ Infraserv GmbH & Co. Höchst KG ++ ITM-Power ++ KOGAS ++ nPlan GmbH ++ OGE ++ ÖVGW ++ RAG Rohöl-Aufsuchungs Aktiengesellschaft ++ RWE Dea ++ RWE Deutschland ++ SGC ++ Shell ++ Solar Turbines Europe S.A. ++ SVGW ++ Synergrid ++ Verband der Chemischen Industrie ++ Volkswagen AG

INTERESTS AND WISHES

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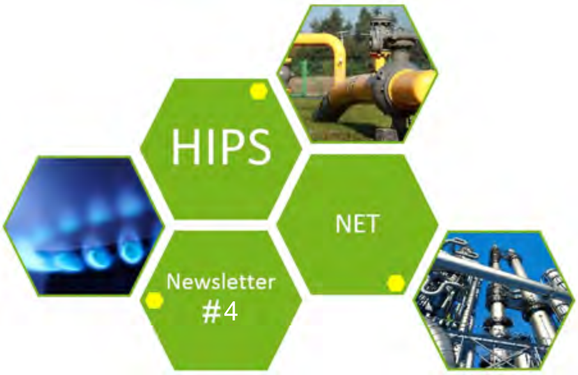
DBI GUT Gas- und Umwelttechnik GmbH

GERG groupe européen de recherches gazières the european gas research group



HIPS-NET

"Establishing a pan-European understanding of admissible hydrogen concentration in the natural gas grid"

Newsletter #4 | **January 2015**

Content Newsletter #4

4th HIPS-NET Newsletter

Dear Project Partners,

The first HIPS-NET project year has come to an end. We thank you very much for the joint work that has been done and would like to let you know that in our perception this first year was a very successful one. We succeeded in uniting 30 partners who share the interest to build up knowledge on the opportunity of using the existing gas infrastructure to transport and use hydrogen together with natural gas. We have identified core topics that need attention and found, with your support, a remarkable amount of R&D projects that provide new knowledge. We also held a very fruitful workshop, which more than 20 of you attended personally and contributed, on a technical level as well as to the development of the network itself. Finally, we used the opportunity to contribute to the European Commission's workshop "Putting science into standards" (described in this newsletter) in order to support paving the way for hydrogen and to receive recognition as a network.

Nevertheless there are many tasks still to be done and our main questions remain, especially regarding the core topics:

- gas turbines and engines;
- natural gas as a working medium and, last but not least;
- cross-border transmission.

The projects that have already provided or intend to give answers in the future on the core topics:

- hydrogen tolerance of underground gas storage facilities (both for above ground installations and underground reservoirs);
- safety characteristics of H_2/natural gas mixtures, and;
- CNG1 vehicle tanks;

will be further observed for you and new findings will be reported by us. Before we go into the technical details, we would like to give you a short summary on the situation of HIPS-NET as well as a short reminder on the tasks we have planned for the second project year.

Power-to-gas - the invisibility of the natural gas grid (Uschi Dreiucker - pixelio.de)

1. General information to the current status of the network HIPS-NET:

The HIPS-NET network was aiming to find 30 partners to perform its planned activities. This aim was reached during the 1st network year. For the second network year, we are currently 27 project partners, while 4 potential partners indicated their strong interest, but the final decisions/contractual preparations are currently in progress (status of 2014-01-30). This is mainly due to necessary contractual adaptations for more than half of the partners involved. They have almost been finalised during recent months, giving us a sound basis for the beginning of the 2nd network year. Corresponding with the intended network member size, the HIPS-NET budget was calculated at 60,000 € per year. The budget was available for the 1st year to cover the mandatory scope that we agreed. The contractually agreed total budget for the 2nd year currently amounts to 54,000 € and we are confident that we will acquire this total budget soon. Therefore, we are starting to perform our scope for the second year as agreed.

2. Outline of the main tasks for the 2nd network year (mandatory scope)

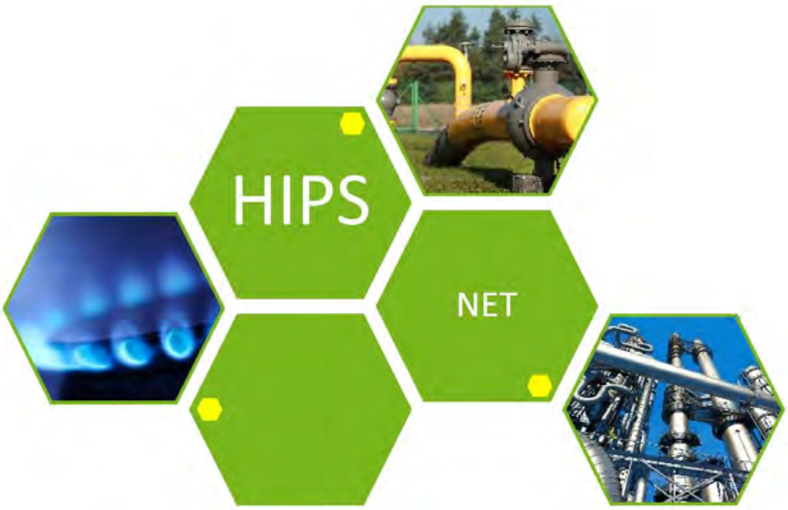
During our workshop in June 2014 we discussed the scope of work, which we want to address during the second HIPS-NET project year. We informed all of the partners and found consensus on the following mandatory scope:

- Investigation of latest information on hydrogen tolerance projects,
- Preparation and issue of quarterly newsletters and realisation of the 2nd annual workshop,
- Preparation of a short final report,
- Preparation of three to four draft proposals concerning the defined core topics (may form the basis for joint research in cooperation with HIPS-NET partners), and
- Adaptation of contracts to continuous duration (applies to more than half of the partners from last year and was mainly finalised; 2 contracts pending)

3. Proposal for additional scope during the 2nd network year (depending on available budget)

Beyond the mandatory scope, we discussed additional activities that would be beneficial in terms of succeeding with the HIPS-NET aims. We originally expected to have budget for additional tasks for the previous year, but this hope was not fulfilled. The ideas (listed in the following) remain and we will cover them in the second project year providing the availability of additional budget:

- Preparation of an overview of regulatory hydrogen limitations in the natural gas grid in Europe (presumably by survey of our HIPS-NET partners and in cooperation with Marcogaz);
- Launch of the HIPS-NET website (mutually agreed by participants of the workshop in June 2014);
- Informing the European Commission on open R&D questions for selected topics (via GERG).



4. Miscellaneous

The final HIPS-NET report for the 1st network year will summarize the main activities and provide an overview of the allocation of the financial resources. We intend to prepare and distribute the final HIPS-NET report within the next few weeks. We thank you for your patience as the last newsletter of project year 1 as well as the final report is late. This will not become a habit as this was caused by the additional contractual work that is now almost finalised.

If you have remarks to the outline for the 2nd year, or suggestions, please get in touch with us. Otherwise, we hope you find the articles in this newsletter an interesting and stimulating read.

The HIPS-NET team
Gert, Dave, Stefan, and Anja

"A network leads to cooperation, cooperation leads to creativity and innovation - this changes the world."

- Marissa Mayer (CEO Yahoo)

DGMK Research Report 756 “Influence of Bio-methane and Hydrogen on the Microbiology of Underground Gas Storage”

The report summarises existing knowledge by means of a literature study to assess the possible effects and risks of a partial injection of hydrogen and bio-methane into underground gas storage facilities.

The authors described various possible microbiological processes and found that although conditions for colonisation of caverns and porous reservoirs with microorganisms are indeed different, microbial growth seems to be possible in almost all German underground gas storage facilities. Only in very deep-lying storage, sterile zones can be assumed due to temperatures above 100 °C or a combination of heat and osmotic stress. High salt concentrations of cavern brine or formation water may only suppress or delay microbial processes, but cannot offer protection against a microbial settlement. Especially porous reservoirs with moderate temperatures (30 – 50 °C) and a low mineralisation grade (0 – 100 g/kg) generally provide good conditions for microbial growth. Under anaerobic conditions hydrogen is, in contrast to methane, an easily utilisable energy source, which is used by many groups of microorganisms. Therefore, the authors are reluctant to specify a safe hydrogen concentration limit for a partial feed-in of hydrogen.

Experiences with town gas storage indicate a turnover period of a few weeks or months. This may, under certain conditions, result in a loss of pressure as well as calorific value and, therefore, cause negative implications for the management and safety of underground gas storage.

The report is available in English and German, was published in May 2013 and may be purchased for 70 € at DGMK (German Society for Petroleum and Coal Science and Technology). (http://www.dgmk.de/berichte.htm)

The abstract of the DGMK-Research Report 756 (http://www.dgmk.de/upstream/abstracts/publications/756.html)

Especially porous rock reservoirs are exposed to a number of risks, such as formation of sulphide (H_2S), microbial induced corrosion (MIC) or reduction of formation permeability. The study explains the risk exposure for porous rock and, additionally, possible effects on caverns. The latter are regarded as less serious.

Measures for the prevention or treatment of microbial damages on underground storages are available to a limited extent and must be adapted to the specific case.

Underground Sun Storage (RAG Austria) (part 1)

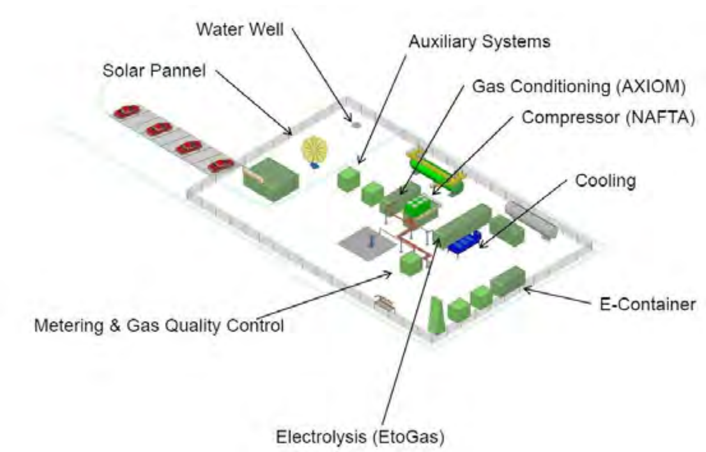
The HyUnder project has been finalised and RAG Austria, as one of our HIPS-NET partners, introduced the “Underground Sun Storage” project during the HIPS-NET workshop in June 2014. The project aims to store natural gas with a 10 vol% concentration of hydrogen in porous rock underground storage. Based on the preliminary results of the first six work packages, the decision has been taken to design, build and operate a pilot facility.

Underground Sun Storage Lehen (RAG Austria)

Design and approval by authorities is currently in progress. Preparation and construction on site will start shortly with the following steps to be carried out:

- USIT (UltraSonic Imager Tool) to check the integrity of the cement bond,
- Verification of material durability as packers, metals and SSSV (sub-surface safety valve),
- Additional water sampling previously to the field test,
- Preparation of the well site,
- Installation of a new completion string with SSSV and VAGTX-Tubing (Voest Alpine Gas Tight Extrem),
- Contact with relevant authorities and preparation to obtain the relevant legal permissions.

UNDERGROUND SUN STORAGE (RAG AUSTRIA) (PART 2)



SITE PLAN UNDERGROUND SUN STORAGE (RAG AUSTRIA)

The field test operation will commence in summer 2015 with the injection phase. Hydrogen will be generated via electrolysis on site and blended into the gas stream. The gas with a concentration of up to 10 vol% hydrogen will be injected by a gas compressor into the porous rock formation. This will go along with material testing.

During the second period, the intermediate phase, the subsurface pressure and temperature, the surface pressure, and gas composition will be monitored. Further regular maintenance and safety checks will be carried out. The gas is stored and not moved during that time. At the beginning of the third period, the production phase, in spring 2016, water and gas samples will be taken prior to the extraction of the gas from the storage formation. The extracted gas will be measured and conditioned by a membrane separator (provided by Axiom). Further material testing will follow.

Further information (http://www.underground-sun-storage.at/en/project/project-description.html)

POWER-TO-GAS-TO-POWER | PILOT PROJECT FOR A STAND-ALONE POWER SYSTEM IN ARGENTINA

The company Hychico has set up a wind park and a hydrogen plant as a semi-industrial project in Patagonia (Argentina). One of the goals is to couple wind turbines with electrolysers for hydrogen and oxygen production, developing a stand-alone power system that would go beyond laboratory scale. The region offers high wind potentials, little population, water availability, infrastructure, and skilled labour from the oil & industry.

HYDROGEN PLANT (WWW.HYCHICO.COM)

The pilot hydrogen plant has two electrolysers with a total capacity of 120 Nm^3/h of hydrogen, 60 Nm^3/h of oxygen and the high purity hydrogen (99.998 %) is suitable for fuel cell applications.

In the pilot plant the hydrogen is mixed with natural gas to feed a 1.4 MW GenSet generator equipped with an internal combustion engine, which is especially adapted to operate flexibly with rich and/or poor gas mixed with hydrogen. The hydrogen concentration rates achieved (up to 42%) are above the customary international ranges for these engines, and have shown good performance and efficiency in reducing CO_2, CO, and NO_x emissions.

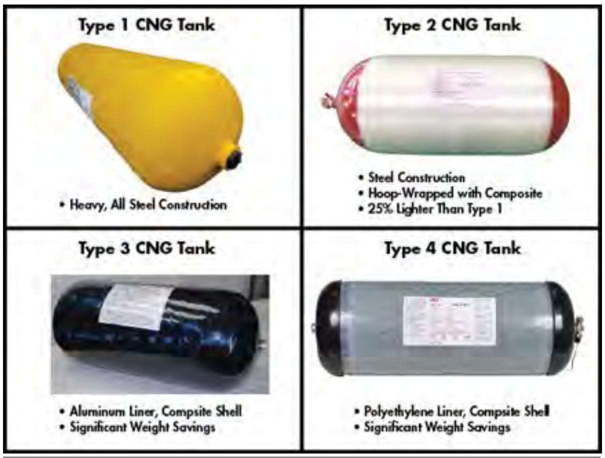
Taking into account that storing large quantities of hydrogen is one of the critical aspects of integrating hydrogen into the energy matrix, and given the proximity of the hydrogen plant to some depleted oil and gas reservoirs, Hychico is running a pilot project related to Underground Hydrogen Storage. The goal is to test the reservoir's capacity, tightness, and behaviour. The hydrogen pipeline and first results are expected in early 2015. Furthermore the susceptibility for hydrogen induced embrittlement and degradation of various steel grades and metals are being tested. In this context a new polymer-hybrid pipe from REHAU, which shows no hydrogen permeation and can be installed over long distances in one piece, has been chosen to be installed for connecting the hydrogen plant and the depleted gas reservoir.

More detailed information about power variation of the generator, emission reduction, and electrolyser performance (http://www.hychico.com/hydrogen-plant.php)
Further information regarding the underground hydrogen storage (http://www.hychico.com/underground-hydrogen-storage.php)

INTRODUCTION OF HYDROGEN CONCENTRATION ABOVE 2 VOL% FOR NATURAL GAS AS FUEL

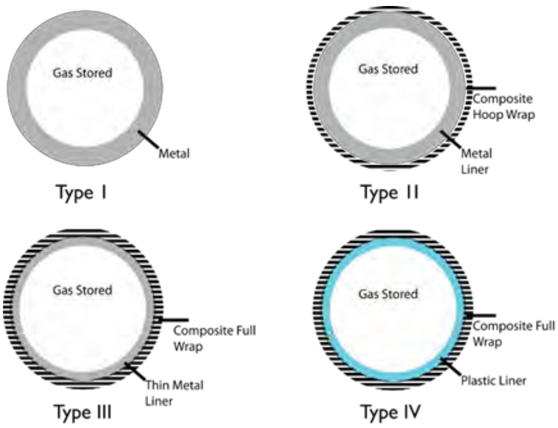
Tanks for vehicles driving on natural gas need to comply with the international technical standard ECE R110 to receive an ECE approval mark. This standard has been adopted in the European standard DIN EN 51624 and thus is valid and binding in European countries. Both standards limit the hydrogen concentration for natural gas used as fuel in steel tanks (with a tensile strength of more than 950 MPa) to 2 vol% (refers to CNG type 1 tanks).

According to the current state of knowledge, material embrittlement cannot be excluded for that steel if it is exposed to hydrogen concentrations exceeding 2 vol%. This does not necessarily mean that exposure does result in embrittlement; it rather means that research has to be conducted for reliable results.



CNG TANK TYPE (HTTP://WWW.CNGPITSTOP.COM)

One strategy, we suggest, is the modification of technical standards. Should the research provide evidence that the current limitation (2 vol%) may be adjusted to 5 vol% or even 10 vol%, the above mentioned standards should be updated and modified. The modification would however require a consensus between the countries represented in the standardisation bodies and the procedure may last some time.

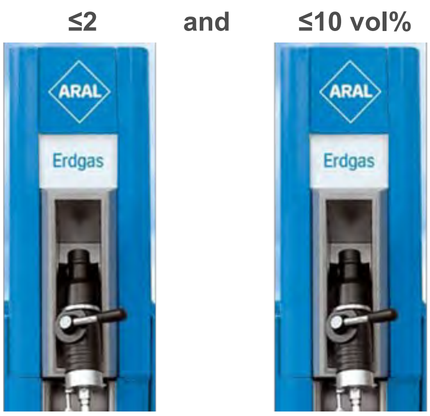


SIMPLIFIED STRUCTURE (HTTP://WWW.GASTOCNGUTAH.COM)

Another strategy, we propose, relies on the material used. The described limitation only applies to old (running) vehicles. New cars may either undergo a surface inspection of the built-in tanks, or use other material compositions. Substitute material may induce higher investment but may be favoured due to advantages such as lower weight and increased hydrogen tolerance.

A third strategy, we offer, refers to the gas offered at petrol stations. Rather than one single filling pump for natural gas, a second pump should be introduced for higher concentrations of hydrogen. Even if the modification of the technical standards would be implemented soon, the used (running) natural gas driven vehicles would impose the 2 vol% restrictions until 2040 (conservative estimation).

The two gas pump system would allow extraction of hydrogen exceeding the 2 vol% by a membrane technology and would offer the possibility to use the extracted hydrogen for a third application, such as feeding fuel cell vehicles or for industrial use. We intend setting up a pilot project proposal on regional scale based on the third strategy to explore the technical implementation undermined by an economic assessment.



SCHEMA TWO GAS PUMP SYSTEM (ARAL)

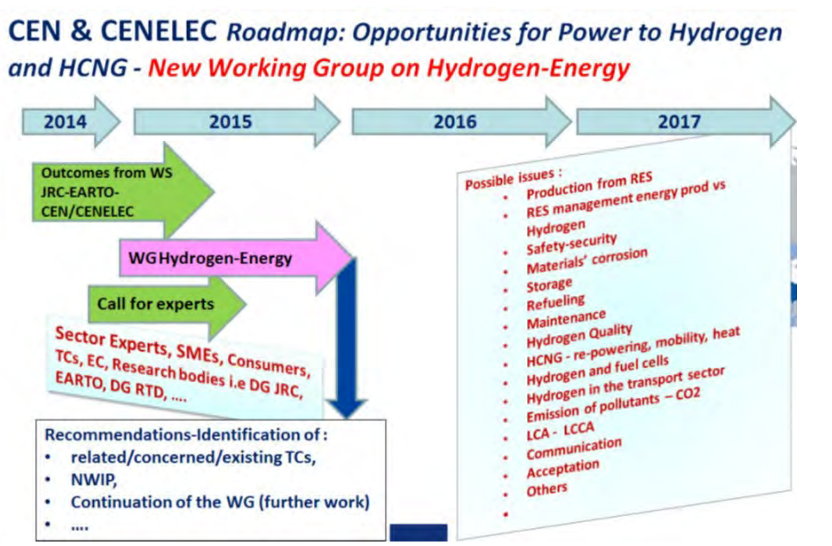
Generally speaking, instead of aiming at single strategies, we propose to evaluate all possible strategies to develop an optimised combination of them.

We aim to develop a research project, preferably with international partners, to assess the strategies described above and to pave the way for hydrogen injection exceeding concentrations of 2 vol% in the whole gas network in future. We accordingly suggest setting up a research proposal and additionally a position paper to promote the issue funding authorities for contribution and support.

If you would like to join please contact us.

STANDARDISATION WORKSHOP PUTTING SCIENCE INTO STANDARDS: POWER-TO-HYDROGEN AND HCNG

On the 21st and 22nd October 2014 the Joint Research Centre (JRC) Petten, CEN/ CENELEC and EARTO held a Workshop on "Power-to-Hydrogen and HCNG" as this technology has been identified as having a promising potential for the integration of renewables, especially with its large-scale storage capacity. The aims of the workshop were to speed up the standardisation process and the internationalisation of standards regarding the production, transportation, distribution and use of hydrogen on a European level and to liaise the activities with ISO TC 197 ("Hydrogen technologies"). In order to succeed with these aims, the four sessions were prepared and run by experts and representatives from different standardisation organisations. Every session defined the next steps for further development of the technology, paying special attention to standardisation aspects. In the following, we try to give a short summary that cannot reflect the whole picture of findings as they were too voluminous to be condensed in a few lines but may give a flavour of the session outcomes.



EC.EUROPA.EU/JRC/SITES/DEFAULT/FILES/HCNG-2014-FINAL-REPORT.PDF

Session 1 – Power to hydrogen

- Defining H_2 as green fuel is considered to be crucial.
- Integration of technologies in electricity, gas and heat grids is important.
- Iterations between demonstration and R&D are required to bridge the gap between demonstrated technical feasibility and the availability of solutions for storing intermittent energy being economically and environmentally relevant.

Session 2 – Injection / admixture of hydrogen to the natural gas grid

- Establishing the limit of H_2 that can safely be injected in the natural gas grid is an important task on European level.
- Further research is needed in the field of CNG tanks and filling stations, appliances and industrial burners, underground storage, compressors, and gas composition analysis devices.
- A macroeconomic evaluation of power to gas routes including the cost for adaption of the existing infrastructure is needed in order to prepare a P2G Roadmap.

Session 3 – Use of HCNG for repowering, mobility, heat

- Pre-normative research regarding flame length, temperature and heat radiation is recommended.
- End user installation certification for HCNG, regarding their compatibility with flame stability and hydrogen embrittlement, is needed.
- Detection devices and mitigating safety measures need to be certified.

Session 4 – Standardisation aspects for provision of to support the electricity grid

- A stronger integration of TSO/DSO into the discussion is needed.
- Definition of test, measurement methods, and load cycles in electrolyser performance standards to enable qualification for ancillary service provision is recommended.
- Definition of quality related parameters to determine the quality of supply of ancillary services.

Beyond the discussion of the technical needs and aspects, the initiators of the workshop informed that a new CEN/ CENELEC SFEM working group on hydrogen will be launched in January 2015 as an open platform for further evaluation/ identification of strategic topics. Part of the scope is also to map existing initiatives, to identify new needs and main challenges to be faced in order to use the potential of hydrogen as HCNG. By the end of the year (2015), the working group will propose an action plan for the up-coming years and will give recommendations e.g. on how to proceed with liaison with CEN TC 197 and suggest a new work item proposal.

INTEGRATION OF HIGH-PRESSURE ALKALINE ELECTROLYSERS FOR ELECTRICITY AND HYDROGEN PRODUCTION

The ELYGRID project aims to reduce the total costs of hydrogen produced via electrolysis using renewable electricity sources and focusing on megawatt size electrolysers (from 0.5 MW and beyond). The objectives are to improve the efficiency of the overall system by 20 % and to reduce costs by 25 %. The work has been structured in three different parts: cells improvements, power electronics and balance of plant (BOP). The project furthermore aims to improve the stability of the electricity grid by using volatile electricity mainly generated by wind turbines and PV. Two scalable prototype high-pressure alkaline electrolysers are tested, which allow the integration of fluctuating electricity sources.

LEFT: IHT ELECTROLYSER TYPE S-556 (760 NM3/H). RIGHT: TEST BENCH ELECTROLYSER AT FHA FACILITIES. (ELYGRID)

The project, which was completed at the end of 2014, has achieved progress in the main technology fields. The unit capacity was increased from 68 kg/h H_2 (state of the art in 2011) to 124 kg/h H_2 (in 2014), mainly due to the enhanced current density. The energy conversion efficiency of the stack (without BOP and power electronics) amounts to 70 % in the laboratory size electrolyser of 200 kW and thus meets the target of the funding authority (FCH-JU) for 2020 already today (target 2020: 64% including BOP and power electronics). According to the calculations in the project, the capital expenses (CAPEX) for the initial investment are below the FCH-JU target for 2020 of 2 M€ with a H_2 production capacity of 1 t/day.

More information may be found under www.elygrid.com.

The ELYGRID project has been funded by the FCH-JU. The partners involved in the project are willing to demonstrate this technology in megawatt range (1-2 MW or beyond) with potential end-users (utilities, gas network operators, etc.) in different applications (P2G, large automotive project, industry, etc.) in order to develop new business models as preceding step for the definitive market deployment.

HYDROGEN MOBILITY INFRASTRUCTURE

Development of hydrogen mobility depends not only on technical advanced vehicles running on hydrogen but also on available, easily accessible filling stations.

More information may be retrieved http://cleanenergypartnership.de/en/h2-infrastructure/refuelling/

LEFT: HYDROGEN FILLING STATION (LINDE AG). RIGHT: (TOTAL / PIERRE ADENIS)

The industrial partners Air Liquide, Air Products, Daimler, Linde and Total Germany signed together with the German Ministry of Transport a letter of intent to develop a network of hydrogen filling stations. A basic supply network will be available in Germany by the end of 2015 with 50 stations and extended until 2023 with up to 400 stations.

FUEL CELL MOBILITY

TOYOTA announced that it will begin selling fuel-cell electric cars in Japan on 15 December, 2014, and in the US and Europe in mid-2015. Thus, Toyota as well as Hyundai, release fuel-cell vehicles thus commercially stepping forward and leaving the mere demonstration sphere. The Toyota Mirai uses the Toyota Fuel Cell System (TFCS), which brings together fuel cell and hybrid technologies. It includes Toyota's new proprietary fuel cell stack, which has a maximum power output of 153bhp (114kW), and high-pressure hydrogen tanks. Hydrogen when compressed has a higher energy density than batteries. The TFCS energy efficiency is more than two times higher than the one of an internal combustion engine and it emits no CO_2 or pollutants when the vehicle is driven. Market launch in Germany is expected at a price around 65,000 € + VAT.

FUELL CELL TOYOTA

TOYOTA MIRAI

HYUNDAI released the first mass-produced hydrogen-powered fuel cell vehicle with the Hyundai ix35 Fuel Cell in 2013. The vehicle is equipped with a 100 kW (136 PS) fuel cell stack and two hydrogen storage tanks, with a total capacity of 5,64 kg. This amount of stored hydrogen enables the ix35 Fuel Cell to travel a total of 588 km on a single refuel. Maximum speed is 160 km/h, and it can reliably start in temperatures as low as minus 25 degrees Celsius. The energy developed is stored in a 24 kW lithium-polymer battery. The ix35 Fuel Cell is offered for leasing at 1,150 € per month or for sale for about 65,000 € (prices in Germany).

FUELL CELL HYUNDAI IX35

SAFETY CHARACTERISTICS OF NATURAL GAS WITH A HYDROGEN CONCENTRATION OF 10 VOL%

This current research project aims to analyse safety characteristics for natural gas/hydrogen mixtures.

The project comprises firstly a literature study, which will be followed by a theoretical estimation using calculation methods for safety characteristics. The results will be validated and/or assessed in a third step by field-testing, to determine such data. The project partners intend to assess safety characteristics of different samples of natural gas from the German gas network. Thus, the varying gas qualities within Germany will be taken into account. They propose to add hydrogen to achieve a concentration of 10 vol% and to perform the safety tests with the samples again. This shall give a profound insight of the behaviour of gas mixtures on:

- Explosion limits and explosion ranges in mixture with inert gases for plant safety and zone determination
- Auto ignition temperature (AIT) for determination of temperature classes
- Maximum experimental safe gap (MESG) for determination of explosion groups
- Maximum explosion pressure and maximum rate of explosion pressure rise
- Ex-zones / propagation behaviour at GPRS (gas pressure regulating stations) and pipelines
- Still under consideration: Determination of the compatibility of gas detectors

There are three partners involved in the research project, among them one employers' liability insurance association: BG ETEM, BAM (Federal Institute for Materials Research and Testing), and DBI. The investigations will probably begin in March 2015 and are expected to run until winter 2015.

According to the final report of the project "Hydrogen in Pipeline Systems" (HIPS), an admixture of 25 vol% hydrogen in natural gas does not affect the gas group according to the ATEX classification (see page 322). If this proves to be true, it would not be necessary to change the equipment at M&R stations. (The stations are certified for ATEX gas group IIA; pure hydrogen however requires group IIC.) Some of the HIPS-NET partners tried to verify the source for this conclusion on hydrogen concentrations of up to 25 % in natural gas but were not able to retrieve it. This information is still lacking and might be answered by the initiated research project.

Important Events - Workshops - Conferences and Partners

Selection of appointments

(focus on the combination of hydrogen and natural gas)

++ E-world energy & water
(10./12. Feb. 2015, Essen)

++ Forum EnergieSpeicher
(02./03. March 2015, Berlin)

++ 4th Conference Power-to-Gas:
Renewable Fuels for Europe´s Energy Industry
(11. March 2015, Düsseldorf)

++ Energy Storage 2015
(09./11. March 2015, Düsseldorf)

++ Münchner Energietage:
Konvergenz von Strom und Gas
(21. April 2015, Munich)

Current partners

Alliander ++ DGC ++ DNV·GL Oil & Gas ++ E.ON Technologies (Ratcliffe) limited ++ Enagas ++ Energinet ++ ETIC ++ EWE Netz GmbH ++ Fluxys ++ Gasnatural ++ Gasum OY ++ GRTgaz ++ grzi ++ Infraserv GmbH & Co. Höchst KG ++ ITM-Power ++ KOGAS ++ nPlan GmbH ++ OGE ++ ÖVGW ++ RAG Rohöl-Aufsuchungs Aktiengesellschaft ++ RWE Dea ++ RWE Deutschland ++ SGC ++ Shell ++ Solar Turbines Europe S.A. ++ SVGW ++ Synergrid ++ Verband der Chemischen Industrie ++ Volkswagen AG

Interests and wishes

Please let us know if you have special interests/wishes for the next newsletter. We look forward to your feedback and we aim to provide quality information that is actually needed and wanted to answer the hydrogen core topics.

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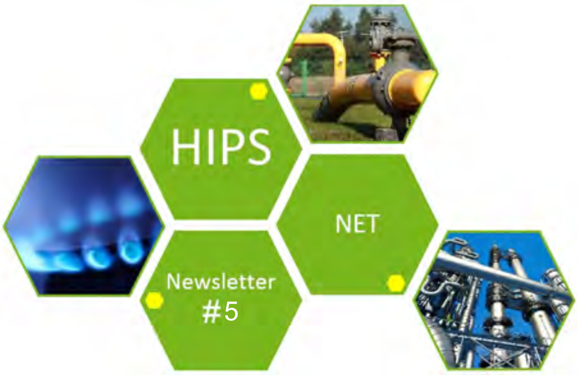


HIPS-NET

"Establishing a pan-European understanding of admissible hydrogen concentration in the natural gas grid"

Newsletter #5 **June 2015**

Content Newsletter #5

5TH HIPS-NET Newsletter

Dear Project Partners,

Welcome to the 2nd year of HIPS-NET network. This newsletter covers topics from the integration of power-to-gas and its impact on the electricity as well as gas network, over mobility applications (including the gas network), to activities on hydrogen transport in the North Sea Region. We have also developed a list of power-to-gas projects worldwide and included it in the newsletter. Please inform us if you have knowledge about further projects. We hope you find the information interesting and informative.

"A network leads to cooperation, cooperation leads to creativity and innovation - this changes the world."

- Marissa Mayer (CEO Yahoo)

The annual HIPS-NET workshop is right ahead of us, taking place on Wednesday, 24th June 2015 - thanks to the friendly hospitality of the GERG secretary Robert Judd - in the GERG premises in Brussels from 9:30 am to 4 pm. We will meet the evening before on Tuesday, 23rd June 2015 at 7 pm for a casual dinner. We expect about 30 participants for the workshop and about 20 joining the dinner.

As explained during last year's workshop, the contracts of about half the partners (16 contracts) went through a renewal procedure, as they automatically ran out after one year. We learned, internally and from the partners, that an automatic prolongation of the contract reduces work on both sides and preserves the flexibility at the same time. Two partners, nPlan (Germany) and Fluxys (Belgium), did not renew their membership by now.

Power-to-gas - the invisibility of the natural gas grid (Uschi Dreiucker - pixelio.de)

Two new partners, GDF SUEZ (France) and NAFTA a.s. (Slovakia), decided to join the network and signed in. We are thus maintaining the stable base of 30 HIPS-NET partners as originally pursued.

We are presently looking forward to the workshop and will afterwards prepare a summary of the presentations to inform the attending partners as well as the partners which were not able to join us in Brussels.

ROLE OF POWER-TO-GAS IN AN INTEGRATED GAS AND ELECTRICITY SYSTEM IN GREAT BRITAIN

The study was performed by Cardiff School of Engineering (Meysam Qadrdan), Cardiff University

The “Role of power-to-gas in an integrated gas and electricity system in Great Britain” was analysed in a study by Cardiff University in 2014. In this study, the energy system of the UK was simulated with the aim to optimize the operating costs. In the process both, the gas and the electricity grid were considered.

Currently, natural gas accounts for 38% of the primary energy demand in the UK. The 280,000 km-long gas grid in operation needs reconstruction in large parts due to aging. The estimated reconstruction investment amounts to approximately £7 billion.

The electricity sector in general and wind energy (onshore and offshore) in particular will gain importance. Due to increasing capacity (in particular wind and nuclear power), significant investment is required to build and reinforce the electricity transmission network. Rising wind capacity will result in increasing curtailment of wind power, amounting to 0.1 TWh/a in 2014 up to 2.8 TWh/a in 2020 and between 50 - 100 TWh/a in 2050.

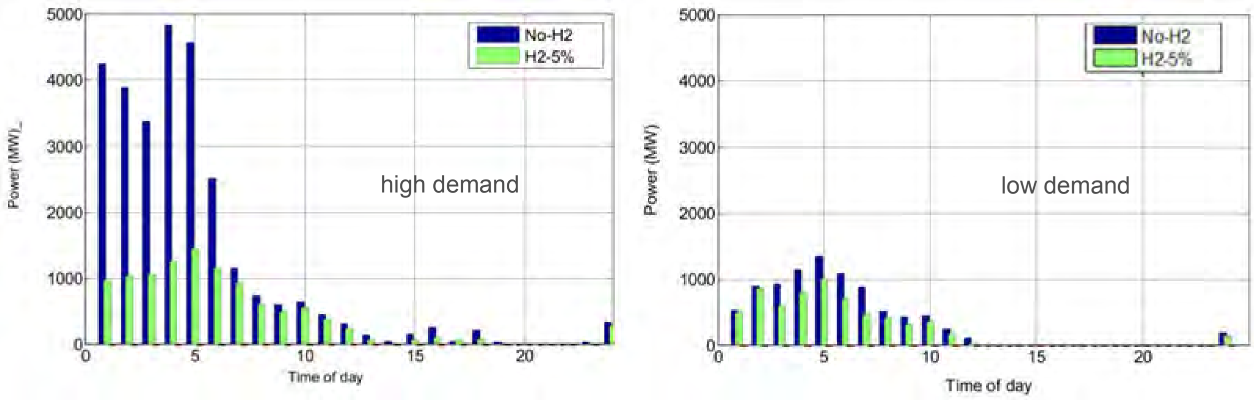
The researchers simulated a detailed future scenario for the year 2020 of the UK’s electricity and gas supply to determine the minimum operating costs of meeting the electricity and gas demand. These operating costs included the economic costs of gas supplies, gas storage operation, power generation and costs of unserved energy. The cost of CO_2-emissions was not included. For the simulation the real electricity and gas transmission systems were simplified. The distribution system was not included to the simulation.

The study compared three scenarios, one without Power-to-Gas (PtG) systems (referred to as No-H_2 case), and two employing PtG systems:

- without PtG: No-H_2 case,
- hydrogen injection limited to 5% of the local grid gas flow: H_2-5% case and
- hydrogen injection unlimited: H_2-Unlimit case.

The three described scenarios were tested for two different electricity demand prognoses (high and low). Both high and low scenarios were based on real-time demand data sourced from the national electricity grid in mid-April mid-January 2013 respectively.

The simulation results show the impact of PtG on different regions of the entire UK gas and electricity transmission systems. Power generation from conventional fuels (nuclear, coal) supplied a significant part of the base load in the No-H_2 case (for both electricity demand). Gas turbines meet the remaining electricity demand (demand not met by wind, nuclear and coal). Wind curtailment was very high (Fig.), especially during the first third of the day (12pm to 8am) and prevalent in the North UK (Scotland and North England regions). This is due to the low power demand during early hours, the highly congested north-south power transmission line and the inflexibility of nuclear power plants.



COMPARISON HIGH AND LOW DEMAND I SOURCE: MEYSAM QADRDAN

The operation of PtG reduced the wind curtailment, in the H_2-5% case by 62.3% (high demand) and by 27% (low demand) in comparison to the No-H_2 case. Wind curtailment was eliminated completely in the H_2-Unlimited case. According to the wind capacity 70-95% of the hydrogen was produced in the north regions. The total share of hydrogen in the entire UK gas network did not exceed 3% of the national gas demand even in the H_2-Unlimited case.

The simulation shows that PtG systems can reduce the operational cost of UK electricity and gas supply. The implementation of PtG can reduce the amount of unserved energy. The produced hydrogen substitutes gas supplies from terminals. An operating cost reduction from 7 to 11% in comparison to the No-H_2 case was shown. Based on this, the simple payback period of investment in PtG technologies amounts to 10 – 14 years. The simulation does not restrict the electricity source, which supplies the PtG system. The hydrogen produced is not CO_2 neutral, as the electricity comes from regenerative and conventional sources.

UK regulation currently limits the hydrogen injection into the natural gas network above 0.1% volume. To realize the potential of hydrogen injection into the gas grid, as illustrated by the study, hydrogen limits will need to be relaxed subject to a full health and safety appraisal. The UK government plans to increase the hydrogen limit to 3% (to commence in 2015).

GRIDGAS – FEASIBILITY STUDY OF POWER-TO-GAS IN GREAT BRITAIN

ITM Power has completed a detailed study of Power-to-Gas as a feasible resource in the UK. The study addresses technical feasibility, the PtG operating regimes, the economic value propositions to the electricity and gas industries and the potential roll out of plants across the period to 2050. The study (conducted jointly with the National Grid, SSE, Shell, Scotia Gas Networks, kiwa-Gastec and SHFCA and funded by the Technology Strategy Board to a level of £100,000) focused principally on PtG systems in the UK, whilst considering the expansion of this technology across Europe.

Analysis determined that polymer electrolyte membrane (PEM) electrolyser technology was the most suitable method for the PtG systems. In addition the study made various recommendations including the adoption of a 3% by volume hydrogen concentration limit in the UK commencing 2015 (instead of the UK's current regulations, which specify a 0.1% concentration). Hydrogen concentrations in excess of 3% by volume may cause flashback problems when switching off some old "yellow flame" appliances, of which an uncertain number still remain in the UK market. In order to achieve this concentration, the process requires dehumidification to -10 °C, 33.3:1 dilution and downstream measurements of flow, composition and combustion properties. The study also recommends the injection of hydrogen only into low-pressure Local Distribution Zones in order to avoid an excess of hydrogen within the network.

The study identified the utilization of PtG plants in combination with existing solar or wind infrastructure as a prospective pathway with a potential hydrogen concentration of 21% by 2050. This pathway would save 4.1 $MtCO_2$ per year and developing a PtG stock capacity of 7.8 GW.

In addition, the study conducted a detailed geographical analysis to determine the most efficient locations for the introduction of PtG systems. This analysis established 40 locations for the roll-out of PtG in the UK. In order to aid development of the P2G pathway in the UK, it also recommended that Feed-In Tariffs (FIT) be extended to include hydrogen for electrolysis, and that CAPEX support be increased.

POWER TO GAS: TECHNOLOGICAL OVERVIEW, SYSTEMS ANALYSIS AND ECONOMIC ASSESSMENT FOR A CASE STUDY IN GERMANY

The centerpiece of the article documents a study, carried out by the researchers, to determine the economic viability of PtG (hydrogen and methane) in the existing natural gas infrastructure and the viability of a dedicated hydrogen gas network for use in the road-transport industry. A key feature of this study is a cost- projection for the development of the respective networks. This projection was based on 2010 electric loads and envisages the continued development of the technology used and continued electrification. For PtG production, the projection also envisages 51,000 km of new pipeline, salt caverns with a capacity of 27-90 TWh and 9,800 refuelling stations.

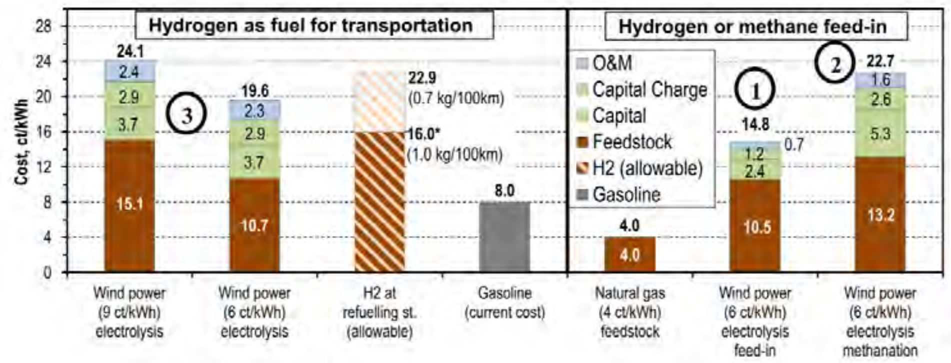
Process chain component	Installed capacity [size or number]			Investment [€ billion]		
Case	H_2 for traffic	H_2 in NG	CH_4 in NG	H_2 for traffic	H_2 in NG	CH_4 in NG
Electrolyzers (η = 70%, € 720/kW_{H2})	59 GW_{H2}	59 GW_{H2}	59 GW_{H2}	42	42	42
Methanation (η = 80%, € 720/kW_{CH4})	–	–	47 GW_{CH4}	–	–	34
Pipeline grid[a]	$5.4 \cdot 10^6$ t/a	–	–	19–25	–	–
Geological storage[b]	27/90 TWh	–	–	5/15	–	–
H_2 refueling stations (€ 2,000,000/unit)	9800 units	–	–	20	–	–
Total investment				**86–102**	**42**	**76**

[a] Comprising transmission (12,000 km) and distribution (39,000 km) networks.
[b] Lower value for seasonal balancing; higher value for 60 day reserve.

INVESTMENT COSTS FOR POWER-TO-GAS PROCESS CHAINS I SOURCE: SCHIEBAHN ET AL.

This data is then used to calculate the comparative costs of the three different scenarios. This comparison covers electricity costs, operation and maintenance, capital costs and costs from capital charges.

The article concludes that, using current technologies, PtG and PtM are not yet cost-efficient alternatives to natural gas for general usage. Feeding PtG in to the existing gas infrastructure would cost € 0.15 /kWh, approximately four times the current cost of natural gas (before considering upgrades necessary to the gas network for increased levels of hydrogen). PtM would cost € 0.23 /kWh due to extra investment costs and the current inefficiency of this technology.



COMPARISON HIGH AND LOW DEMAND I SOURCE: MEYSAM QADRDAN

However, the continued development of these technologies may change this. PtG would already provide a viable alternative to natural gas for use in the road-transport industry. At present hydrogen fuel-cell technology is only 23% less efficient than petrol/gasoline and therefore already more efficient than natural gas. The study concludes that, with continued investment, hydrogen may soon become just as efficient as petrol/gasoline for automotive purposes. (2015, Hydrogen Energy Publications, LLC.)

REGIO-ENERGIE SOLOTHURN

Development is continuing on the Hybridwerk Aarmatt hybrid power plant in Switzerland. The project intends to utilize a mix of energy sources and storage methods to provide an efficient energy solution for the town. Solothurn intends to connect the gas network, electricity grid and district heating network by creating a power plant with an integrated heating plant and thermal energy storage system, a combined heat and power installation, and a power-to-gas facility with hydrogen storage capabilities. Participating in the project are RegioEnergie Solothurn, Erdgas/Biogas, Solothurn Municipal Government, Gasverbund Mittelland, the Swiss Federal Office of Energy (SFOE), Canton of Solothurn Department of Buildings, the Lucerne University of Applied Sciences and Arts and the University of Applied Sciences Rapperswil.

The first elements of the project were initiated in 2013 with the creation of the 6MW heating plant including two 5.5 MWh thermal energy storage systems, which will serve the district heating network. One out of two cogeneration elements of the plant were completed, leaving spare capacity for a second combined heat and power unit, each with an output of 1.2 MW. In order to make the plant more responsive to fluctuations in power demand and to better utilize excess renewable energy supplies, the plant will include a power-to-gas unit, in which excess power will be converted by means of electrolysis into hydrogen. This hydrogen will then be fed in to the local gas network at a concentration of 2%. The installation of a 180 m³ buffer tank will allow the constant and regulated flow of hydrogen into the network.

Alternatively, this hydrogen can be stored on-site in hydrogen storage tanks. In late February this year the hydrogen storage tanks (with a capacity of 180 Nm³ at 30 bar) were delivered and these will be connected to the PEM electrolysers (with an input power of 350 kW and a hydrogen output of 60 Nm³ at an efficiency level of 50-60%) to form the core elements of the power-to-gas conversion and storage process. The strategic solution for the feed-in of hydrogen has been developed by the Lucerne University of Applied Sciences and Arts with support from the Swiss Federal Office for Energy (BFE). The plant's electrolysers will also be used by several universities in the region for further research into hydrogen levels in the gas network. Theoretical studies in this field have already been concluded by the University of Applied Sciences Rapperswil.

Future plans to further develop the hybrid power plant include the installation of methanisation technology for the creation of synthetic natural gas. The plant envisages that gas produced by this technology (using surplus hydrogen from the power -to-gas process and carbon dioxide from the combined heat and power plant), could be used as fuel for the local public transport network. Provisions have also been made for the possible installation of wood gas generators or a geothermal system in addition to the planned power plant.

Further details on the development of this project can be found here: www.hybridwerk.ch

In addition, the project is exploring other strategic solutions with regard to power-to-gas technology. Research into the possibility to combine electrolysers with battery storage in order to increase the storage capacity of a power-to-gas unit is planned. The recovery of residual heat and the utilization of electrolysers in connection with a combined heat and power installation will also be analysed.

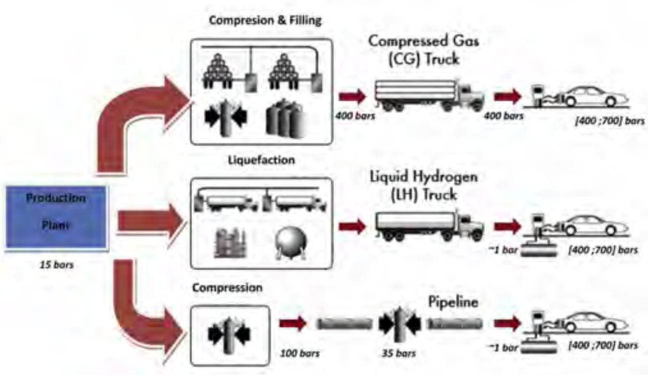
STUDY FOR MOBILITY APPLICATIONS: EVALUATION OF THREE DIFFERENT HYDROGEN SUPPLY STRATEGIES IN FRANCE

The research aimed to evaluate the costs and the design to distribute hydrogen using various deployment strategies. The approach considers the distribution by pipeline and compares it with other hydrogen carriers namely compressed gas trucks and liquid cryogenic trucks. The software ECOTRANSHY, which has been developed during the research project, answers the following questions:

- What is the optimal design (topology and diameters) of a new-built hydrogen pipeline network?
- Taking into account an increasing market share of hydrogen, when will a pipeline network reach economic viability versus a delivery by trucks?

The authors found that before 2025, and considering a low market share of hydrogen as fuel, supply by trucks would remain the most economical option. However, beyond 2025, the pipeline option is considered as an economically viable option as soon as the market share for the car fuelling reaches 10%.

The delivery costs by truck or pipeline increase with the distance from the central plant. The pipeline delivery costs are higher than the delivery by truck for the nearest points to the production unit and lower than the delivery costs by truck for the furthest points to the production. Over short distances, gaseous truck delivery is the favoured option especially at low flow rates, but pipeline based supply is preferred at higher flow rates.



HYDROGEN SUPPLY CHAINS | SOURCE: ANDRÉ ET AL.

EFFECTIVE HYDROGEN NETWORK IN 2025, NORTH, HIGH DEMAND I SOURCE: ANDRÉ ET AL.

The delivery by truck combines the advantages of low initial investment costs and flexibility to deliver small and infrequent amounts of hydrogen. However, the supply chains by truck have to rely on significant investments on liquefiers (for the cryogenic option) or compressor stations (to fill the trailers) with long-term payback periods. The pipeline, though, requires a significant amount of capital costs with a long-term return on investments.

The study was performed under participation of GDF UEZ, CREST-ENSAI, Université du Littoral, INRA, and TOTAL Raffinage Marketing. The article “Time development of new hydrogen transmission pipeline networks for France”

HYDROGEN MOBILITY TRAM

The world’s first hydrogen-powered tram has been launched in China. The Qingdao Sifang Co. officially unveiled the first vehicles in March this year as part of a planned $32 billion investment in hydrogen-powered transport over the coming five years.

The trams, capable of transporting up to 380 people over three wagons, can reach a top speed of 69 kph and are powered by hydrogen fuel cells connected to a battery. The cells refuel in three minutes and can run for approximately 100 km.

At present China only contains 134 km of tram track. However this figure is expected to expand greatly in coming years as a part of the new investment initiative. The city of Foshan in southern China has already announced plans to build its own tram network this year and will invest $72 million to become the manufacturing centre for the new technology. (QueQingdao Sifang Co.)

HYDROGEN TRAM | SOURCE: QINGDAO SIFANG CO.

HYTREC - HYDROGEN TRANSPORT ECONOMY FOR THE NORTH SEA REGION

The Hydrogen Transport Economy (HyTrEc) project is a collaboration of eight partners from six countries of the North Sea Region. The project aims to improve access to and advance the adoption of hydrogen as an alternative energy vector across the North Sea Region. It will identify and address structural impediments constraining development of, access to, and adoption of this alternative fuel in urban and rural settings. Partners from the UK, Germany, Denmark, Belgium, and Sweden are working together to improve cross border collaboration, share best practice and support joint activities.

(http://www.hytrec.eu/)

HyTrEc
Hydrogen Transport Economy for the North Sea Region

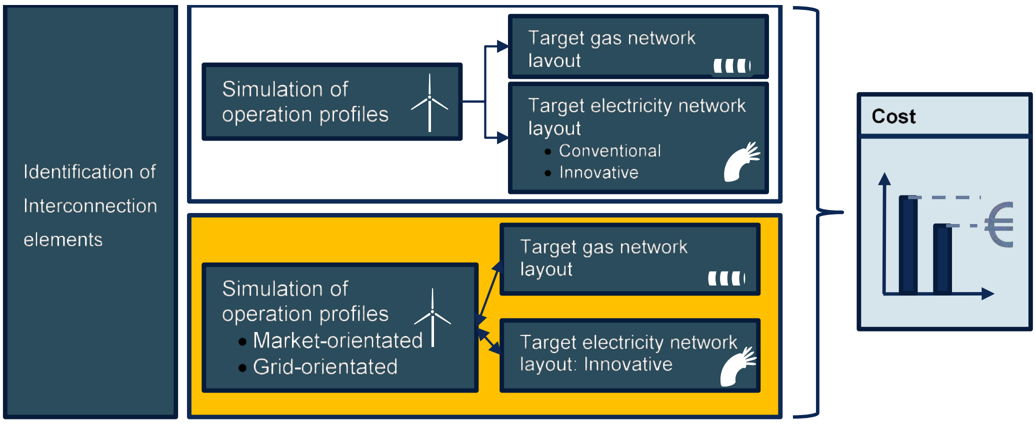
PROJECT: "BENEFITS OF SMART-GRID-CONCEPTIONS INVOLVING POWER-TO-GAS TECHNOLOGY"

The project assessed possible benefits by integrating the electricity as well as the gas supply systems at pilot locations in the already existing grid and interconnected both systems. The results might contribute to the conversion of an integrated energy system at optimised macroeconomic efforts.

Power-to-Gas and bivalent gas preheating units served as interconnection between the electricity and gas networks. The 'bivalent' drive of the latter means they may either run on gas or on electricity for heat generation. Both units provided sufficient load shifting potential to reduce the demand for electricity grid expansion significantly. This applied only if the operation was optimised to the needs of the electricity grid. Power-to-Gas facilities would additionally provide a mid- to long-term energy storage function and thus enhance the integration of renewable electricity. The considered Smart-Grid-Conceptions may gain economic viability by:

The project was funded by the DVGW (German Association of Gas and Water) and supported by EWE Netz GmbH; the performing partners were Bergische Universität Wuppertal, IAEW of the RWTH Aachen University, DBI GTI, and Engler-Bunte-Institute. The final report of the DVGW (G 3/03/12) was published in March 2014.

- Contribution margins of the market (sale of gas) and the network (avoided grid expansion),
- Interconnection of the gas and electricity grid on the lowest possible voltage level with renewable energy integration,
- Capital expenses for small Power-to-Gas facilities of about € 1,000 /kW_{el} (including grid injection station), and
- Sufficient amount of permitted H_2 concentration in the gas network.



INTERCONNECTION ELEMENTS I SOURCE: FINAL PRESENTATION (DVGW FEB. 2015)

Apart from avoided electricity grid expansion on low voltage, the interconnection on low voltage leads to reduced expansion needs of medium and high voltage grid. As this study only concentrated on low and medium voltage grid, the achievements for the high voltage grid were not quantified within the project and are being addressed in a currently conducted research project.

SHORT SUMMARIZED OVERVIEW OF POWER TO GAS PROJECTS WORLDWIDE

Researched by DBI - current work status May 2015. All partners are invited to provide additional or new information. DBI has a detailed table with more technical information of each project and a corresponding graphical overview.

No.	Country	Projekt	Installed power [kW]	Electrolysis technique	Application	Power load	Status
1	United Kingdom	Hydrogen Mini-Grid - Rotherham	36	n/s	Mobility, Fuel Cell	Direct (wind)	in operation
2		HARI - Leicestershire	36	alkaline	Fuel Cell	Direct (wind, solar, water)	in operation
3		Glamorgan Smart Grid Project - Port Talbot	100	alkaline	Mobilty, Fuel Cell	Direct (wind, solar)	in operation
4	Norway	Wind Power and Hydrogen Plant - Utsira	48	alkaline	Fuel Cell	Direct (wind)	closed down
5	France	GRHYD - Dünkirchen	n/s	n/s	Gas grid	n/s	in operation
6		ALT-HY-TUDE - Dünkirchen	n/s	n/s	Mobility	Grid (wind)	closed down
7		MYRTE - Korsika	25	PEM	Fuel Cell	Direkt (solar)	in operation
8		Nantes	n/s	n/s	n/s	n/s	n/s
9	Spain	Aragon Hydrogen Foundation - Huesca	200	alkaline	Mobility, Fuel Cell	n/s	in operation
10		Sotavento Wind Farm - Xermade	300	alkaline	Engine	Direct (wind)	in operation
11		RES2H2 - Pozo Izquierdo	n/s	n/s	Fuel Cell	n/s	closed down
12		Tahivilla - Cadiz	41	PEM	Fuel Cell	Direct (wind)	closed down
13	Itali	INGRID - Puglia	n/s	n/s	Engine	Grid (solar, wind)	planning
14	Denmark	Samsø Energy Academy - Samsø	20	n/s	n/s	Grid (solar, wind)	in operation
15		Lolland - Vestenskov	n/s	n/s	Engine	Grid	in operation
16	Austria	Linz	6	PEM	Gas grid	Grid	in operation
17	Greece	RES2H2 - Keratea	25	alkaline	Fuel Cell	Grid (wind)	closed down
18	Belgium	Colruyt - Brüssel	n/s	alkaline	Mobility	Direct (solar, wind)	in operation
19		DonQuichote - Brüssel	n/s	PEM	Fuel Cell	Direct (solar, wind)	planning
20	Netherlands	Ameland Projekt - Ameland	n/s	PEM	Gas grid	n/s	closed down
21	Germany	Speicherung elektrischer Energie - Stuttgart	400	alkaline	Mobility	Grid (renewable)	in operation
22		ZSW - Stuttgart	370	alkaline	n/s	Grid (renewable)	in operation
23		Kompaktes Wasserelektrolysesystem - Freiburg	40	PEM	Mobility	Grid (renewable)	in operation
24		Hybridkraftwerk - Prenzlau	600	alkaline	Gas grid, Mobility, Fuel Cell	Grid (renewable)	in operation
25		WindGas - Falkenhagen	2.000	alkaline	Gas grid	Grid (day-ahead)	in operation
26		H2BER - Berlin	500	alkaline	Mobility, Fuel Cell	Grid (renewable)	in operation
27		Wasserstofftankstelle HafenCity - Hamburg	n/s	alkaline	Mobility	Grid (renewable)	in operation
28		Strom zu Gas - Frankfurt/M.	400	PEM	Gas grid	Balancing power	in operation
29		RH2-WKA - Grapzow	1.000	alkaline	Gas grid, Mobility, Fuel Cell	Grid (renewable)	in operation
30		RWE-Demonstrationsanlage - Ibbenbüren	150	PEM	Gas grid, Fuel Cell	Grid (renewable)	in operation
31		H2Herten - Herten	150	alkaline	Mobility, Fuel Cell	Grid (renewable)	in operation
32		H2-Forschungszentrum - Cottbus	145	alkaline	n/s	Grid	in operation
33		Energiepark - Mainz	6.000	PEM	Gas grid, Mobility	Grid (renewable)	under construction
34		Stromlückenfüller - Reußenköge	n/s	PEM	Fuel Cell	Balancing power	under construction
35		TwinLab - Berlin	7	PEM	Gas grid	Balancing power (renewable)	planning
36		WindGas - Hamburg	1.000	PEM	Gas grid	Grid (renewable)	planning
37		Kavernenspeicher - Etzel	n/s	n/s	Storage	Balancing power (renewable)	planning
38		Energielandschaft - Morbach	25	n/s	n/s	Grid (wind)	closed down
39	Japan	JHFC Sagamihara Hydrogen Station - Sagamihara	n/s	n/s	Mobility	Grid (renewable)	in operation
40		Nikko Hydrogen Station - Nikko	n/s	n/s	Mobility	Grid	in operation
41		Kyushu University Hydrogen Station - Fukuoka	n/s	PEM	Mobility	Grid	in operation
42	Argentina	Hychico - Comodoro Rivadavia	650	n/s	Engine	Direct (wind)	in operation
43	New Zealand	HYLINK - Totara Valley	n/s	PEM	Gas grid, Fuel Cell	Direct (wind)	closed down
44	USA	SoCalGas P2G - Wallingford	67	PEM	Gas grid	n/s	planning
45	Canada	Ontario Grid Frequency Regulation - Ontario	n/s	alkaline	Fuel Cell	Balancing power	in operation
46	Switzerland	Hybridkraftwerk Aarmatt - Zuchwil	350	PEM	Gas grid, Engine	Grid (renewable)	in operation

POWER TO GAS PROJECTS (CENTRAL EUROPE)

Important Events - Workshops - Conferences and Partners

Selection of appointments
(focus on the combination of hydrogen and natural gas)

++ SEGE 2015 - International Conference on Smart Energy Grid Engineering
(17./19. Aug. 2015, Oshawa)

++ HYPOTHESIS - Hydrogen power theoretical and Engineering Solutions international Symposium
(06./09. Aug. 2015, Toledo)

++ DBI-Fachforum Energiespeicher
(16./17. Sept. 2015, Berlin)

++ WHTC2015 - World Hydrogen Technologies Convention
(11./14. Oct. 2015, Sydney)

++ World of Energy Solutions
(12./14. Oct. 2015, Stuttgart)

++ ICHS - International Conference on Hydrogen Safety
(19./21. Oct. 2015, Yokohama)

++ gat 2015 - leading congress gas
(26./28. Oct. 2015, Essen)

++ 6th dena energy efficiency congress
(16./17. Nov. 2015, Berlin)

++ 3rd Zing Hydrogen & Fuel Cells Conference
(17./20. Nov. 2015, Cancun)

Current Partners

++ Alliander ++ DGC ++ DNV·GL Oil & Gas ++ E.ON Technologies (Ratcliffe) limited ++ Enagas ++ Energinet ++ ETIC ++ EWE Netz GmbH ++ GDF SUEZ ++ Gasnatural ++ Gasum OY ++ GRTgaz ++ grzi ++ Infraserv GmbH & Co. Höchst KG ++ ITM-Power ++ KOGAS ++ NAFTA a.s ++ OGE ++ ÖVGW ++ RAG Rohöl-Aufsuchungs Aktiengesellschaft ++ RWE Dea ++ RWE Deutschland ++ SGC ++ Shell ++ Solar Turbines Europe S.A. ++ SVGW ++ Synergrid ++ Verband der Chemischen Industrie ++ Volkswagen AG ++

Interests and wishes

Please let us know if you have special interests/wishes for the next newsletter. We look forward to your feedback and we aim to provide quality information that is actually needed and wanted to answer the hydrogen core topics.

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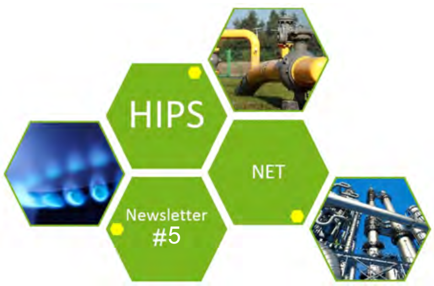

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HIPS-NET

"ESTABLISHING A PAN-EUROPEAN UNDERSTANDING OF ADMISSIBLE HYDROGEN CONCENTRATION IN THE NATURAL GAS GRID"

NEWSLETTER #6	September 2015

CONTENT NEWSLETTER #6

6th HIPS-NET NEWSLETTER

Dear Partners, dear Colleagues,

June 2015 marked the 2nd annual HIPS-NET Workshop in Brussels. We really appreciated and enjoyed the exchange with the 28 participants who attended the workshop. Thank you for your interest and your engagement that led to an open and informative atmosphere. We especially thank those who presented projects and views from their home organisations and countries.

POWER-TO-GAS - THE INVISIBILITY OF THE NATURAL GAS GRID (USCHI DREIUCKER - PIXELIO.DE)

This newsletter, the 6th volume, provides a selection of articles but also summarises the expert presentations held at the workshop. For those who were able to join the workshop, we hope it helps you to remember key information. For those who could not attend, the newsletter provide an overview on the workshop and allow you to decide for further selected reading of the presentations. All presentations were distributed (download link) after the workshop via e-mail (29th June 2015 by Gert Müller-Syring). Please get in touch with us if you missed the download.

We furthermore included information from the FCH-JU Study on Energy Storage in Europe, summarised various U.S. activities, and briefly introduced a Spanish Hydrogen Foundation which will, together with other organisations and bodies, host next year's World Hydrogen Energy Conference. We hope that you enjoy reading this issue of our Newsletter.

The HIPS-NET Team
Gert, Dave, Stefan, Anja & Gideon

Please feel invited to join the 3rd **HIPS-NET workshop** which will take place on **22nd/23rd June 2016** in Brussels (GERG office). We hope the early invitation will ensure meeting most of you again next year.

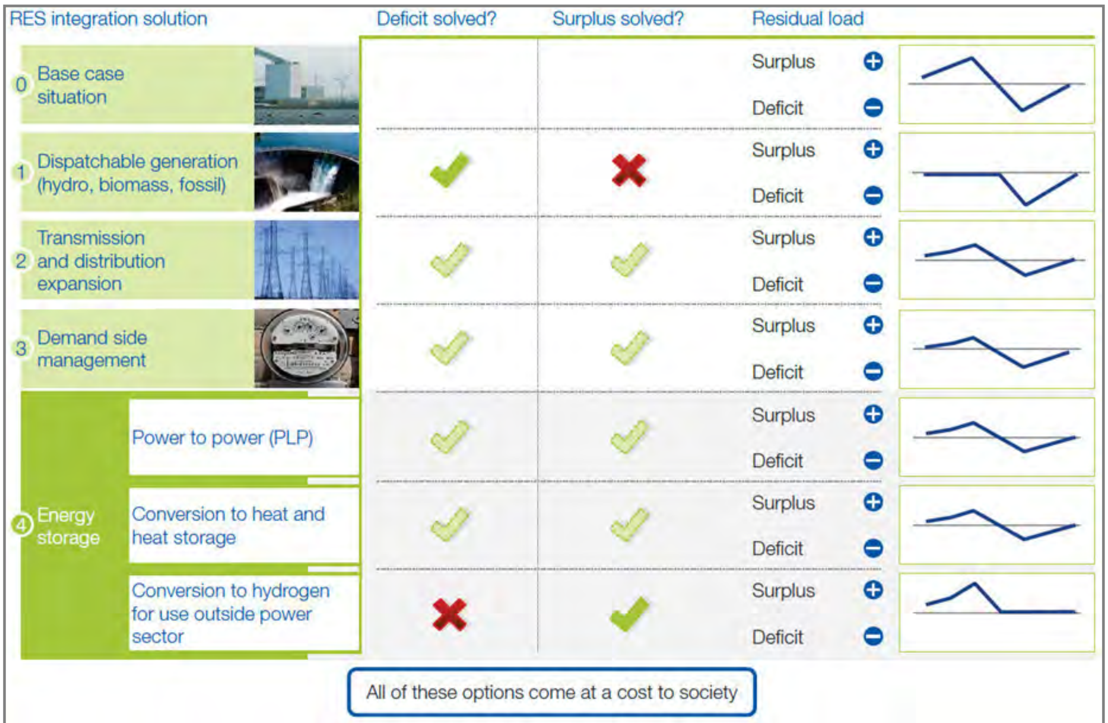
FCH-JU STUDY "COMMERCIALISATION OF ENERGY STORAGE IN EUROPE"

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING (FCH-JU) published the report "Commercialisation of Energy Storage in Europe" in March 2015. It was specifically written to inform decision-makers about the potential contribution of storage in order to integrate renewable energy sources (RES) and about the actions required to ensure that storage is allowed to compete with the other flexibility options.

The study focuses on the European electric power market towards 2030 with an outlook to 2050. It also investigates other energy markets (gas, heat, hydrogen) to the extent that they are connected with the electricity sector and relevant to the topic of storing electricity produced from renewable sources.

The authors recognise four main options for providing the required flexibility to the power system (dispatchable generation, transmission and distribution expansion, demand side management, and energy storage). This study focuses on the latter option, energy storage, and was conducted with the assumption of technology neutrality. Its objective was to consider a broad range of storage technologies and to test the sensitivity of storage demand to different electricity grid constraints. Three categories of energy storage technologies were assessed:

- P2P storage (lead-acid, Li-ion, flow and NaS batteries, pumped hydro energy storage, compressed air energy storage (CAES), liquid air energy storage (LAES), and electrolytic hydrogen production and re-electrification)
- Conversion of electricity to heat and storage for later use
- Conversion of electricity to hydrogen for use outside the electric power sector (PEM, alkaline and solid oxide electrolysers).



MAIN TECHNOLOGY OPTIONS FOR THE INTEGRATION OF VOLATILE RENEWABLE ENERGY (FCH-JU STUDY)

The cost comparison of the different storage technologies is based on an LCoE metric (levelised cost of electricity) which compares the unit cost over their technical lifetime. LCoE takes into account all CAPEX and OPEX costs of storage and puts them in relation to the amount of energy produced. The study calculates the LCoE for short, medium and long term storage. Long term storage is discharged once per year (storage cycle) and is expected to result in LCoE in 2030 for battery technologies of more than 9,000 €/MWh, for mechanical storage of 450 €/MWh (pumped-hydro) to 3,000 €/MWh (CAES, LAES). The most cost-effective technology for long-term energy storage is producing hydrogen (by electrolysis) storing it in a salt cavern and re-electrifying by burning it in a turbine resulting in LCoE of 140 €/MWh.

(Continued on next page)

Based on the optimistic range, the CAPEX for the electrolyser unit is estimated to drop down to 250 €/kW (PEM) and 370 €/kW (Alkaline) in 2030 (including power supply, system control and gas drying).

The power systems of four European countries or regions (Germany, Spain, Sweden and the Greek island of Crete) were chosen for modelling based on their differing characteristics. The RES penetration targets for electricity demand by 2030 (45-60 %) and 2050 (80 %) were taken as granted (exogenous input data). The key outputs were

- the amount of excess electricity (0 GWh in 2030; 152 GWh in 2050 for Sweden, Spain and Germany combined),
- the required non-RES power generation and capacity as well as
- the costs of the non-RES generation, including costs of CO2.

Based on this model, the study examined, the decrease in non-RES generation costs at different installed storage capacities. In addition, the ability of conversion to heat and hydrogen to utilise the excess renewable energy was assessed.

The study shows that both P2P storage and conversion to other carriers have the potential to play an important role in providing flexibility to the electricity system. They will make it possible to ensure that large amounts of renewable energy are not wasted, but are rather used to reduce the amount of required non-RES generation and decarbonise heating, transportation and the gas grid.

The authors estimate the economic potential of P2P storage in 2050 (60% and more volatile renewable energy) at about 400 GW in the EU.

Conversion of electricity to heat and heat storage is a proven and relatively low-cost option for providing flexibility to the power system. However, the potential of conversion to heat to integrate VRE is limited by the share of electricity demand required for heating and by its seasonality.

Conversion of electricity to hydrogen and use of this hydrogen in the gas grid (PtG), mobility or industry can productively utilise nearly all excess renewable energy in the high-RES scenario, contributing to the decarbonisation of these sectors.

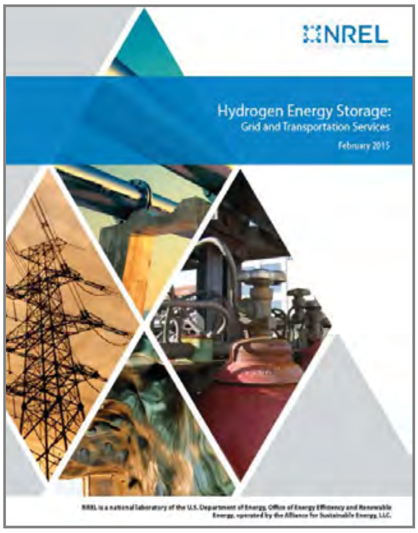
There is a low degree of regulatory acknowledgement of storage as a specific component of the electric power value chain – and hence a lack of storage-specific rules and insufficient consideration of the impact of regulation on storage. Three key obstacles to storage were identified by the study, including

- the lack of clarity on the rules under which transmission and distribution system operator may operate storage or purchase it as service,
- the final consumption fees,
- the payments for curtailment to the RES producers.

The study was prepared by more than 30 stakeholders (including storage technology developers (mechanical, electrochemical and chemical storage), utilities, energy companies, research institutions, regulatory authorities and European institutions).

The report may be retrieved under:
http://www.fch.europa.eu/sites/default/files/CommercializationofEnergyStorageFinal_3.pdf

Two NREL Reports "Hydrogen Energy Storage: Grid and Transportation Services" & "Blending Hydrogen into Natural Gas Pipeline Networks: A Review of Key Issues"



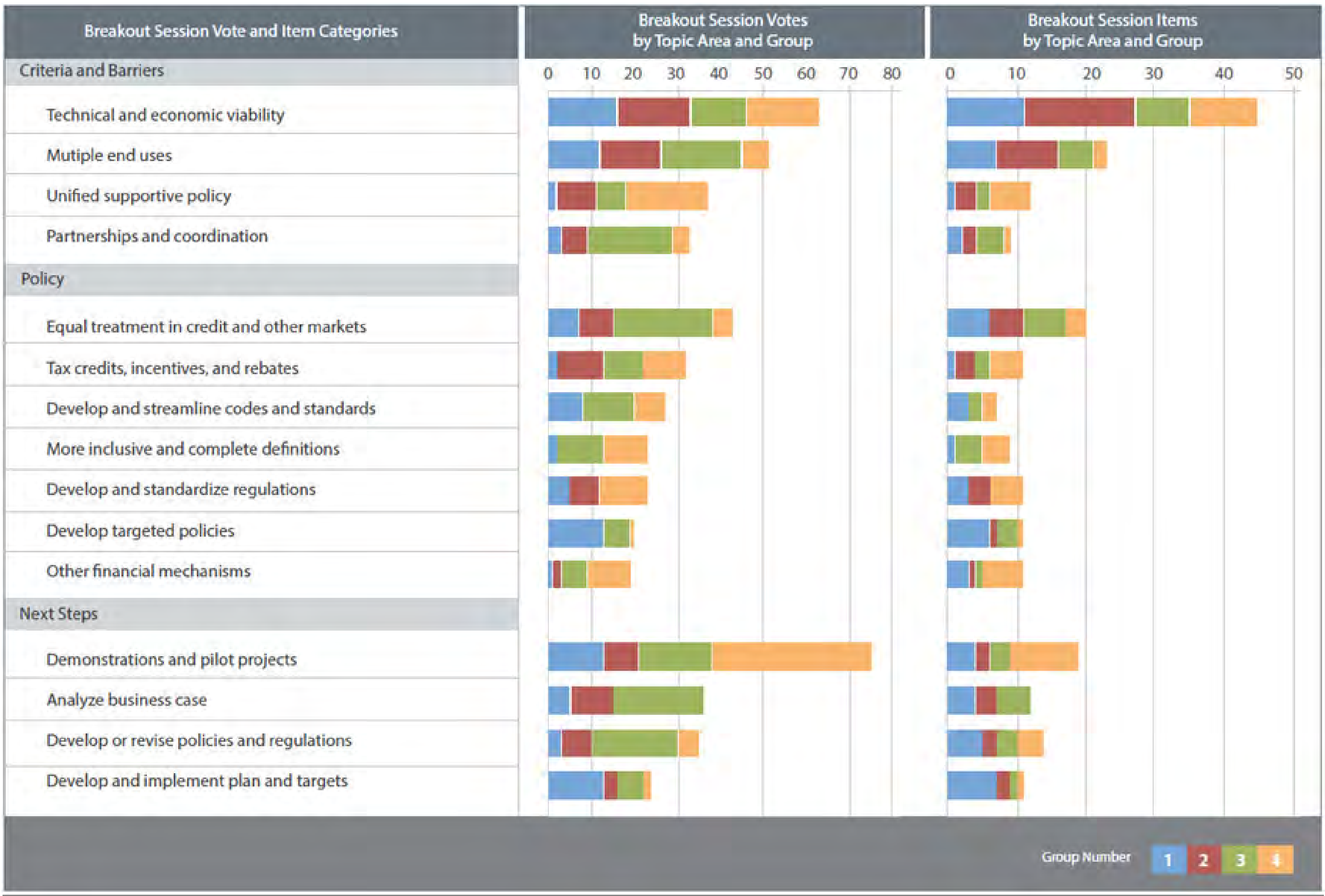
The NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy and published in February 2015 the report on "***Hydrogen Energy Storage: Grid and Transportation Services***".

This report summarises a stakeholder workshop with 17 expert presentations and 4 breakout sessions assessing hydrogen energy storage systems convened by the U.S. Department of Energy and Industry Canada on 14th/15th May 2014, in Sacramento, California. Hydrogen systems are seen as an opportunity to increase the flexibility and resiliency of sustainable energy supply systems while potentially reducing overall energy costs on account of system integration and better utilization of renewables. Beyond the sole storage and re-electrification, they also provide ancillary grid services; fuel for fuel cell electric vehicles (FCEVs); backup power supply; and feedstock supply for industrial processes. Additionally, the opportunity exists for the natural gas industry and regulators to enable hydrogen blending that could increase renewable energy supply via the extensive natural gas infrastructure.

The workshop attendees identified high-priority items on the path to employ hydrogen energy storage systems, including (1) criteria and barriers; (2) policy; and (3) next steps. The high-priority items for the third category 'next steps' involve:

- demonstration and pilot projects,
- analyse business cases,
- develop or revise policies and regulations, and
- develop and implement plan and targets.

(Continued on next page)



Breakout Session Votes & Items - NREL Report "Hydrogen Energy Storage"

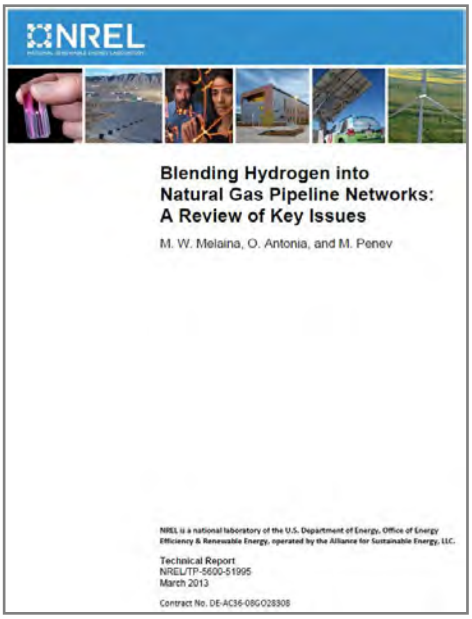
Hydrogen Projects

The report also proposes roles for various stakeholders, divided in lead roles, supporting roles, and advisory roles, to get in action and initiate the identified next steps. The roles vary for different steps but lead roles are suggested to lay mainly in the hands of the industry, analysts, and U.S. Department of Energy.

> The report may be retrieved under:
> http://www.nrel.gov/docs/fy15osti/62518.pdf

The attendees acknowledge that natural gas quality standards for hydrogen blends need to be developed. The report refers to activities in Europe as the standardisation workshop in Petten (under participation of DBI, see newsletter #3 and #4) and activities by the European Association of Research and Technology Association (EARTO).

As for questions regarding admixtures of hydrogen into natural gas networks, the report summarised above refers to a preceding NREL report "***Blending Hydrogen into Natural Gas Pipeline Networks: A Review of Key Issues***" published in March 2013. This study relies on existing literature, is a desktop study and addresses foremost technical questions. It reviews seven key issues concerning blending hydrogen into natural gas pipeline networks:



1. benefits of blending,
2. extent of the U.S. natural gas pipeline network,
3. impact on end-use systems,
4. safety,
5. material durability and integrity management,
6. leakage, and
7. downstream extraction.

The report concentrates on admixtures of 5-15% hydrogen into the natural gas to increase the output from renewable energy production in the near term and to fuel FCEV or stationary fuel cells. According to the authors, the admixture appears to be feasible with very few modifications to the existing pipeline system or end user appliances. The report concludes giving recommendation for future work to modify U.S. pipeline integrity management systems, detailed assessment of the impact of hydrogen on end-use systems (households, power production, etc.), dynamic analysis of future scenarios where hydrogen blending is prevalent in the U.S. natural gas system, and others.

> The report may be retrieved under:
> http://www.nrel.gov/docs/fy13osti/51995.pdf

The report relies on reviewed NaturalHy studies for many fields of expertise. The state of knowledge seems comparable to the European situation and underlines the importance of the core topics we defined for our HIPS-NET project.

Foundation for Hydrogen in Aragon in Spain

The Aragon Hydrogen Foundation was founded in 2004 and currently comprises 63 entities, research centres and companies. The foundation organises a wide range of actions to generate, store and transport hydrogen, for its use in fuel cells, in transport applications or for the generation of distributed energy. In this way it aims to foster research and technological development to integrate energy from regenerative sources. We have already reported in previous newsletters about the ELYGRID and the HyUnder Project. The foundation has been involved in the development of these and various other hydrogen-related projects.

> Further information may be retrieved under:
> http://hidrogenoaragon.org/en/
>
> Please note, the next **World Hydrogen Energy Conference** will take place in Zaragoza (region Aragon in Spain) in 13th-16th June 2016. More information may be found under: http://www.whec2016.com/

Hydrogen Projects

SoCalGas Launches First Power-to-Gas Project in U.S.

Southern California Gas Company (SoCalGas) has joined with the Energy Department's National Renewable Energy Laboratory (NREL) and the National Fuel Cell Research Center (NFCRC) to launch demonstration projects to create and test a carbon-free, power-to-gas system for the first time ever in the U.S.

Located at the NFCRC at the University of California, Irvine, and NREL's laboratories in Golden, Colorado, the power-to-gas demonstrations will also assess the feasibility and potential benefits of using the natural gas pipeline system to store photovoltaic and wind-produced energy.

California is expected to produce 33% of its electricity from renewable sources within five years, and new state energy goals call for increasing that level to 50% by 2030. As the amount of power produced from renewable resources increases, storing it for later use presents a worldwide challenge.

While much attention has been focused on developing batteries to store excess energy, battery capabilities are still limited to short-term storage and batteries remain expensive. Power-to-gas offers longer term storage capacity and cost-effective use of existing natural gas infrastructure to potentially create the world's largest storage technology. In addition, power-to-gas storage can conserve the significant amount of energy currently wasted when renewable production exceeds consumption.

SoCalGas' power-to-gas project is expected to provide valuable data on the dynamics of hydrogen production in a system with excess renewable electricity, including the feasibility and potential benefits of using the natural gas pipeline system to store photovoltaic and wind-produced energy. Initial project results are expected by year end 2015.

Source:
http://sempra.mediaroom.com/index.php?s=19080&item=137032

Important Events - Workshops - Conferences and Partners

Selection of Appointments

(Focus on the combination of hydrogen and natural gas)

++ XIV International Congress of Mexican Hydrogen Society
(30. September - 04. October 2015, Cancun)

++ WHTC2015 - World Hydrogen Technologies Convention
(11. - 14. October 2015, Sydney)

++ World of Energy Solutions
(12. - 14. October 2015, Stuttgart)

++ ICHS - International Conference on Hydrogen Safety
(19. - 21. October 2015, Yokohama)

++ gat2015 - Leading Congress Gas
(26. - 28. October 2015, Essen)

++ 15th IERE Meeting - International Energy Systems in Transition
(11. - 13. November 2015, Berlin)

++ 6th dena energy efficiency congress
(16. - 17.11. November 2015)

++ 3rd Zing Hydrogen & Fuell Cells Conference
(17. - 20. November 2015, Cancun)

++ cCarTec 2015
(20. - 22. November 2015, Munich)

Current Partners

++ Alliander ++DEA Deutsche Erdoel AG ++ DGC ++ DNV·GL Oil & Gas ++ E.ON Technologies (Ratcliffe) limited ++ Enagas ++ Energiforsk ++ Energinet ++ ETIC ++ EWE AG ++ Gasnatural ++ Gasunie ++ Gasum OY ++ GDF SUEZ ++ grzi ++ GRTgaz ++ Infraserv GmbH & Co. Höchst KG ++ ITM-Power ++ KOGAS ++ NAFTA a.s ++ OGE ++ ÖVGW ++ RAG Rohöl-Aufsuchungs Aktiengesellschaft ++ RWE Deutschland ++ Shell ++ Solar Turbines Europe S.A. ++ SVGW ++ Synergrid ++ Verband der Chemischen Industrie ++ Volkswagen AG ++

Interests and Wishes

Please let us know if you have special interests/wishes for the next newsletter. We look forward to your feedback and aim to provide quality information that is actually needed and wanted to answer the hydrogen core topics.

REVIEW OF CURRENT POWER-TO-GAS PROJECTS | DR JOHN NEWTON (ITM POWER | U.K.)

- Recommends the EU report „Commericalisation of Energy Storage in Europe“
  (Remark HIPS-NET team: Summary is included in this newsletter, see page 2 - 3)
- **Thüga Project**
  – Fully integrated PEM electrolyser for Mainova AG in Frankfurt, developed with Thüga
  – Decision currently being made whether to develop the project further or hand over to Thüga partners
- **RWE Project - Ibbenbühren**
  – More advanced PEM electrolyser than Thüga project (downsized components, higher current density permits higher output per stack)
  – Factory and site-acceptance testing are complete. More information is available after the commissioning on 17th August 2015.
  – Hydrogen to be injected into the regional transmission system without compression
- **Power-to-Gas in the UK – EMEC - Orkney**
  – Electrolyser with storage
  – Integrated system for tidal energy
  – Project will run without connection to the national electricity grid
- **Power-to-Methane in the UK**
  – Government-funded feasibility study currently in process

HYDROGEN AND PTG IN FINLAND | ARI SUOMILAMMI (GASUM | FINLAND)

- Project presentation of hydrogen production for industrial use in Joutseno
  – Max 3,500 m³/h pure H_2
  – Feasibility completed for 5 km pipeline with compressors
- Woikoski plant
  – Largest $P2H_2$ facility in Europe producing hydrogen from water by electrolysis. It will also produce ultra-pure oxygen simultaneously.
  – 3 x 3 MW pressurized alkaline electrolysis
  – Industrial use of H_2 in cobalt reduction process
- Neo Carbon Energy Project
  – 2014-2019 14m Euro
- Draws attention to Directives 98/70/EC and 2009/28/EC re-definition of renewable liquid and gaseous fuels of non-biological origin
- CO_2 from Pulp Mills as resource for production of CH_4
  – Estimated 70-80 TWh CH_4 can be produced – enough to cover the gas needs of Finland and the Baltics
  – Half of Finnish pulp mills already connected to gas network
- Case Study UPM Kaukas Mill
- CH_4 production is profitable today for transportation use if electrolyser provides grid services for the electricity transmission system operator

PTG – 2 STUDIES FROM SWEDEN | JONAS DAHL (ENERGIFORSK | SWEDEN)

- Energiforsk is a new company – SGC, Värmeforsk, Fjärrsyn and Elforsk are part of Energiforsk
- Nuclear plants replacement starts 2025 (not economical) – Wind energy intended to play a bigger role
- Fossil-free transports envisaged by 2030 – liquid and gas biofuels to play a bigger role
- Gas grid in Sweden requires significant development
- Presentation of two studies concerning PtG in Sweden – Both available for free download (Continued on page 8)

- **1st Locational Study – Power to Gas**
  – Investigating conditions suitable for building a first demo and possible commercial size PtG plant in Sweden
  – Findings: Either in the north (Pitea – close to a biofuels research centre) or in the south (good connections to wind energy generation, existing filling stations); and more.
- **2nd Study of Hydrogen as Fuel in Gas Turbines**
  – Continuation of previous research by Siemens
  – Analysis of the effect on gas turbines of adding hydrogen to natural gas (flammability, flame velocity etc)
  – Findings: H_2 promotes the flammability and velocity of methane (depending on other gases present); Kinetic modelling appropriate at 1 atm; and more.

Results and Status of three Danish Projects with hydrogen | Jesper Bruun (Energinet.de | Denmark)

- **1st Project: Renewable Energy Storage for the Future**
  – Analysis of the potential of hydrogen injection into the Danish grid and technical barriers
  – Phase 1: Gas system and appliance suitability for hydrogen (almost finished)
  – Phase 2: Design of demonstration project - small grid system (underway)
  – Phase 3: Demonstration of the operation of gas networks with hydrogen (currently on hold due to cost issues)
- **2nd Project: Field Test of Hydrogen in the Natural Gas Grid**
  – Intended to explore feasibility of hydrogen transport using the natural gas grid
  – Stand-alone miniature gas grid built
  – Mostly positive results – limited leakage in steel pipes
  – X70 steel natural gas transmission pipeline test and analysis
  – Intended to explore fatigue limits and fatigue life of existing pipes when used for H_2-admixture transport
  – Welds showed no recognizable damage from the hydrogen
  – Report (in English) may be downloaded from DGC homepage
- **3rd Project: Hydrogen Injected into the Gas Grid via Electrolysis Field Test**
  – Two year project to analyse the costs and solutions for upgrading the existing gas grid to support hydrogen admixtures
  – Key components in the project is two old meter and regulator stations that will be a part of the test loop
  – Varied amounts of hydrogen up to 15% envisaged
  – Intended to provide public guideline for handling of grid upgrade
  – Project partners are: Energinet.dk, Dong Energy, IRD and Danish Gas Technology centre.
- The 2nd and the 3rd project have been presented at the 23. World Gas Conference in Amsterdam 2006: Field Test of Hydrogen in the Natural Gas Grid. Henrik Iskov, Jan Jensen and at the World Hydrogen Energy Conference 2010: WHEC 2010, Essen: Poster Session Title/No. HI.1 Hydrogen Distribution Technologies Field test of hydrogen in the natural gas grid. Henrik Iskov, Mats Backman, Hans Peter Nielsen.

Standardisation: Activities of SFEM WG Hydrogen | Francoise de Jong (NEN | Netherlands)

- Working group created to provide:
  - CEN/BT and CENELEC/BT with concrete proposals concerning standardization
  - EC and concerned stakeholder with R&D and innovation in this field
- One main topic of the WG
  - WG Scope of Work: Mapping standardization initiatives and needs, preparing a roadmap strategy and list of priorities, liaise with ISO, IEA, FCH-JU, CEN, IEC TCs, ...
  - Mapping RDI needs: Strengthen cooperation between regulatory work, standardisation and RDI programs
- 60 parties have expressed an interest to follow/actively participate including members of CEN/CENELEC, EC (JRC, ENER, RTD, GROW), Fuel Cells and Hydrogen Joint Undertaking, research institutes, consumer representatives and industry experts

HYREADY Project | Onno Florisson (DNV GL | Netherlands)

- Goals of the HYREADY project:
  - Develop a set of engineering guidelines at both system level and component level for TSOs and DSOs to help them prepare their networks for hydrogen injection (both pure, and as an admixture to NG)
  - Analyse the natural gas grid from high-pressure transmission grid up to distribution grid and including industrial and domestic end-user appliances
  - Create guidelines to forecast effects of hydrogen injection and offer solutions for negative consequences
- Further partners are welcome. The project hasn't commenced yet.

Power-to-Gas in EU Energy Policy | Jyri Ylkanen (European Commission Directorate General for Energy)

- Expressed an interest in integrating hydrogen into energy policy – important geopolitical as well as technological consequences
- List of key activities relevant to PtG, e.g. new market design for the electricity market (consultation ongoing), alternative fuels, etc.
- Steps/activities to create an Energy Union, e.g. European Councils conclusions on the Energy Union , report on state of the energy union expected by the end of 2015, etc.
- Forecast for energy system investment needs presented (estimation of over €1 trillion investment needs in the electricity and gas sector between 2010-2020). Incentives for low-carbon technologies through government subsidies seem to be insufficient. EU funding for sustainable energy between 2014-2020:
  - EU Cohesion Policy to allocate €38 billion (estimate) to energy efficiency, renewable energy, smart grids, and urban mobility
  - Horizon 2020 to allocate €5.4 billion to research and innovation in "secure clean and efficient energy" (growing increasingly open to possibility of hydrogen and natural gas mix)
  - Connecting Europe Facility to allocate €5 billion to investments in TEN-E Infrastructure of highest European added value
  - European Structural Investment Funds, European Agricultural Fund for Rural Development, European Maritime and Fisheries Fund, European Social Fund, Life+, COSME and EEEF may also be sources
  - "Juncker Plan" European Fund for Strategic Investments to mobilise at least €315 billion in additional investment
- Various regulatory and policy topics - electricity and gas – presented. PtG one possible flexibility option depending on the market situation.
- Reluctance towards regulatory changes regarding acceptable hydrogen levels as this may lead to high investment costs in parts of the EU (certain issues need to be addressed e.g. gas quality, standards, etc.)

ORGANISATIONAL ASPECTS OF THE HIPS-NET | GERT MÜLLER-SYRING (DBI GUT | GERMANY)

- Overview of partners in HIPS-NET project – NAFTA a.s. (Slovakia) and GDF Suez (France) joined HIPS-NET. A stable number of 30 organisations form our network.
- HIPS-NET website planned (depending on additional budget; not yet available) - exact design (independent or attached to the DBI homepage) has not yet been decided. Intended to include a public area with general information, as well as a secure area with newsletters, links and publications solely for HIPS-NET partners.
- Overview of current projects
  - CNG Tank project update provided
  - Project to identify the number and distribution of sensitive elements in gas infrastructure (turbines, chemical plants etc.) provided
  - Updated map of European PtG projects to be created
  - Identification of open issues on safety (e.g. defining ex-zones)
- Working plan for 3rd year (Oct15-Sep16) presented.
- Annual workshop scheduled for **22nd/ 23rd June 2016**. Please save the date.

A METHODOLOGY FOR UNDERSTANDING SOCIAL STAKES OF NEW ENERGIES | JACQUES DUBOST (GDF SUEZ | FRANCE)

- CRIGEN (Research and Innovation Centre in Gas and New Energies) project Energy and Society utilises the following approach to evaluate social acceptance of new energies:
  - Use of sociological competencies (sociology of science and technology, urban sociology, sociology of consumption etc.)
  - Sociotechnical controversy – empirical research to gather data (often using new media) concerning developing attitudes to new concepts (in this case non-conventional energies)
- Application of Energy and Society to GRHYD
  - Analysis of levers and obstacles towards social acceptance of hydrogen and natural gas energy
  - Sociological research of attitudes to hydrogen energy in the areas of Dunkerque and Capelle-la-Grande, e.g. by questionnaire-based research
  - First results indicate local uncertainty towards the siting of electrolyser technology in Cappelle-la-Grande.

STUDY ON THE USE OF PTG TECHNOLOGY TO SUPPORT THE 110KV ELECTRICITY DISTRIBUTION NETWORK | GERT MÜLLER-SYRING (DBI GUT | GERMANY)

- Goal of study: Evaluation of separate and integrated planning of electricity and gas networks by cost comparison based on a target network planning in Emsland (Germany)
  - Methodology: Economic framework with three base years - 2023, 2033 and 2050
  - Simulation and test network (High Voltage Network - Emsland, Germany)
- Capacity analysis - gas network: Results indicate potential for PtG facilities to unburden the electricity network
- Economic evaluation of PtG technology
  - PtG facilities generate income through avoidance of network expansion, fuel production and an optimized balance area
  - Small-scale PtG facilities can become economical at 520 €/kW
  - PtG facilities are generally less economical than expansion using cutting-edge technologies (overhead line monitoring, heat-resistant aluminium)
  - At unit prices of 1,400 €/kW, the utilization of small-scale PtG facilities is more economical than network expansion with buried cable on all three network levels (low-, medium-, and high-voltage)
  - Network integration elements in lower voltage levels with grid-orientated operation scheme significantly reduce the necessity to expand the network at higher voltage levels
- Results suggest the integration of electricity at the lowest possible levels.

Power-to-Gas Projects, Business Models and Related Regulatory Aspects | Gregor Waldstein (ETOGAS | Germany)

- Supplier for turnkey hardware for power-to-gas and power-to-methane projects, including related consulting and services.
- Supplier in charge of design, installation and ramp-up for the world's largest power-to-methane project (6.3 MW Audi e-gas Plant in Werlte, Germany)
  - Completed in June 2013 (in operation since end of 2013)
  - Plant combines electrolysis and methanation using CO_2 from a biogas upgrading plant
  - Delivers methane to the local gas network ("e-gas")
  - Measured data shows dynamic operation of e-gas production (quick response)
- Cooperation with Audi to introduce the new A3 g-tron carbon-neutral car
  - Utilizes renewable CNG e-gas (950 designated fuelling stations across Germany)
  - Produces significantly lower cradle-to-the-grave emissions than other fuel options
  - Audi calculation argues that A3 g-tron with e-gas costs no more than a standard petrol-powered A3. Use of non-renewable CNG is, however, more cost-efficient.
- Regulatory Requirements:
  - Implement advanced biofuels regulation on a national level to create attractive sales opportunities for low GHG-emissions fuels like hydrogen and methane
  - Support demand conforming delivery from renewable asset portfolios
  - Allow exploiting revenue potentials outside the power sector

Underground Sun Storage – Project Update | Stefan Bauer (RAG | Austria)

- Project: Chemical storage of renewable energy in porous subsurface reservoirs with exemplary in-situ field experiment including Research effects of hydrogen/methane (up to 10% hydrogen) to demonstrate capability to store renewable energies via synthetic gases.
- Intermediate Laboratory Research Results:
  - No indication of problems with storage integrity (permeability, formation of H2S, well completion materials)
  - Microbial activity verified
- Pilot Plant In-situ field experiment
  - All permits valid
  - Site currently under construction
  - Commissioning 08/2015 – 09/2015
  - Operation starting 10/2015

Participants at the HIPS-NET Workshop #2

DBI Gas- und Umwelttechnik, Germany - **Gert Müller-Syring, Janko König, Anja Wehling** # DEA Deutsche Erdoel AG, Germany - **Dr Kai Schulze** # DNV GL, Netherlands - **Onno Florisson** # DPinchbeck Consultancy Limited, United Kingdom - **Dave Pinchbeck** # E.ON New Build & Technology, United Kingdom - **Stuart James** # Enagas, Spain - **Jose Lana Calvo, Jorge Modrego** # Energiforsk, Sweden - **Dr Jonas Dahl** # Energinet, Denmark - **Rune Gjermundbo, Jesper Bruun** # ETOGAS GmbH, Germany - **Gregor Waldstein** # European Commission Directorate-General for Energy - **Jyri Ylkanen** # EWE AG, Germany - **Thomas Götze** # Gasnatural, Spain - **Antoni Julia Sirvent** # Gasum OY, Finland - **Ari Suomilammi** # GERG, Belgium - **Robert Judd** # GDF SUEZ, France - **Jacques Dubost** # GRTgaz, France - **Christian Copin** # Infraserv GmbH & Co. Höchst KG, Germany - **Dr Heinrich Lienkamp** # ITM-Power, United Kingdom - **Dr John Newton** # NAFTA, Slovakia - **Thomas Ferencz** # NEN, Netherlands - **Françoise de Jong** # RAG Rohöl-Aufsuchungs-Aktiengesellschaft, Austria - **Stephan Bauer** # Solar Turbines Europe S.A., Belgium - **Christophe Huth** # Synergrid/EANDIS, Belgium - **Kevin Sleuyter** # Volkswagen AG, Germany - **Juliane Muth**

Impressions of the HIPS-NET Workshop #2 Brussels 2015

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Certified DIN EN ISO 9001:2008

HIPS-NET

"Establishing a pan-European understanding of admissible hydrogen concentration in the natural gas grid"

Newsletter #7 | **December 2015**

Content Newsletter #7

*"A network leads to
cooperation, cooperation leads to creativity and innovation - this changes the world."*

- Marissa Mayer (CEO Yahoo)

7th HIPS-NET Newsletter

Dear Dear Partners,
Dear Colleagues,

The present 7th volume of the HIPS-NET newsletter provides an overview of the hydrogen-related topics of the leading European Gas Technology Conference in Vienna in November 2015, recent results of the Sector Forum Energy Management (SFEM) WG Hydrogen on standardisation issues, and a variety of projects to gain further knowledge on hydrogen/natural gas blends in pipeline systems.

We furthermore scanned 625 presentations and papers presented during the World Gas Conference in Paris in June 2015. Even though Hydrogen was not as prominently represented as during the EGATEC 2015 in Vienna, we found interesting news on Japanese R&D activities with pure hydrogen, and gained an impression on views/approaches there.

HIPS-NET was presented at the EGATEC 2015 by Gert Müller-Syring. To further increase the visibility of our network, we are working on an easy-to-read but informative HIPS-NET website and hope to publish it during the 1st quarter of the coming year. We will come back to you with further information in early 2016. We believe the website will increase the awareness level of HIPS-NET (mainly for third-parties) and provide a platform (solely for our partners) to access our existing internal information.

Power-to-Gas - the invisibility of the natural gas grid (Uschi Dreiucker - pixelio.de)

We hope you will enjoy reading and wish you a merry and peaceful Christmas with your loved ones and families. Enjoy the days on vacation with happy and light-hearted New Year's celebrations.

Your HIPS-NET Team

Gert, Dave, Stefan, Anja & Gideon

EUROPEAN GAS TECHNOLOGY CONFERENCE EGATEC 2015

EGATEC as the leading European Gas Technology Conference, jointly organised by Marcogaz (Technical Association of the European Natural Gas Industry) and GERG (The European Gas Research Group) as well as ÖVGW (Austrian Association for Gas and Water) as the local host, took place from 25th to 26th November 2015 in Vienna, Austria.

This year EGATEC presented new strategies and innovative ideas covering the main topic „Creating the Gas Revolution“ and attracted more than 250 high level representatives from the European gas industry, delegates from science and research organizations, international companies and many other stakeholders.

In particular the following main topics were addressed:

- Strategy for Gas in Europe 2030
- Power to Gas
- Sources, Supply & Security for Europe
- Renewable Gas
- Gas in Transport & Mobility in Europe
- Innovative Gas Appliances & Domestic Systems

For more information on EGATEC 2015 please visit: http://www.egatec2015.com or contact Alexander Schwanzer (schwanzer@ovgw.at) from ÖVGW

The Power to Gas session was one of the sessions with the highest density of presentations, clearly showing the importance of the topic in Europe. Six speakers, moderated by Prof.-Dr. Hartmut Krause (CEO of the DBI group), provided up to date news to the well-represented audience with focus on:

- Current DVGW PtG projects in the field of Power to Gas (Dr. Frank Graf, EBI),
- HIPS NET and the need for establishing a European understanding for admissible hydrogen concentrations in the natural gas system (Gert Müller-Syring, DBI),
- Innovative energy storage - WindGas Hamburg (René Schoof, EGS GmbH),
- HYREADY (Onno Florisson, DNV GL),
- Underground Sun Storage Project (Stephan Bauer, RAG), and
- A novel Power to Gas approach to heat city development areas such as Aspern, Vienna´s Urban lakeside (Helga Prazak-Reisinger, OMV)

The presentations and the subsequent discussions made clear that Power to Gas plays a crucial role in the future energy system even though the commercial outlook for the technology is inconsistent. René Schoof reported that the improvement of the whole plant performance, including the electrolyser, has increased significantly over the last five years from approximately 60 % up to nearly 75 %. This was possible through intensive R&D and massive demonstration projects that led to efficient tailor-made concepts, instead of compiling standard components. Furthermore, he made clear that there is still a huge technological potential that needs to be developed resulting in facilities in a multi-megawatt class in order to be able to shift/store sufficient energy in the future.

Gert Müller-Syring presented the need to further establish a pan-European understanding of admissible hydrogen concentrations, the role that standardisation and pre-normative research can play in this context, and what has been achieved so far by HIPS NET (GERG-Project) and Working Group Hydrogen under the Sector Forum Energy Management (CEN/CENELEC). In this presentation Gert Müller-Syring also explained the complementary roles of HIPS-NET, WG Hydrogen and Hyready.

Onno Florisson from DNV-GL introduced the HYREADY initiative that is aiming to provide engineering guidelines to support TSOs and DSOs to prepare their natural gas systems for the accommodation of hydrogen with acceptable consequences. This joint industry project is open for further partners.

The latest developments on the Underground Sun Storage project were presented by Stephan Bauer. He emphasised that the first project phase has shown very promising results, convincing RAG and its partners to enter the second project phase, where hydrogen with concentrations up to 10 vol% will be injected in a small and isolated underground storage reservoir.

Further very positive news was presented by Helga Prazak-Reisinger from OMV. OMV has been taking part in a feasibility study with the City of Vienna, which is active in developing new city districts such as Aspern. It was shown that Power to Gas and the use of natural gas hydrogen mixtures with shares of 60 vol% hydrogen in a local grid, as well as provision of 4 vol% of hydrogen to existing customers, can be an economically feasible option to supply heat to city districts when this option is properly integrated in the development phase.

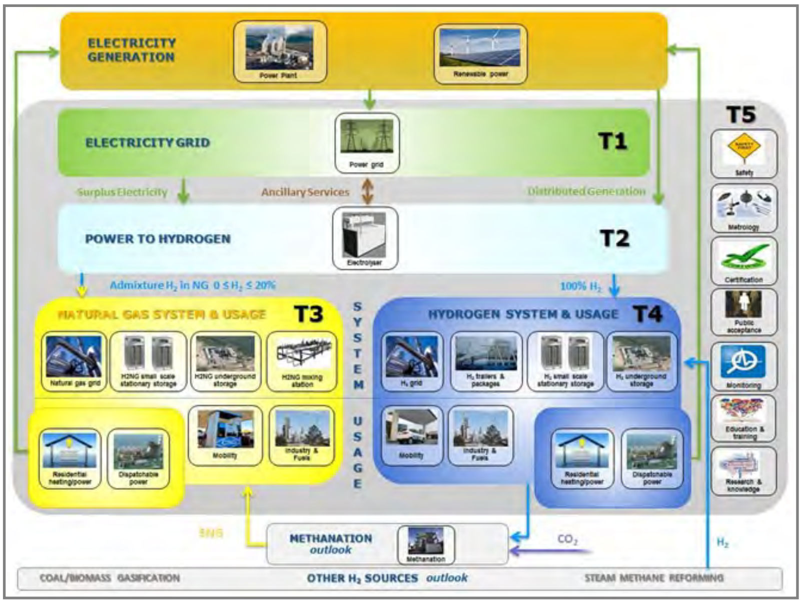
SECTOR FORUM ENERGY MANAGEMENT WORKING GROUP HYDROGEN

The Working Group Hydrogen was established following the outcome of the workshop 'Putting Science into Standards: Power-to-Hydrogen and HCNG' held at the JRC in Petten in October 2014 (we reported in HIPS-NET Newsletter #4 page 6). In consideration of the strong interest and real needs from industry that were expressed at the workshop, a CEN/CENELEC Working Group (WG) on Hydrogen under the Sector Forum Energy Management (SFEM) was approved by the CEN/CENELEC technical board in December 2014 with the task to provide concrete proposals on the way forward to address research and standardisation needs in this emerging field. The scope of work included a mapping of hydrogen-energy-related issues and challenges, as well as of existing standardisation initiatives, needs and gaps in a holistic manner.

- The main objective of the SFEM/WG Hydrogen was to perform an analysis of the state of the art of technology and standardisation and a gap analysis on the main barriers including challenges and needs.
- A second objective was to establish contact with key stakeholders from gas sector, grids, electric supply, mobility, the EC services and the Fuel Cells and Hydrogen Joint Undertaking (FCH JU) to perform the work in the most effective way and to have broad support from the stakeholders for identifying the key challenges.
- The final objective was to set a long term collaborative framework (liaison) with major bodies in order to strengthen cooperation between regulatory work, standardisation work and RDI programs (e.g. European Commission, JRC, FCH2 JU, IEA, ISO, IEC).

The scope (see figure) of the working group covered the production of hydrogen through electrolysis and the transportation, distribution and usage of hydrogen in pure form or as a natural gas dominant mixture (H2NG). In addition, actions in cross-cutting fields such as safety and training of personnel were identified. Five Task Forces have been formed mainly around the interfaces of the power-to-hydrogen related technologies (electricity grid, natural gas grid, hydrogen infrastructure). Francoise de Jong (NEN/Netherlands) gave an overview of the work and the structure during the HIPS-NET Workshop in Brussels in June this year.

A final report has been prepared, which will be submitted to the CEN/CENELEC board shortly and made publicly available following approval.



SCOPE OF THE TASK FORCES I SOURCE: FINAL REPORT CEN - CENELEC SECTOR FORUM ENERGY MANAGEMENT/ WORKING GROUP HYDROGEN

Results

Priority challenges have been identified for the various technical areas and recommendations have been given on proposed actions and means of implementation. The actions have been visualised in a roadmap in which actions are prioritised, and indicated with the required timespan. Technical gaps have been identified for new operational modes of electrolysers, which call for advances in technology related to safety and performance (e.g. partial load, intermittent operation and fast response). Interconnection standards to allow physical connection and communication between electrolysers and the grid control systems are needed.

Key challenges and early topics for standardisation related to the injection of hydrogen into the natural gas grid have been identified. Establishing a European understanding of an acceptable hydrogen concentration in the natural gas system is seen as an overarching theme, which first requires filling a number of knowledge gaps. Pre normative research (PNR) and standardisation challenges and needs related to the hydrogen system and the use of pure hydrogen have been analysed.

Hydrogen will have the highest value when used in the mobility sector, therefore the technology can be best supported by first focusing on the issues related to the refuelling infrastructure, which is currently being rolled out across Europe.

For further information please contact Eveline Weidner (JRC) or Gert Müller-Syring (DBI). We will share findings of the SFEM/WG Hydrogen summarised in the final report after publication in one of the upcoming newsletters.

The cross-cutting items were also addressed such as safety (H2NG and hydrogen system), the related technical topics (metrology monitoring and testing), regulation/legislation, certification, and societal aspects. The key items identified for PNR and standardization actions were safety related topics, certification (Guarantee of Origin) and training of personnel.

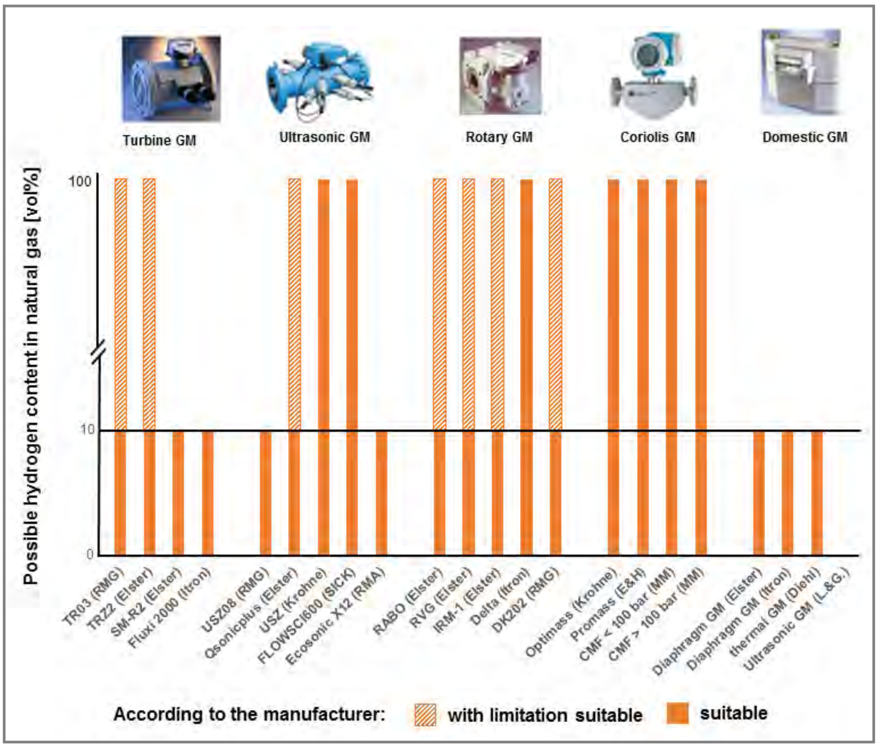
Follow-up activities will include a dedicated workshop next year.

INFLUENCE OF HYDROGEN ON THE ENERGY METERING AND BILLING (1/2)

The HIPS-NET Newsletter #2 briefly introduced the work packages of the DVGW project G3-02-12, especially the work packages „Metering of Gas Quality“ and „Metering of Hydrogen by Volume“. The results of the study performed by a team with interdisciplinary background of E.ON Technologies GmbH, DBI GUT GmbH, and Ruhr University Bochum are now available.

Metering of Hydrogen by Volume

The figure below shows the results of the survey among manufacturers of gas meters (GM) by volume. All gas meters are suitable for 10 vol% hydrogen in natural gas and did not show any concerns regarding safety and installed material. One third of the gas meters can be used for hydrogen concentrations of up to 100 vol%. Another third is suitable for 100 vol% with limitations, e.g. smaller range of measurement, larger minimum flow and higher operating pressure.



FINAL PROJECT REPORT I SOURCE: DVGW – FORSCHUNG APRIL 2014

Since 2015 the National Metrology Institute of Germany (PTB Physikalisch -Technische Bundesanstalt) does not require a separate approval of gas meters for custody transfer measurement of natural gas with admixtures of up to 5 vol% hydrogen. For the future, gas meter manufacturers will have to state the range of the suitable hydrogen content.

Reconstruction of Heating Value in Gas Transmission Grids

The heating value in the high-pressure network is mainly determined by heating value reconstruction systems based on calculations. If there is more than 0.2 vol% hydrogen in the natural gas, hydrogen has to be determined by a process gas chromatograph (PGC). More than 500 PGCs in the German gas network are unable to detect hydrogen, of which only 10 % can be refitted for the new application. The others have to be replaced by new acquisitions, which will cost more than €55 million, according to initial estimates. This amount should be revised because many installed PGCs are old and have to be substituted in the course of regular maintenance.

In general, PGCs are stable and sealed for the examined hydrogen concentrations and pressures. PGCs that can detect 5 vol% hydrogen for custody transfer measurement are available on the market. PGCs approved for hydrogen concentrations of up to 25 vol% using the carrier gas helium and argon will be launched shortly.

In addition to new PGCs, the volume correctors (in Germany more than 3,300 devices) and the software for reconstruction of heating value have to be expanded to consider hydrogen as a parameter.

Reconstruction of Heating Value in Gas Distribution Grids

Transmission grid operators often use software for the reconstruction of the heating value, in distribution grids, however, the software calculations are not accurate enough as soon as hydrogen is added (due to insufficient measurements of the gas flow at the exit points). The technical standard DVGW G 685 only allows a deviation of up to 2 % for billing of end customers with reconstruction devices. In most cases of hydrogen injection the standard calculation approach of these devices is not able to satisfy the G 685.

INFLUENCE OF HYDROGEN ON THE ENERGY METERING AND BILLING (2/2)

E.ON developed the program “SmartSim” to solve this problem. “SmartSim” calculates the heating value for each exit point based on the past consumption data and the current ambient temperature. The field test proved that the reconstructed heating value by calculation matches the real value for 5 vol% hydrogen in natural gas. The developed software may therefore be deployed for billing because it meets the requirements of the technical standard G 685.

The study furthermore analysed limitations of the compressibility factor calculation for hydrogen and natural gas blends.

Please contact the HIPS-NET Team for further information. The results are only available in German: http://www.dvgw-innovation.de/die-projekte/archiv/energiemessung/

GERG PROJECT DOMHYDRO | HYDROGEN TOLERANCE OF DOMESTIC GAS APPLIANCES (1/2)

The GERG Project DOMHYDRO gathers insights in performance, emissions, efficiency, durability, and safety of domestic gas appliances when natural gas is blended with hydrogen. The project assesses new and existing appliances covered by the Gas Appliance Directive (GAD) under varying concentrations of hydrogen admixture. The project partners Kiwa, E.ON Technologies, DVGW-Forschungsstelle at the Engler-Bunte-Institute (DVGW-EBI), and Gas- und Wärme-Institute (GWI) intend to foster future decision making concerning permissible hydrogen concentrations in natural gas systems on a technical basis.

The work packages of the partners DVGW-EBI and GWI comprise literature, research, simulations of flames, and laboratory experiments to prepare and support the field test as follows:

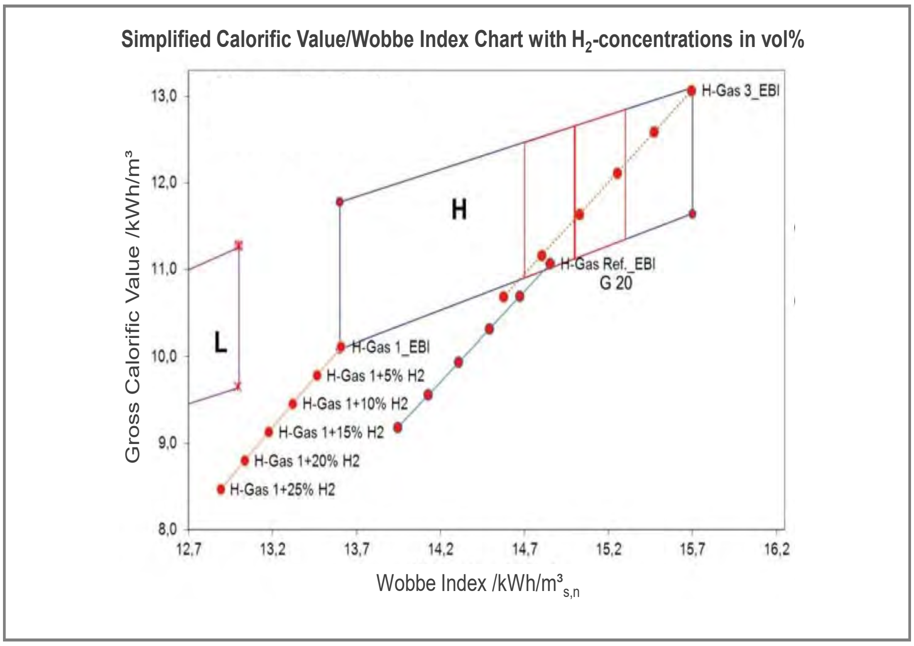
1. Detailed assessment of the impact of hydrogen admixture on flame properties.
2. Assessment of effects of the hydrogen admixture on methods for advanced combustion controls in domestic appliances.
3. Determination of hydrogen concentration limits for admixture to natural gas for domestic appliances.
4. Impact of hydrogen on micro cogeneration units (micro-CHP).

Intermediate laboratory results did not show any indication for relevant impacts, regarding safety, performance and emissions, when blending up to 10 vol% hydrogen to natural gas. The currently available results support the realisation of a successful field test with hydrogen blending of up to 10 vol% to natural gas in northern Germany carried out by DVGW-EBI and E.ON (see HYGRID Project).

A short overview of selected project results is given here:

Results of hydrogen admixture and combustion control
The experiments did not show any detrimental effects on combustion control even with concentrations up to 55 vol% hydrogen (slightly warmer burner surface in a condensing boiler, shrinking maximum performance due to lower heating value).

Results of hydrogen admixture on micro-CHP
The testing on stirling engines did not show any negative effects on the running performance up to a concentration of 45 vol% hydrogen. The emissions of CO and NOx were reduced by hydrogen admixture. The ignition behaviour did not cause any problems up to 30 vol% for warm and cold starts (down to -15 °C).



DETERMINATION OF THE HYDROGEN TOLERANCE OF GAS APPLIANCES I SOURCE: PRESENTATION OF DÖRR/BURMEISTER SEPTEMBER 2015 IN ESSEN/GERMANY

GERG PROJECT DOMHYDRO | HYDROGEN TOLERANCE OF DOMESTIC GAS APPLIANCES (2/2)

Results of hydrogen admixture on gas metering devices

The tested gas metering devices based on three different metering principles (commercial models currently in operation in domestic homes) show deviations of up to 20 % upon an admixture of 14 vol% hydrogen. This is mainly due to the impact of hydrogen on sound-propagation velocity, thermal conductivity, and thermal capacity of the natural gas-hydrogen blends.

Please contact Dr. Holger Dörr (doerr@dvgw-ebi.de) or Frank Burmeister (burmeister@gwi-essen.de) for further information.

The project results from Kiwa and E.ON Technology are not yet available and will be presented in one of the upcoming newsletters.

HYDROGEN BLENDING WITH NATURAL GAS – INTEGRITY AND COMPATIBILITY OF PIPELINE COMPONENTS

The Gas Technology Institute (GTI) in Chicago is currently undertaking further research on the potential levels of hydrogen blending. Their research is based on a previous report from the National Renewable Energy Lab (NREL, Colorado) titled "Blending hydrogen into the existing natural gas pipeline networks", March, 2013 (see also HIPS-NET Newsletter #6 page 5). The GTI assesses by extensive laboratory testing

The project results are expected in April 2016. The information was gathered by: Eddie Johnston "Hydrogen Blending with Natural Gas – Increasing the Relevance of Pipelines in Renewable Energy Planning", World Gas Conference Paris, June 2015.

- the material integrity of various non-metallic pipeline materials, fusion connections, elastomer couplings and welds, thus the compatibility of the pipeline system and
- the integrity of defective welds joining low strength carbon steel pipe

by exposing components to a 5 % hydrogen blend. In the next step system upgrades are evaluated to determine which would be needed to reduce the risks of a 5 % hydrogen blend.

LABORATORY GTI

For testing non-metallic pipeline materials a "custom test rig was designed and constructed to test the effect of hydrogen permeation on the ductile strength and Slow Crack Growth (SCG) by Rate Process Method (RPM) hydrostatic pressure testing". The result was that "for both Ductile & SCG the material performs within original material prediction limits".

The fusion connections (PE 2406 saddle fusions) were connected to a pipe that was unexposed and a pipe "that was fully saturated with either baseline or hydrogen-blended gas". As a result the exposed fusion connections were not negatively impacted. The leakage and ignition characteristics of a 5% hydrogen blending were within statistical tolerances. The leakage rate of a 5% hydrogen blended gas through elastomer couplings is not different from the leakage rate of methane. The study shows that "due to the required flow increase of hydrogen, mechanical limitations of in-place meters will probably necessitate replacement with similar but larger capacity meters".

The embrittlement of steel pipelines is an area of concern, where further research is needed.

The table right presents a summary of the laboratory testing. The green-marked items are unproblematic, red-marked items are areas of concern. The short term and long term testing is on-going.

Pipeline Component Evaluated	Finding
Aldyl A MDPE – Ductile Performance	Material performs within original material prediction limits
Aldyl A MDPE – SCG Performance	Material performs within original material prediction limits
Aldyl A Fusion Quality	No negative impact on quality
Leakage and Ignition Characteristics	Within statistical tolerances of baseline blend
Combustion Risk and Safety	Similar to methane blend
Existing In-place Components	Meter replacement necessary due to higher flow rates
Leakage through Mechanical Coupling Elastomeric Seals	Higher leakage of H_2 through elastomers **Further Research Needed**
Impact on Pipeline Steels	Areas of concern: Hydrogen-Environment Embrittlement, Fracture Toughness and Crack Propagation Resistance **Further Research Needed**

SOURCE: EDDIE JOHNSTON | GAS TECHNOLOGY INSTITUTE

GERG PROJECT HYGRID - PRACTICAL EXPERIENCE OF HYDROGEN FEED-IN TO A NATURAL GAS DISTRIBUTION NETWORK

E.ON Technologies, in collaboration with HanseWerk AG, Schleswig Holstein Netz AG and Engler-Bunte-Institute (DVGW-EBI), have completed a study of the technical feasibility of hydrogen feed-in to an existing natural gas distribution network. The focus is on the investigation of today's gas consumer appliances in a field test under real conditions. The feed-in of hydrogen was phased to 2, 3, 4, 6.5 and 9 vol%. First results (up to 4 vol%) were previously presented in October 2014 in the 3rd HIPS-NET Newsletter.

The results are only available in German.
Source: "Praxiserfahrungen mit der Wasserstoffeinspeisung in ein Erdgasverteilnetz", http://www.energie-wasser-praxis.de/fileadmin/Bilder/ewp/10_2015/Nitschke_Kowsky_ewp_1015.pdf

Authors:
Dr. Petra Nitschke-Kowsky and
Dipl.-Ing. Werner Weßing (E.ON Technologies)
Dr. Holger Dörr and
Dipl.-Ing. (FH) Kerstin Kröger (DVGW-EBI)

Gas distribution network Klanxbüll/ Neukirchen	
Year of construction	*1997*
Pressure (gas pressure regulation station)	*40 – 60 bar*
Pressure (distribution network)	*500 mbar*
Length	*ca. 18 km*
Injection point (entry point)	*1*
Odorant	*Odor-S-Free*
Structure of consumption	
Gas consumption	*max. 170 Nm³/h*
calorific value (project duration)	*12.2 kWh/m³*
Wobbe-Index (project duration)	*15.2 kWh/m³*
Inhabitans Klanxbüll/ Neukirchen	*ca. 2,000*
Consumer	*177*
Year of construction of the buildings	*1951 – 1985*
Building type	*Predominantly sin-*
Commercial clients	*Hotel, Restaurant*
Natural-gas filling station	*None*

CHARACTERISTICS OF THE GAS DISTRIBUTION NETWORK KLANXBÜLL/NEUKIRCH

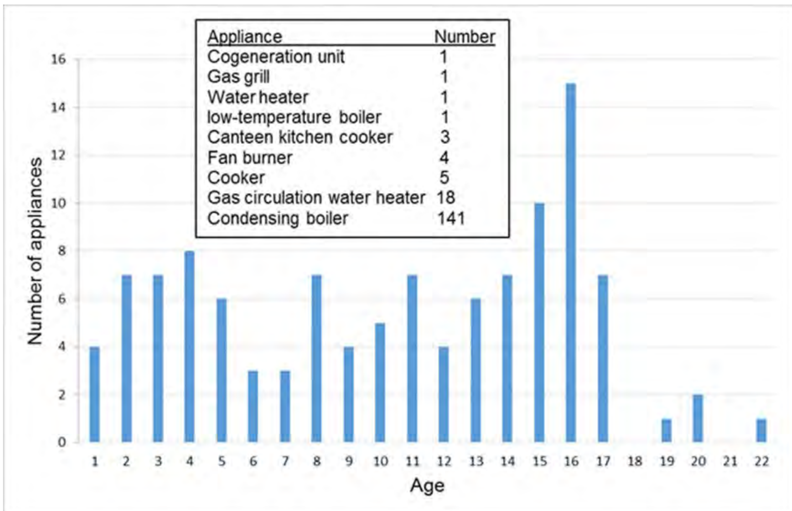
The distribution network Klanxbüll/Neukirchen (Schleswig Holstein) was selected as the testing site. The essential characteristics of the grid are given in Table (left).

The hydrogen injection unit was installed next to the gas pressure regulator station and a new measuring and billing concept was developed in close cooperation with the German calibration authority. For measurement purposes, new gas flow meters suitable for hydrogen were installed at the gas pressure regulator station.

Previous to the field test, 39 appliances were tested under laboratory conditions and up to a hydrogen level of 30 vol% as part of the linked project HYGRID (see previous article in this newsletter). Before the start of the hydrogen injection process, all gas home appliances were registered and measured by the project partners. The registered appliances show a wide spread with regard to model, age and manufacturer (see figure 2 below).

More than 30 representative appliances were selected based on their type and age and underwent periodical re-measurements for control and analysis during the increasing hydrogen injection. CO_2 and O_2, for calculation of the air factor as well as emissions of CO, temperatures of combustion air and exhaust gas were measured. Additionally installers and customers are invited to give information in case of any disturbances. The appliances were only analysed if owners or installers reported malfunctions.

The results of the project confirmed that the gas quality met the requirements of the German gas quality standard (DVGW G 260, G 262) at all times. As such, the characteristics of the distributed gas complied with the given tolerances of the combustion characteristics (e.g. Wobbe index, calorific value and relative density) and a single-digit hydrogen concentration (below 10 vol%). In the whole field test no hydrogen induced problems were noticed for any installed appliances, no negative influences to the specific CO-emissions were observed. During the whole test process all requirements from the German gas quality standards were fulfilled.



INSTALLED GAS HOME APPLIANCE IN THE TEST AREA (TYPE AND AGE)

RENEWABLES AND HYDROGEN-BASED OFF-GRID ENERGY SUPPLY SYSTEM DEMONSTRATION IN KAWASAKI /JAPAN

SOURCE: TOSHIBA

Toshiba, in cooperation with Kawasaki City/Japan, is currently running a demonstration testing of an off-the-grid energy supply system utilising renewable energy and hydrogen. The stand-alone energy supply system combines solar photovoltaics, storage batteries, hydrogen-producing water electrolysis equipment, fuel cells, and other equipment. The testing began in April 2015 and will continue until 2020.

http://www.japanfs.org/en/news/archives/news_id035164.html; http://www.toshiba.co.jp/about/press/2015_04/pr2001.htm

The system is located in a designated emergency evacuation area, the installed system will be able to provide an estimated 300 evacuees with electricity and hot water for about one week, even if lifelines are cut due to a disaster. Under normal circumstances, the system's energy management system will be used to shift and reduce peak power demand.

WORLD'S FIRST COMMUNITY LEVEL HYDROGEN TOWN PROJECT IN KITAKYUSHU/JAPAN (1/2)

The Kitakyushu Hydrogen Town project ran from 2011 to 2014 performed by the Research Association of Hydrogen Supply/Utilization Technology (HySUT). The project supplied odor-mixed hydrogen to neighbouring housing complexes, single-family homes, commercial complexes and public facilities via pipelines. The hydrogen source was the local steel industry (by-product). The project verified the test operations of hydrogen fuel cells at homes and businesses, and an electric power supply system by interoperation among the fuel cells, solar power generation and secondary batteries.

Pipeline Characteristics

The selected hydrogen pipeline had the following characteristics:

Material	SGP carbon steel pipe for ordinary piping (JIS G3452)
Outer diameter	100A (114.3mm), 50A (60.5mm), 25A (34mm)
Thickness	100A-4.5mm, 50A-3.8mm, 25A-3.2mm
Coating	Polyethylene coating (outside). 100A pipes are coated also inside.
Fitting	Welded

The selected material SGP was compared with STPG (carbon steel pipe for pressure service), and polyethylene. All three materials are reported to be hardly embrittled by hydrogen in “The Study of Hydrogen Supply System Safety Technology” (2005-2007; by METI). SGP has a tensile strength of more than 290 N/mm² and, in the end, the better price-performance ratio.

Odorising of Hydrogen Gas

According to the Japanese Gas Business Act, the odorised gas shall be perceptible at a concentration of 0.1vol% in the air. The project partners evaluated five different odorants: cyclohexene, cyclohexene/TBM (tertiary-buthylmercaptan), TBM/DMS (dimethyl sulfide), TBM/THT (tetrahydro thiophene), and THT and finally decided to add cyclohexene (perceptible at 0.05 vol%). The odorant leads to slight cell voltage drops in fuel cells during short term tests. The effect of long term exposure has to be tested and evaluated.

Metering

Out of eight different volume metering devices, three were selected and installed and being used for billing purposes (see table next side)

WORLD'S FIRST COMMUNITY LEVEL HYDROGEN TOWN PROJECT IN KITAKYUSHU/JAPAN (2/2)

Evaluated H_2 flowmeters as a gauge for billing

Method	Positive displace	Variable area	Differential pressure	Turbine	Vortex	Ultrasonic	Thermal	Coriolis
Applicability	○	△	○	○	△	○	○	○
Safety	○	○	○	○	○	○	○	○
Accuracy	○	△	×	○	○	○	○	○
Cost	△	△	○	○	○	○	△	×
Environmental tolerance	○	△	○	○	△	△	○	△
Fitness for pipe work	○	△	△	△	△	△	△	△
Long-term stability	×	△	○	△	○	○	×	○
Availability	○ Under development	×	×	×	×	○ Under development	○	○

Selected PD, Thermal and Ultrasonic to be used in the town

SOURCE: HYSUT; YUKIO AWAZU

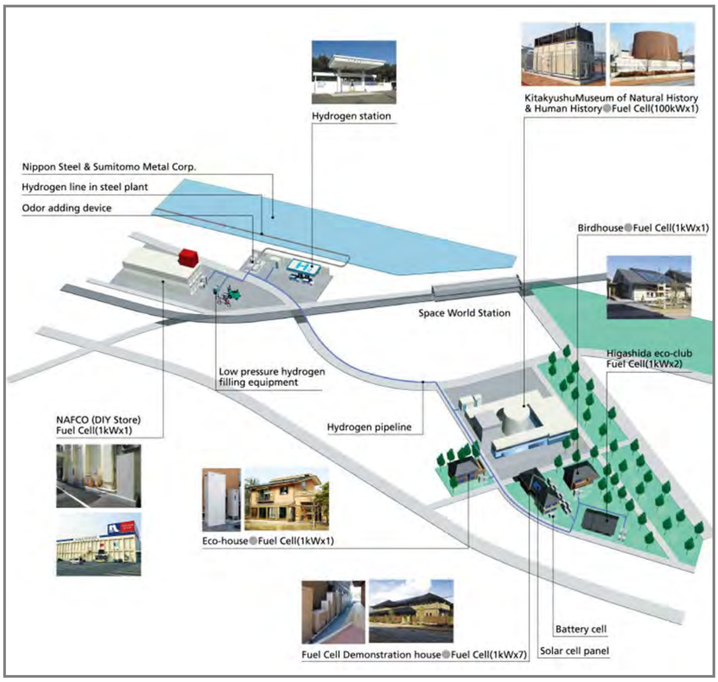
Metering

Out of eight different volume metering devices, three were selected and installed and being used for billing purposes (see table left)

According to the Japan Times, Japan plans to have 100 hydrogen stations running in 2015 and 1,000 by 2025. HySUT owns 12 hydrogen stations in Japan. These stations are used for demonstration and R&D. Tokyo Gas presented the following figure at the World Gas Conference 2015.

The association HySUT has undertaken various projects since 2009. Further information may be retrieved on the website http://hysut.or.jp/en/. An image film of the Kitakyushu project may be found here: https://www.youtube.com/watch?v=P4iD6U_Hx8Y

Authors:
Jun Komiya "The present state and marketing prospects of hydrogen stations", TOKYO GAS Co., Ltd. Technology Strategy Department (presentation World Gas Conference Paris 2015)
Yukio Awazu "Demonstration of Hydrogen Supply through Pipeline at Kitakyushu Hydrogen Town", HySUT, FC EXPO 2012



SOURCE: HYSUT; YUKIO AWAZU

NETWORK TOPICS

We are aiming to spread/exchange knowledge in order to better understand the impact of hydrogen/natural gas blends in pipeline systems. Our core topics comprise

- GAS TURBINES AND ENGINES
- POROUS UNDERGROUND GAS STORAGE
- STEEL CNG1 VEHICLE TANKS
- NATURAL GAS AS WORKING MEDIUM
- CROSS BORDER TRANSMISSION
- SAFETY CHARACTERISTICS OF H2/NATURAL GAS BLENDS

We additionally keep a minor focus on the general development of power to gas, hydrogen networks, and further topics around the utilisation of (renewable) hydrogen.

Important Events - Workshops - Conferences and Partners

Selection of appointments
(focus on the combination of hydrogen and natural gas)

++ Hydrogen for the Energy Industry – Large Reservoirs and Pipelines / Technology and Licensing Issues
(20. January 2016, Duisburg)

++ HyVolution – Hydrogen Energy Days
(4. – 5. February 2016, Paris)

++ 5th Workshop Admission – Certification – Standardisation (Security & Quality of Hydrogen and Fuel Cell Technology
(16. – 17. February 2016, Duisburg)

++ E-world energy & water
(16. – 18. February 2016, Essen)

++ Hydrogen and Fuel Cell Technology Supplier Marketplace
(10. March 2016, Berlin)

++ IRES – Energy Storage Europe
(International Conference & Exhibition for the Storage of Renewable Energies)
(15. – 17. March 2016, Düsseldorf)

++ 5th Conference Power-to-Gas & Power-to-X for Europe's Energy Transition
(16. March 2016, Düsseldorf)

++ WHEC2016 – 21. World Hydrogen Energy Conference
(13. – 16. June 2016, Zaragoza, Spain)

Current partners

Alliander ++ DGC ++ DNV·GL Oil & Gas ++ E.ON Technologies (Ratcliffe) limited ++ Enagas ++ Energinet ++ ETIC ++ EWE Netz GmbH ++ Fluxys ++ Gasnatural ++ Gasum OY ++ GRTgaz ++ grzi ++ Infraserv GmbH & Co. Höchst KG ++ ITM-Power ++ KOGAS ++ nPlan GmbH ++ OGE ++ ÖVGW ++ RAG Rohöl-Aufsuchungs Aktiengesellschaft ++ RWE Dea ++ RWE Deutschland ++ SGC ++ Shell ++ Solar Turbines Europe S.A. ++ SVGW ++ Synergrid ++ Verband der Chemischen Industrie ++ Volkswagen AG

Interests and wishes

Please let us know if you have special interests/wishes for the next newsletter. We look forward to your feedback and we aim to provide quality information that is actually needed and wanted to answer the hydrogen core topics.

Contact Notes

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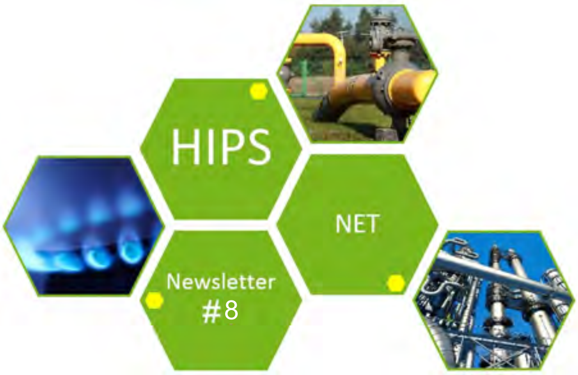


HIPS-NET

"Establishing a pan-European understanding of admissible hydrogen concentration in the natural gas grid"

Newsletter #8	February 2016

Content Newsletter #8

"A network leads to cooperation, cooperation leads to creativity and innovation - this changes the world." - Marissa Mayer (CEO Yahoo)

8TH HIPS-NET Newsletter

Dear Partners,
Dear Colleagues,

we would like to thank you here for reading our HIPS-NET newsletters for two years by now. Thank you for supporting the network, your curiosity in the topic and your trust in us as organisers! Most of you are HIPS-NET members right from the beginning in 2013/14. We maintain our stable base for the 3rd network year 2015/16 of about 30 partners. We regret to loose ETIC Canada for the 3rd year due to changes in their internal policy. The HIPS-NET team actively promotes the network and is in touch with potential partners to keep the network a stable and reliable source of information and exchange. The annual workshop was in the past two years well supported with 25 participants in 2014 and 28 participants in 2015. We agreed there, in 2015, to meet again for the HIPS-NET workshop on **22nd/23rd June 2016** in Brussels. Having said this, we hope to see as many of you in June 2016 again.

Power-to-Gas - the invisibility of the natural gas grid (Uschi Dreiucker - pixelio.de)

The present 8th newsletter focusses on Power-to-Gas (PtG) facilities; all are set up for research and demonstration purposes and cover different aspects of the technology, as you will read. It further contains two articles published in the frame of the World Gas Conference last year in Paris, one from Iranian and the other from French researchers. As explained in the last newsletter, we scanned an enormous amount of 625 presentation held in Paris and these are the last two topics we are sharing out of this research fund.

We also included a comparative study on hydrogen in the mobility sector and the gas industry, to understand joint and unlike positions of both industries. Our first article describes the results of a study on hydrogen production using electricity of a regional electricity distribution grid having large shares of renewables in the electricity mix.

We hope you enjoy reading!

Your HIPS-NET Team
Gert, Dave, Stefan, Anja & Gideon

POTENTIAL OF HYDROGEN BLENDING | ANALYSIS BASED ON AN EXISTING GAS AND ELECTRICITY INFRASTRUCTURE IN NORTH-WEST GERMANY (1/2)

The project partners EWE and DBI GUT analysed the potential of the gas network to accommodate hydrogen in order to relieve the burden of electricity network induced by volatile electricity generation of wind and PV. The renewable electricity production amounts in the region to 9.14 TWhel per year which equals a share of approximately 50 % of the electricity demand in the region. The increasing electricity production requires network expansion in all voltage levels. Previously performed research indicated the advantages of implementing power-to-gas facilities to optimise the electricity network expansion. This study concentrates on the question which conditions are central to enhance the benefits when connecting the gas and the power grid, mainly by simulation of the gas network.

Source: Thomas Götze, Jens Hüttenrauch, Gert Müller-Syring "Potenziale zur Wasserstoffeinspeisung im Versorgungsgebiet der EWE Netz GmbH", energie | wasser-praxis 1/2016 p. 54 (in German)

The authors see under current (regulatory) conditions, the following optimised installation of PtG facilities for the investigated area:

- 9 locations (out of 73),
- single electric PtG capacity between 100 kW_{el} and 1.1 MW_{el} (5 MW_{el} in total)

This would result in

- hydrogen production of 43,000 MWh_{H2} per year which
- equals about 1 % of the produced electricity by wind and PV in the region.

The sole implementation of intermediary storage increases the utilised capacity of the PtG facilities by 46 % without changing any of the below mentioned conditions.

The authors further evaluated the impact on the hydrogen injection capacity of the gas grid if the currently existing (regulatory) conditions were changed, for example (based on the examined region north-west Germany):

- Increasing the limitation of hydrogen concentration of the gas grid beyond 2 vol% up to 10 vol% and 15 vol%.
- Reduction of the hydrogen feed-in availability of the gas network from 96 % to 40 %.
- Implementation of intermediary storage to bridge up to 12 hours with low gas demand.

The reduction of the legal gas network availability requirements to 40 % would allow for installing significantly larger PtG facilities (enhanced power capacity). The power layout is original optimised for a year-round hydrogen feed-in capability of the gas network and the enhanced version is optimised for feed-in capability in times when the transported amount of natural gas is higher (during the heating season).

The most effective approach to increase the feed-in capacity remain the raising of admissible hydrogen concentration in the gas network. The capacity rises proportionally by five times if the hydrogen concentration rises from 2 to 10 vol%. Up to 10 vol% hydrogen is the maximum concentration allowed under German gas quality standards (DVGW G 260, G 262) if the adjacent technical facilities are not hydrogen sensitive.

Results in an Optimised Scenario

The project partners identified an optimised scenario with 15 vol% admissible hydrogen concentration in the gas network and reduced hydrogen feed-in availability of 40 % leading to:

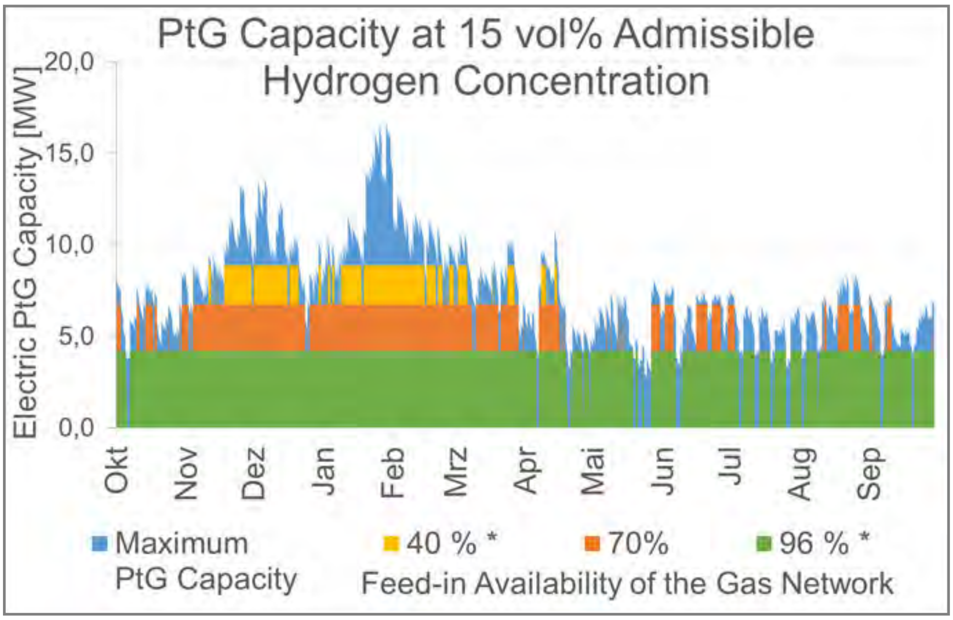
- 30 suitable PtG locations (out of 73) and
- electric PtG capacity between 100 kW_{el} and 8.2 MW_{el} (260 MW_{el} in total).

This would result in :

- hydrogen production of 0,9 TWh_{H2} per year which
- equals about 15 % of the produced electricity of wind and PV in the region and covers about 3 % of the regional gas demand.

The swap from natural gas to hydrogen reduces the CO2 intensity of the gas supply, as the combustion of hydrogen does not lead to greenhouse gas emissions. CO2 emissions could be reduced by 7,000 t-CO2 per year under current (regulatory) conditions and by 163.000 t-CO2 in the optimised scenario.

POTENTIAL OF HYDROGEN BLENDING | ANALYSIS BASED ON AN EXISTING GAS AND ELECTRICITY INFRASTRUCTURE IN NORTH-WEST GERMANY (2/2)



PTG CAPACITY AT 15 VOL% I SOURCE: DBI GUT

Recommendations and Outlook

The project partners recognise the current technical uncertainties for raising the admissible hydrogen concentration due to sensitive elements in adjacent installations (e.g. gas turbines, natural gas filling stations, underground gas storages) and fluctuating hydrogen concentrations. They suggest preparing the gas network for the injections of rising hydrogen concentrations in the course of regular maintenance and in the upcoming alteration of the gas qualities in Germany (from low to high calorific gas).

COMPARATIVE STUDY OF THE POTENTIAL TO INTEGRATE HYDROGEN IN THE MOBILITY SECTOR AND THE GAS INDUSTRY | GERMANY

Source: Gert Müller-Syring, Marco Henel, Anja Wehling, Martin Weiße „Metastudie zur Untersuchung der Potenziale von Wasserstoff für die Integration von Verkehrs- und Energiewirtschaft“ supported by Dr. Oliver Ehret, Hans Rasmusson, René Schoof

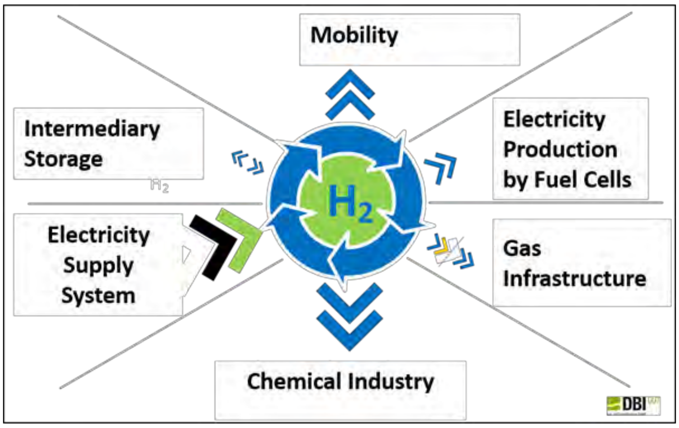
The German National Organisation Hydrogen and Fuel Cell Technology (NOW GmbH) and the German Association for Gas and Water (DVGW) set up a research project to improve the understanding of multiple uses of hydrogen, mainly as a fuel and for injection into the natural gas network. While the automobile industry concentrates on the use of pure hydrogen, the gas industry focuses on hydrogen/natural gas blends. Both industries have ‘traditionally’ pursued their own technological and economic strategies, without having them compared or aligned with regard to joint utilisation concepts. The research project, respectively study, funded by NOW and DVGW, thus reviews the technical and economical pathway analyses of two previously completed studies. Based on this, the research project establishes combined economic value chains, including technical preconditions, development needs, and economic feasibility predictions for the future.

Results

The comparative analysis of the two ‘source’ studies shows different, but supplementary, hydrogen utilisation concepts and economic assessments. The new study defines and investigates different value chains, and compares the economic feasibility of single-sector with combined - multi-sector - utilisation approaches (in three different scenarios). The newly developed combined approaches suggest advanced economic viability by lowering the production costs of hydrogen by up to 30 %.

The study identifies two main R&D issues:

- Combination of utilisation approaches in different industries (see example in the figure)
- Cost optimisation for technical components as well as operational management



SUGGESTION FOR A COMBINED UTILISATION APPROACH „CHEMICAL INDUSTRY + MOBILITY“ (INCLUDING ADDITIONAL REVENUES) I SOURCE: DBI GUT

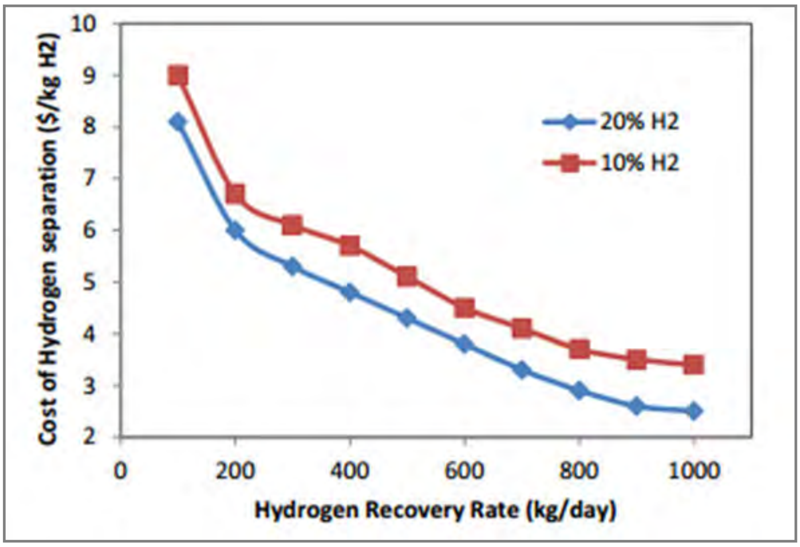
BLENDING HYDROGEN INTO NATURAL GAS PIPELINE NETWORKS | IRAN (1/2)

Power to gas (PtG) is a topic in Iran because the country has not only the second largest sources of natural gas worldwide but also a pipeline network that covers nearly the entire country. Some Iranian regions face periods of excess electricity, when the generated electricity exceeds the existing demand, while the storage capacities are insufficient. PtG is seen as a technology, which enables the gas grid as energy storage for renewable electricity and additionally an approach to optimise the electricity grid extension. Furthermore, it enables lowering the carbon intensity and improving the sustainability of natural gas.

The allowed hydrogen content in the natural gas distribution network in Iran is about 5 vol%; this benchmark may differ from one region to another. This article summarises findings of a study performed of two Iranian universities, the Kermanshah University of Technology and the Razi University, in cooperation with the Kermanshah Province Gas Company, based on literature review and calculations of the economic feasibility. The paper addresses five key issues:

1. Impact on End-Use Systems
2. Material Durability
3. Safety
4. End-Use Extraction
5. Leakage (Emissions)

They found that a hydrogen blending of maximum 20 vol% is possible without large modifications of the end-use systems. It would however require upgrading the pipeline systems; the investment costs impose further restrictions. In case of adding 4 vol% hydrogen, the cost of required modification of the sensors amount to about $ 500,000 in Iran.



COST OF HYDROGEN SEPARATION I SOURCE: SOHRAB FATHI, ET AL.

The researchers found that the risk of ignition with low hydrogen concentration (less than 20 vol%) remains at minor level and can be ignored. Also, in case of safety zones in explosion for natural gas leakage, 20 vol% or less hydrogen would result minor increases in the severity of the explosion. Even the risk of explosion is considered as not severe. An admixture of more than 50 vol% hydrogen showed that the overall risk significantly increases.

The emissions (leakage) of natural gas in pipelines are comparable if hydrogen concentration rises up to 20 vol% (insignificant increase). The age of the pipeline does not influence the leakage rate upon increasing hydrogen levels.

Methods for extracting hydrogen from the mixture with natural gas are for example membranes or pressure swing adsorption. The authors evaluated the cost of using the pressure swing adsorption. With this technique a recovery of 80 % of the added hydrogen is possible. In the figure below you can see the relation between the separation cost and the recovery rate for an admixture of 20 vol% and an admixture of 10 vol% hydrogen. "For a pipeline with 10% concentration of hydrogen, the separation cost is about $3.4-$9.0/kg of extracted hydrogen, varying by recovery rate of hydrogen per day […]. For a 20% hydrogen concentration, the separation cost decreases to $2.5-$8.1/kg of extracted hydrogen."

Source: Sohrab Fathi, Saeed Ovaysi, Roozbeh Mehdiabadi: "Technological and Economic Aspects of Blending Hydrogen into Natural Gas Pipeline Networks: Determination of Key Issues for a Selected Gas Pipeline in Iran", World Gas Conference Paris, June 2015
The paper is available here: http://www.researchgate.net/publication/279708593_Technological_and_Economic_Aspects_of_Blending_Hydrogen_into_Natural_Gas_Pipeline_Networks_Determination_of_Key_Issues_for_a_Selected_Gas_Pipeline_in_Iran

The study argues that a hydrogen blending of 5 vol% does not require any modification of the pipeline and may be used by end-user without hydrogen extraction.

The authors intend to promote the engagement of the gas network for synthetic renewable gases, the development of a fuel cells based mobility, and the use in further field as the chemical industry. Apart from the described evaluation of the hydrogen blending, the paper does not mention any further activities planned to realise PtG projects in Iran.

HYDROGEN-BASED ENERGY STORAGE | FRANCE

The SBC Energy Institute (SBC EI) presented during the World Gas Conference 2015 an exhaustive techno-economic analysis for hydrogen-based electricity storage by assessing the entire value chain, from intermittent electricity conversion to end-uses of hydrogen. The study summarizes nine business cases, which are mainly derived from literature review and more than 50 interviews with a variety of hydrogen-industry stakeholders. Environmental impacts, safety and social-acceptance issues are also addressed.

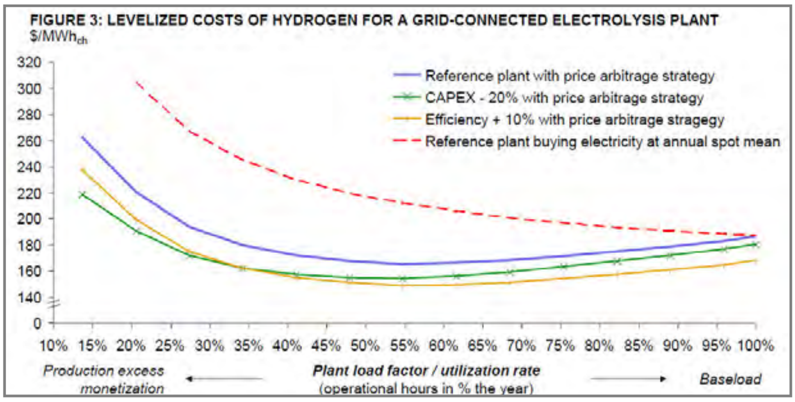
Source: Claude Mandil, Romain Debarre, Benoit Decourt (SBC Energy Institute) "Hydrogen-Based Energy Conversion | More than Storage: System Flexibility. Focus on Power-to-Gas", WGC Paris 2015.

SBC published a peer reviewed FactBook (about 260 pages) and a presentation: http://www.sbc.slb.com/en/SBCInstitute/Publications/Hydrogen.aspx

Hydrogen Storage and Transport

The authors assess various hydrogen storage options as compression in salt caverns and pressurised tanks; liquefaction in cryogenic tanks; and absorption in metal hydrides. Hydrogen storage incurred additional costs and efficiency losses. The study assigns energy losses of 5-15 % in the case of compression (depending on pressure differentials), 25-45 % during liquefaction, and 5 -20 % in the case of absorption into metal hydrides, varying according to heat-capture, storage and recycling capability. Pressurised tanks are likely to remain the main means of storing hydrogen, benefiting from the chemicals and petrochemicals industries' extensive experience of hydrogen utilisation. The storage means, though, may be shifting in the mid or long term perspective.

The transportation of hydrogen in the natural gas grid is a low-cost option but faces three main constraints: the integrity and safe use of pipeline and grid appliances; the energy capacity of the grid; and the sensitivity of end-use appliances to hydrogen/methane blends. The SBC EI proposes that blending of 1-5 vol% hydrogen at any point in the gas grid is technically feasible and finds, the network should tolerate an admixture of up to 20 vol% hydrogen in distribution pipelines. Their research on the hydrogen tolerance rests upon the DVGW research performed by DBI (see hydrogen tolerance matrix in HIPS-NET newsletter #1 page 2).



LEVELIZED COSTS FOR HYDROGEN I SOURCE: MANDIL ET AL.

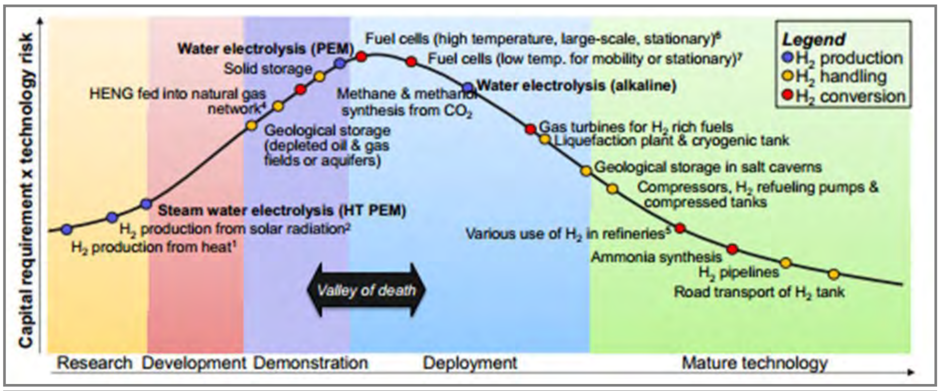
Commercial Viability

The authors identify as main parameters that could help electrolyser commercial viability, in decreasing order of importance: reductions in the capital costs of electrolysers, the introduction of mechanisms to reward short-term grid-stability services or long-term storage services, and reductions in electricity input prices or greater electricity-price volatility.

The example in figure 3 is based on 8.5 MW_{el} electrolysis (5 alkaline stacks of 1.7 MW_{el} each), with total installed system CAPEX: $765/$MWh_{,H2}$ efficiency: 79 % GCV, project lifetime: 30 years and real discount rate after tax of 10 %.

The production costs of hydrogen from electrolysis are currently not competitive. The main influencing factors are the daily electricity prices and the utilisation rate. The business models will also depend on the existence of feed-in-tariffs for 'green gas'.

The figure shows the maturity curve of hydrogen-related technologies. Many of technologies are either in the deployment phase or even technologically mature but electrolysis and power-to-gas are in the 'valley of death' where demonstration is expensive and the feasibility is still uncertain. As a result, public and corporate funding remain essential.



MATURITY CURVE OF A HYDROGEN-BASED TECHNOLOGYI SOURCE: MANDIL ET AL.

MYRTE PROJECT – HYDROGEN STORAGE AND ELECTRICITY PRODUCTION | FRENCH ISLAND CORSICA

The MYRTE project is a joint venture by AREVA, CEA, the University of Corsica and the CNRS. Its goals are to support peak shaving in the Corsica grid through the efficient use of photovoltaic units and hydrogen storage. The project is running in two phases; during the first phase, beginning in October 2011 the following facility was designed, set up, and operated since early 2013.

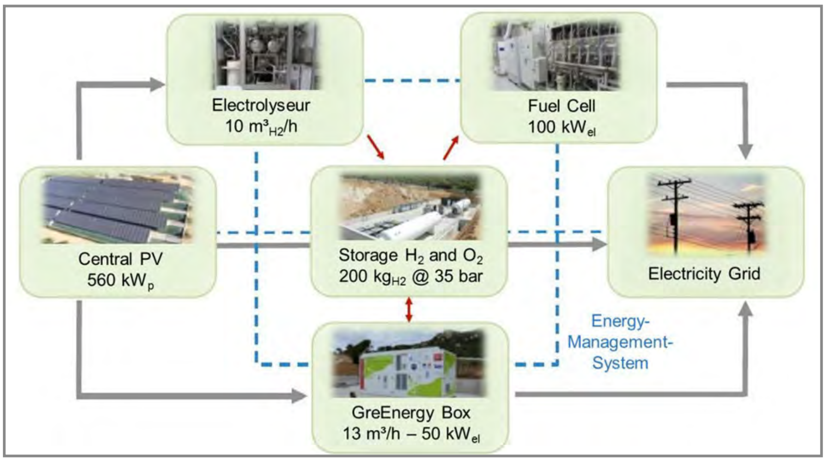
- The **560 kWp provided by the photovoltaic units** will either be delivered directly to the grid as required by the Corsican grid operator (for example to contribute towards peak shaving) or be converted into hydrogen using
- the facility's **two PEM electrolysers** (combined **total capacity: 110 kW_{el}** and 10/13 m^3_{H2}/h respectively).
- The facility has a **hydrogen storage capacity of 200 kg_{H2} @ 35 bars**, the equivalent of 17.5 hours of electricity providing by the fuel cells of 100 kW_{el} (1.75 MWh_{el}).
- It also includes **two PEM fuel cells** with a combined **output of 150 kW_{el}** (100 kW_{el} and 50 kW_{el} respectively).

GREENERGY BOXTM I SOURCE: AREVA

The inversion process would allow stored hydrogen to be converted into electricity for the high voltage grid, thereby allowing the Corsican grid operator greater flexibility with the use of photovoltaic power.

The second phase has started in June 2014. The project partners installed a GreEnergy Box^{TM}, to achieve photovoltaic smoothing. The box, manufactured in co-operation between AREVA and Schneider Electric, is an automated energy management facility intended to remotely control and optimize the usage of the MYRTE plant

- through use one PEM fuel cell of 50 kW_{el}
- use one electrolyser of 13 m^3_{H2}/h.



SIMPLIFIED OVERVIEW OF THE FACILITY DESIGN I SOURCE: POGGI ET AL., MYRTE KEYNOTE; PRESENTATION 2015-10-14; GDR HYSPÀC

In a study case, during the solar eclipse in March 2015, the fuel cell of 100 kW_{el} was used for up to 16 hours continuously with an electricity output of 859 kWh_{el} and thermal energy of up to 571 kWh_{HEAT}. This process has an energy efficiency of 53 % (experimental testing), however this can be increased by a further 14 % through use of cogeneration technology (efficiency based on lower heating value). Testing by AREVA has shown the ability of the facility to react to fluctuations in electricity production and may supply electricity in less than 15 minutes and in up to 29 cycles per day. A full black start can be achieved in less than one hour. The GreEnergy Box has also resulted in a 30 % increase in energy efficiency compared to the first equipment (electrolyser of 10 m^3_{H2}/h and fuel cell of 100 kW_{el}) installed.

Until October 2015, over 6,300 hours of operation for the hydrogen chain, producing 43 MWh of electricity via the fuel cells and 4,000 kg of hydrogen via the electrolysers. The photovoltaic units had produced 2.8 GWh of electricity. The MYRTE project was originally conceived as an energy solution for remote French overseas regions (Guadeloupe, La Reunion, Guyana) but could be utilised for other inaccessible locations, such as national parks, small cities in remote regions or critical infrastructure. The research will now continue and analyse

- the exergy efficiency of the facility,
- the recovery of heat using a stage compressor with different metal hydrides for the purpose of achieving a suitable pressure with which to supply a hydrogen station for mobility.
- the changes in facility performance due to aging, the internal temperature in the cell core and its effect on water management.

Sources: http://www.windkraft-journal.de/2014/05/16/hydrogen-energy-storage-power-ramp-up-at-the-myrte-test-platform/52483
http://www.iphe.net/docs/Events/Seville_11-12/Workshop/Presentations/Session%202/2.4_IPHE%20workshop_Gosset.pdf

WINDGAS HAMBURG | POWER TO GAS DEMONSTRATION PLANT | GERMANY

An ambitious Power-to-Gas project in the north of Germany is set to take an important step forward. In autumn last year the new prototype Power-to-Gas facility at Hamburg-Reitbrook was officially commissioned.

AERIAL PICTURE OF THE WINDGAS FACILITY HAMBURG-REITBROOK | GREGOR SZIELASKO, 2015

The facility, which has been developed by a consortium featuring Uniper, will convert surplus energy (more than two-thirds of which will be sourced from the high concentration of wind turbines in northern Germany) into hydrogen (290 m^3_{H2}/h) using a PEM electrolyser. This will then be fed into the local gas network for later usage. The electrolyser, which has a 1.5 MW_{el} capacity, is the most modern in the world to date generating a power density of 4,000 watts/litre – a new industry benchmark. One notable feature of the electrolyser is its relatively small size – the unit is approximately 55 x 70 x 90 cm, despite maintaining a comparable performance to other large PEM electrolysers.

The project has undergone extended operational testing in which the durability and the suitability of this technology for projects on a larger scale was analysed. Further testing by the project partners will continue throughout the first period of operation. Uniper hopes to use the technology to support natural fluctuations in the supply from renewable energy resources and to expand the technology for use with mobility systems.

The full list of project partners is: Uniper AG, Uniper Energy Storage GmbH, HanseWerk Gruppe, Hydrogenics GmbH, SolviCore GmbH & Co. KG, the German Aerospace Center and the Fraunhofer Institut for Solar Energy. 48% of the €13.5 million investment costs were subsidised by the German Federal Ministry of Traffic and Digital Infrastructure.

Further information may be retrieved here:
http://www.streetinsider.com/Corporate+News/Hydrogenics+%28HYGS%29+1.5-MW+PEM+Electrolyzer+System+Passes+Factory+Acceptance+Testing/10515060.html (English)
www.windgas-hamburg.com (German)

Please contact for further information: René Schoof (rene.schoof@uniper.energy) and Thomas Brauer (thomas.brauer@eon-hanse.com).

WINDGAS FALKENHAGEN | POWER TO GAS DEMONSTRATION PLANT | GERMANY (1/2)

The Uniper Energy Storage GmbH initiated in 2011 the Power to Gas Plant in Falkenhagen (Brandenburg, North East Germany) with the following aims:

- Demonstrate the process chain
- Optimize the operating concept
- Gain experience with the technology, costs, approval procedure and trading

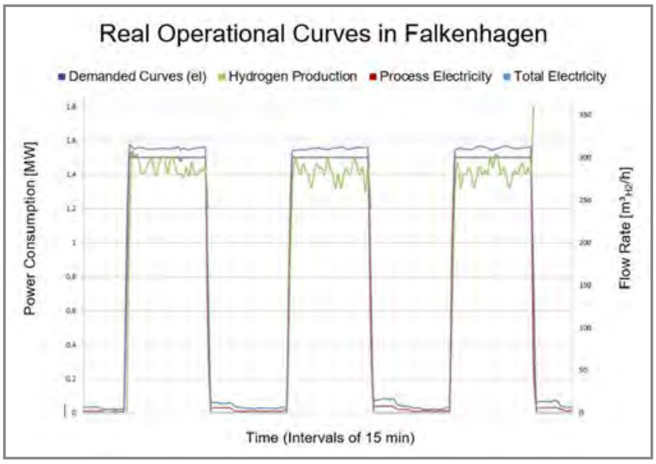
Source:
"Power-to-Gas – Erfahrungen bei der Erzeugung von regenerativem Wasserstoff mittels Alkali / PEM-Elektrolyse" – René Schoof (Uniper); DBI Fachforum Energiespeicher; Berlin, 16th September 2015

For further information, contact René Schoof (rene.schoof@uniper.energy).

In the north of Germany, renewable electricity generation is more commonly installed than in the south. The region around Falkenhagen produces two to three times more electricity than it consumes. The transformer station in Falkenhagen only transferred electricity from the lower voltage electricity grid to the 20 kV grid during the years 2009 to 2012 (recovery). This excess electricity continuously increases. In addition, there are extreme power peaks and sharp fluctuations. These conditions and the proximity to the natural gas transmission system form the basis for the Power to Gas project.

The first demonstration phase will be closed in 2016. The construction of the plant took one year and was completed in August 2013.

WINDGAS FALKENHAGEN | POWER TO GAS DEMONSTRATION PLANT | GERMANY (2/2)



OPERATING BEHAVIOUR OF THE PTG PLANT FOR ANXILLARY ELECTRICITY GRID SERVICES I SOURCE: UNIPER

WINDGAS FALKENHAGEN I SOURCE: UNIPER

Six alkaline water electrolysers were installed, each with an overall electrical power consumption of 2 MW_{el} and a hydrogen production of 360 m^3_{H2}/h, running 2,000 to 2,500 hours of full load per year. Two compressors (a diaphragm and a piston compressor; 70 % of full load each) increase the pressure of the produced hydrogen from 10 up to 55 bar. The hydrogen injection is limited by the natural gas grid operator to a maximum of 2 vol%. The overall efficiency (from production to injection) amounts to 61 %, based on higher caloric value.

Metering Devices in Operation for Testing

A rotary displacement meter (positive displacement flow meter) was installed for operation with pure hydrogen and certified by the German calibration authority. In addition, a Coriolis mass flow meter (volumetric calculation based on Coriolis effect) and a thermal metering device were installed as part of the leakage detection system for the hydrogen injection pipeline and to test the measuring systems for pure hydrogen.

The quality of the hydrogen is measured by a process gas chromatograph (not certified by the German calibration authority). The results provide for high hydrogen purity of 99.995 vol%.

THE E-GAS PROJECT AT THE BIOGAS PLANT IN WERLTE | GERMANY (1/2)

The e-gas project in Werlte/Germany presents the world's first large-scale plant for the production and supply of synthetic natural gas and is a collaboration of AUDI AG, EWE Netz GmbH, and EWE ERNEUERBARE ENERGIEN GmbH.

AUDI AG has built a Power to Gas facility next to the Werlte biogas plant (operated by EWE since 2006) with three electrolysers (2 MW_{el} each) and a methanation plant. The operation for the production and injection of the 'green' synthetic natural gas (short: e-gas) began in June 2013. It is expected to produce about 1,000 tons of e-gas per year, thereby utilising 2,800 tons of regenerative CO_2. The efficiency of the entire system amounts to approximately 56 %.

The injection of the two gases into the natural gas grid takes place separately. The biogas is passed from the upgrading plant to the biogas injection facility while the e-gas is passed from the methanation plant to the e-gas injection facility. This separate injection is necessary so that the intermittent injection of the e-gas can be tested in the course of the running production process to study the impact of volatile generation using regenerative electricity. The intermittent operation of the PtG facility is scientifically evaluated by ETOGAS, Fraunhofer IWES, and the research project "WOMBAT" at the ZSW in Stuttgart.

Source: Kurt Osman, Thomas Götze, Jan Adrian Schönrock „Das e-gas-Projekt am Biogasanlagenstandort in Werlte", gwf-Gas|Erdgas, May 2014, page 304-309.

The article is available only in German may be retrieved under: https://www.di-verlag.de/media/content/gwf-GE/gwf_Gas_5_14/gwf-GE_05_2014_FB_Kurt.pdf?xaf26a=7841c984ef837209544e821cb79b6b23

An image film in English may be found here: https://www.youtube.com/watch?v=RPTjxW4dQEw

THE E-GAS PROJECT AT THE BIOGAS PLANT IN WERLTE | GERMANY (2/2)

The biogas is delivered up to the connection point with a maximum volume flow of 770 m³/h and the e-gas has a volume flow of maximum 340 m³/h with a hydrogen content of maximum 5 vol% and a pressure of 7.5 bar. Both gases are injected into the local gas distribution network (1 bar design pressure) and, in times of limited capacity after compression, injected into the regional high-pressure gas network (84 bar design pressure).

SOURCE: SPOHN/KLAAS "IGU WORKING COMMITTEE 4 – DISTRIBUTION", COMMITTEE REPORT, PRESENTATION AT WORLD GAS CONFERENCE PARIS JUNE 2015

Three compressors ensure the injection into the high pressure network; a biogas compressor with a capacity of 770 m³/h, a biogas/e-gas compressor with 1,100 m³/h and an e-gas compressor with 350 m³/h.

The injection of the biogas and the e-gas into the same grid ensures sufficient mixing of the two gases, and therefore the compliance with the gas quality of the technical standards (DVGW G 260 and 262) and a hydrogen concentration of less than 2 vol% because of the simultaneous injection with biogas in either of the gas networks. The measurement of the characteristics of e-gas takes place with a 13-component process gas chromatograph and simultaneously ensures the quality of the gas. Another analyser is installed at the entrance of the gas injection facility in order to measure and evaluate permanently the concentrations of oxygen, hydrogen, hydrogen sulphide and carbon dioxide. If the produced gas is not compliant with the technical standards, it is passed on to an automated emergency flare station.

AERIAL PICTURE OF THE E-GAS PROJECT I SOURCE: EWE AG

Reliving the electricity grid

The e-gas project in Werlte could relieve the electricity grid at peak load times if run in a grid-orientated operation mode instead of a market-driven operation mode. The local electricity production in the region around Werlte already exceeds the electricity demand and an excess is transferred into the higher voltage grid through 80 % of the year. The PtG facility would run for 5,100 full load hours yearly (using the year 2013 as a basis).

THÜGA POWER TO GAS PLANT EXCEEDS EXPECTATIONS | FRANKFURT/M. GERMANY (1/2)

Further information can be found at the link below:
www.szg-energiespeicher.de
http://www.itm-power.com/project/thuga-power-to-gas

The Thüga Group has announced that its Power to Gas project in Frankfurt/Main has exceeded its expected efficiency levels during initial performance testing. The plant, which contains a PEM electrolyser built by ITM Power, was the first unit in Germany to inject hydrogen directly into the local gas distribution network. The plant first went online in November 2013. After initial site-acceptance testing, the unit has been tested extensively according to a program designed by the European Institute for Energy Research (EIFER) and the German Association for Gas and Water (DVGW), which includes multiple start/stop tests and load modulation over the systems full range, in order to analyse its performance, its reliability, and its capacity to assimilate intermittent renewable power.

Within the relevant operating range of the unit of 50 to approx. 325 kW_{el}, the first stress testing recorded an overall efficiency rate of up to 77 % (with reference to the upper heating value) across the whole system, from electricity input to injection into the gas network. According to Thüga CEO Michael Riechel, one of the reasons for this high efficiency rate is that the plant can feed directly into the natural gas distribution network and does not require a compressor. These tests will be repeated on two further occasions.

THÜGA POWER TO GAS PLANT EXCEEDS EXPECTATIONS | FRANKFURT/M. GERMANY (2/2)

SOURCE: THÜGA AG, ITM POWER

The gas mixing plant ensures that the hydrogen level in the natural gas network does not exceed 2 % by volume. In August 2015 the project demonstrated the suitability of Power to Gas to function as a grid balancing technology. Now the plant joins the German market for balancing energy. In fall 2015 the partners additionally showed that the technology is suitable for being part of a smart grid. The plant will remain online until completion of the comprehensive testing activities in the end of 2016.

Facts about the gas demonstration plant Thüga Group

- **Location:** Schielestraße 201, 60314 Frankfurt/Main
- **Project duration:** 2012 until the end of 2016
- **Project participants:** 13 companies of the Thüga Group
- **Investment cost:** approx. 1.5 million EUR (without personnel cost)
- **Technology:** Proton exchange membrane (PEM), electrolyser of ITM Power
- **Electrical nominal power:** approx. 300 kW
- **Generation:** approx. 60 m³ hydrogen per hour, 3000 m³ hydrogen blended natural gas
- **Integration:** injection of 2 vol.-% hydrogen with a pressure of 3.5 bar in the gas distribution network
- **Promotion:** Hessian Ministry of Economy, Transport, Urban and Regional Development & European Commission

SOURCE: THÜGA AG, ITM POWER

NETWORK TOPICS

We are aiming to spread/exchange knowledge in order to better understand the impact of hydrogen/natural gas blends in pipeline systems. Our core topics comprise

- GAS TURBINES AND ENGINES
- POROUS UNDERGROUND GAS STORAGE
- STEEL CNG1 VEHICLE TANKS
- NATURAL GAS AS WORKING MEDIUM
- CROSS BORDER TRANSMISSION
- SAFETY CHARACTERISTICS OF H2/NATURAL GAS BLENDS

We additionally keep a minor focus on the general development of power to gas, hydrogen networks, and further topics around the utilisation of (renewable) hydrogen.

SELECTION OF APPOINTMENTS

(FOCUS ON THE COMBINATION OF HYDROGEN AND NATURAL GAS)

++ Hydrogen for the Energy Industry – Large Reservoirs and Pipelines / Technology and Licensing Issues
(20. January 2016, Duisburg)

++ HyVolution – Hydrogen Energy Days
(4. – 5. February 2016, Paris)

++ 5th Workshop Admission – Certification – Standardisation (Security & Quality of Hydrogen and Fuel Cell Technolgy
(16. – 17. February 2016, Duisburg)

++ E-world energy & water
(16. – 18. February 2016, Essen)

++ Hydrogen and Fuel Cell Technology Supplier Marketplace
(10. March 2016, Berlin)

++ IRES – Energy Storage Europe (International Conference & Exhibi tion for the Storage of Renewable Energies)
(15. – 17. March 2016, Düs seldorf)

++ 5th Conference Power-to-Gas & Power-to-X for Europe's Energy Transition
(16. March 2016, Düsseldorf)

++ WHEC2016 – 21. World Hydrogen Energy Conference
(13. – 16. June 2016, Zaragoza, Spain)

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INTERESTS AND WISHES

Please let us know if you have special interests/wishes for the next newsletter. We look forward to your feedback and we aim to provide quality information that is actually needed and wanted to answer the hydrogen core topics.

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DBI GUT Gas- und Umwelttechnik GmbH

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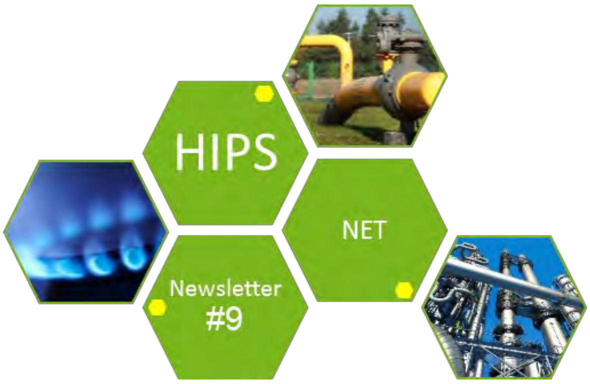


HIPS-NET

"Establishing a pan-European understanding of admissible hydrogen concentration in the natural gas grid"

Newsletter #9	April 2016

Content Newsletter #9

"A network leads to cooperation, cooperation leads to creativity and innovation - this changes the world." - Marissa Mayer (CEO Yahoo)

9th HIPS-NET Newsletter

Dear Partners,
Dear Colleagues,

Once again we are happy to provide you with a HIPS-NET newsletter with information on our core topics and general developments around Power-to-Gas and hydrogen. We hope you find the articles interesting and informative. Please let us know if you have interest in specific topics, or have heard of any further advances in the state of the art.

We would like to take this opportunity to express our gratitude to Dave Pinchbeck for his valued commitment to HIPS-NET. Dave has continually supported our network for the past two years. Dave was a crucial figure in the conception of the network, supported us with articles for the newsletters and, last but not least, guided us through our annual workshops and enriched the discussion with his experience as a senior professional. Dave has asked us to wish his HIPS-NET friends and colleagues continued success with their hydrogen activities.

The next HIPS-NET workshop will take place on 22nd/23rd June 2016 in the GERG premises in Brussels. We are currently working on the agenda and will disseminate the programme as well as further travel information in the course of May.

Your HIPS-NET Team

Gert, Stefan, Anja, Josephine & Gideon

STORE&GO | GERMANY, SWITZERLAND, ITALY

The project "STORE&GO" will demonstrate three innovative storage concepts at three "living" best practice Power-to-Gas (PtG) locations in Germany, Switzerland and Italy using different methanation processes. The main focus is to tackle technical, economic, social and legal barriers. It will be realised within the EU programme "Horizon 2020" under the topic "Large Scale Energy Storage".

PTG FALKENHAGEN
(UNIPER ENERGY STORAGE GMBH)

Falkenhagen in Germany is one of the three demonstration sites. The project comprises innovative honeycomb (structured wall) reactor methanation technology at 1 MW_{el} scale, utilisation of CO_2 from biogenous source, interconnection to the high pressure transport gas grid, and potential thermal energy integration with local industrial facilities in order to further increase the overall efficiency and economy. (We presented the Falkenhagen PtG facility in more detail in newsletter #8 page 8.)

PTG SOLOTHURN
(REGIO ENERGIE)

The Swiss demonstration plant at **Solothurn** includes a 700 kW_{el} PtG facility based on an innovative biological methanation process. This facility will be embedded in the grid and production infrastructure of the utility. To increase the operation flexibility and the energy efficiency, the plant will be connected to the local electricity and gas distribution grid. (We described the Solothurn facility in more detail in newsletter #5 page 4.)

The Italian demonstration project will be realised in **Troia**, a community in the region of Puglia. In this region, high PV production capacities are available. The demonstration plant will be established at the existing INGRID PtG demonstration site. The innovative concept at this demo site consists of adsorptive CO_2 enrichment from the atmosphere and a modular micro-reactor based methanation concept. This plant will offer the direct utilisation of the produced SNG in the transport sector.

27 participants from six European countries are taking part in this project including DBI GUT. The project started on 1st of March 2016 with a duration of four years and a budget of 28 million €.

For further information, please contact the project coordinator Dr. Frank Graf (graf@dvgw-ebi.de).
Sources: Website STORE&GO

POWER-TO-GAS DEMONSTRATION PLANT IN IBBENBÜREN | GERMANY (1/2)

RWE International SE and its gas distribution system operator Westnetz GmbH operate a Power-to-Gas demonstration plant in Ibbenbüren/Germany.

Objectives of the demonstration plant:

- Installation of an PtG-based electrical storage for green electricity (realisation of the complete storage chain) with highest possible utilization rate
- Testing electrolysis in the context of fluctuating intermittent renewable energy production
- Technical testing of the interconnection between the power grid to the gas grid

The gas network in Ibbenbüren was chosen due to its island topology as the injected hydrogen can solely disseminate in the selected part of the gas network. The network is fed by the regional transport network and has no further interconnection with upstream gas networks. The hydrogen is injected in the gas pressure regulation facility connecting the upstream transport grid with the local grid in the Ibbenbüren region.

OVERVIEW MAIN CHARACTERISTICS OF IBBENBÜREN PTG-PLANT

Start of Operation	March 2015
Electrical Power Capacity Layout	150 kW_{el}
Hydrogen Production	30 m^3_{H2}/h
Electrolyser Type	PEM
Outlet Pressure of Hydrogen	14 bar_{H2}
Utilisation of Hydrogen	(1) injection in gas distribution grid (2) reconversion to electricity by CHP
Utilisation of Residual Heat	Yes; heat extraction
Efficiency (GCV) Electrolyser	71 %
Efficiency (GCV) Overall Plant	86 % (including heat extraction)

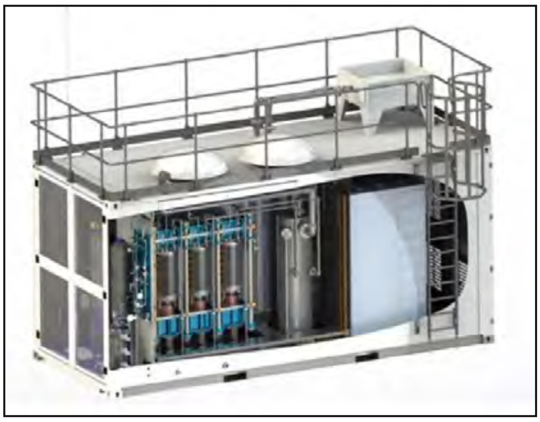
POWER-TO-GAS DEMONSTRATION PLANT IN IBBENBÜREN | GERMANY (2/2)

(continued)

The **hydrogen concentration** within the natural gas never exceeds 1 vol% due to the high volume flow of natural gas even in summer time.

In preparation of the demonstration, DBI examined the **hydrogen tolerance**, in particular:

- The effects of an theoretical injection of hydrogen of up to 2 vol% in the downstream gas network and its end users (domestic and industrial appliances)
- The planned concept and structure of the injection facility handling 100 vol% hydrogen in terms of safety-related and material-related aspects



PTG IBBENBÜREN
(RWE INTERNATIONAL SE)

A tolerance of 100 vol% hydrogen is given for the system components of the injection facility and a hydrogen tolerance of 2 vol% is given for the downstream gas network. This limited hydrogen volume blended in at Ibbenbüren would have no noticeable effect on the end user.

The **metering concept** at the demonstration plant includes:

- Measurement of hydrogen volume by means of a thermal mass flow meter; located within the gas pressure regulation facility and before the injection in the gas network.
- Measurement of the gas quality with a process gas chromatograph (PGC) to determine the hydrogen concentration in the natural gas grid. The PGC is able to detect up to 5 vol% hydrogen and monitors the actual hydrogen concentration.

The efficiency of the overall demonstration plant reaches 86 %. The electrolyser's efficiency reaches up to 71 % and is increased by the usage of the process heat from the electrolyser for the gas preheating in the adjacent gas pressure regulation facility.

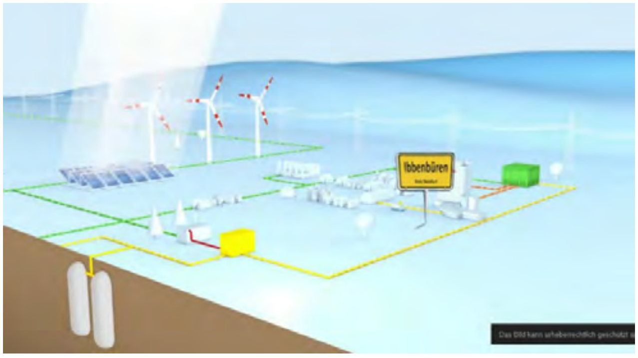
For further information, please contact Carsten Stabenau, Westnetz GmbH (carsten.stabenau@westnetz.de) or Marco Henel, DBI GUT GmbH (marco.henel@dbi-gut.de).

Sources: Image Film and Website RWE

RAUHY Field Test Site

For field-testing purposes, REHAU installed a bypass line with the newly developed RAUHY material. The bypass is integrated in the gas pressure regulating station in Ibbenbüren and transports pure hydrogen. The RAUHY pipeline system consists of multi-layer composite tubes (carrier tube made of PE-Xa and a hydrogen barrier layer) and a new type of press-fitted joints. The RAUHY material characterises an increased tightness that prevents permeation through the pipe walls, among further advantages. RAUHY has been originally developed to transport liquid substances and shall be tested for the transport of hydrogen. First laboratory tests, performed by DBI, have confirmed the tightness of the pipes, bond strength (delamination) and long-term stress resistance.

Following these positive results, the field test shall verify the suitability and proof the tightness under real conditions in Ibbenbüren. DBI will install four in-house developed measuring cells, two cells to monitor possible permeation of the pipe and two cells to monitor leakage of the press-fitted joints in a long-term test. The test is expected to start in May 2016 and will continue for 12 months.



NETWORK-SYMBIOSIS IN IBBENBÜREN
(RWE INTERNATIONAL SE)

RAUHY does not belong to the established technologies for gas distribution yet and aims to pass the certification process (DIN etc). The described tests as well as an intended future field test for buried (underground) installation in the frame of HYPOS strive to establish RAUHY as state of the art pipeline system.

RENOVAGAS SYNTHETIC NATURAL GAS FROM RENEWABLE ENERGY SOURCES | SPAIN (1/2)

AUTHOR: JOSÉ A. LANA | ENAGAS

RENOVAGAS is a project aimed at the development of a demonstration plant for the production of Synthetic Natural Gas (SNG). This gas is created by the electrolytic production of hydrogen with renewable energy sources (RES) and raw biogas through a methanation process. As a result, the natural gas obtained is fully renewable.

The project is led by Enagás, gas Transmission System Operator, as part of a Spanish consortium with:

- Gas operator: Gas Natural Fenosa.
- Technological institutions: Centro Nacional del Hidrógeno (CNH2), Consejo Superior de Investigaciones Científicas (CSIC) and Tecnalia Research & Innovation.
- Companies involved in the renewable sector: Abengoa Hidrógeno and FCC Aqualia.

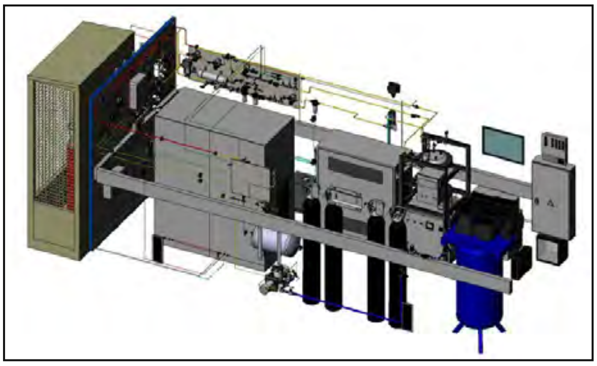
RENOVAGAS is a unique demonstration project in Spain, whose results will enhance knowledge of the technical and economic feasibility of Power-to-Gas systems.

The project focuses on the design and development of a pilot plant in which the main equipment is:

- 15 kW_{el} electrolyser
- Methanation reactor
- Auxiliary systems.

This is the first step in the scaling-up process to 250 kW_{el} and later to megawatts depending on the results of the pilot plant.

The main innovations in the RENOVAGAS project are described below.



SKETCH OF EQUIPMENT LAYOUT IN THE CONTAINER (RENOVAGAS)

Optimisation of hydrogen production from RES

Hydrogen is produced by using an efficient and low-cost electrolytic process: an advanced alkaline electrolyser based on anionic membranes with control strategies developed within the project for its electrical integration with RES such as solar and wind energy.

Utilisation of raw biogas

Raw biogas, i.e. without separating CO_2, and methane is the CO_2 source. Biogas is only cleaned from contaminant components harmful for the methanation catalyst.

In RENOVAGAS, the biogas comes from a waste water treatment plant.

New catalysts for methanation reaction

New catalysts have been developed for the methanation reaction in order to improve its efficiency and durability. These catalysts will enable the direct use of biogas in the methanation process. The new catalysts have a high activity, high CO_2 conversion rate, and high selectivity for methane. The high activity of the catalyst allows for the development of a smaller reactor.

Multi-channel reactor

A multi-channel methanation reactor has been designed which allows execution of the methanation reaction in one stage, compared to the traditional several-stage process.

The channels have a diameter of a few millimetres, packed with the catalyst to maximise the gas contact. This system allows a very good management of the temperature control of the reactor, which will be carried out through a thermal oil system.

The Power-to-Gas demonstrator of 15 kW_{el} has been integrated within a container, and a fully automatic control of the pilot plant, which allows a continuous monitoring of the different variables in the process, has been developed.

EQUIPMENT INSIDE THE CONTAINER (RENOVAGAS)

RENOVAGAS SYNTHETIC NATURAL GAS FROM RENEWABLE ENERGY SOURCES | SPAIN (2/2)

(continued)

This facility will produce up to 1 Nm^3/h of SNG with high methane content and a quality compliant with Spanish natural gas regulation. The produced gas could therefore be injected directly into the gas grid.

The system developed is flexible, easily scalable and modular in order to allow an adjustment to specific conditions. It will be tested in conjunction with a real biogas plant to validate the performance in real conditions. Testing of the demonstrator under real conditions is expected during the second and third quarter of 2016.

Other activities carried out in the project are:

- Basic and detailed engineering of a 250 kW_{el} unit
- Study about the potential availability of RES power surplus, CO_2 and a suitable location in Spain
- Economical study of the technology.

Please contact for further information José A. Lana (jalana@enagas.es).

MAIN CHARACTERISTICS OF ELECTROLYSER	
Maximum H_2 production	2 Nm^3/h
Electolyte	$KCO_3/KHCO_3$ approx. 1 %
Outlet H_2 pressure	30 bar
H_2 purity	99.94 %
Efficiency at nominal point	4.8 kWh_{el}/Nm^3
Maximum power consumption	15 kW

MAIN PROPERTIES OF THE CATALYST DEVELOPED IN THE PROJECT	
Gas Hourly Space Velocity (GHSV)	8,000 - 18,000 h^{-1}
Temperature	330 - 340 °C
Pressure	≥ 25 bar
H_2/CO_2	= 4 mol/mol
Selectivity for CH_4	> 99 %
Conversion of CO_2	> 95 %

This project is funded by the Spanish Ministry of Economy and Competitiveness (MINECO) in the frame of the National Programme for Research Aimed at the Challenges of Society, dossier number RTC-2014-2975-3.

GOBIERNO DE ESPAÑA MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD

INNOVATIVE USE OF POWER-TO-GAS TO SUPPORT AEROSPACE TECHNOLOGY | GERMANY

HYDROGEN REFUELLING STATION (ITM POWER)

ZEAG Energie AG and the German Aerospace Centre (DLR) are co-operating in a new Power-to-Gas project in Lampoldshausen in southern Germany.

The H2orizon project, supported by the federal state of Baden-Württemberg, involves the creation of a complete process chain for the creation and storage of hydrogen produced from renewable energy sources. A central component of the project is the installation of a 1 MW PEM electrolysis unit supplied by ITM Power to convert surplus electricity from the Harthäuser Wald wind park (42 MW). The electrolyser and storage facilities will be located at the German Aerospace Centre in Lampoldshausen where the hydrogen will be used to support South German mobility projects as well as the Centre's power and heating demands and also as a fuel for rocket propulsion projects.

The German Aerospace Centre is one of Europe's foremost research centres for rocket design with more than 25 years of experience. It is also one of Europe's largest hydrogen consumers. Hydrogen is a common fuel for rocket propulsion (the Ariane 5 rocket, for example, uses 46 kg/sec of liquid hydrogen in order to achieve 4 million bhp). As such the site already boasts excellent hydrogen infrastructure and a highly competent staff with experience handling and utilizing the gas.

Delivery and installation are due to take place in the third quarter of 2017. The H2orizon project is partly funded by the federal state of Baden-Württemberg, which has made a commitment to source 35 % of the state's electricity needs from renewables by 2020, 80 % by 2050.

Further information on the development of this project can be found here.

Congratulations Hermes Award Nomination

ITM Power's compact electrolyser technology is widely regarded as cutting-edge. The UK-based company has been shortlisted for the prestigious Hermes Award – one of the world's most recognised prizes for practical technological innovation. Even though the ITM electrolyser did not receive the award, the nomination acknowledges the technical achievements. (Source)

Hydrogen Projects

H2-MEM Investigation of Carbon-Membranes for the Separation of Hydrogen and Natural Gas | Germany

The generation of electricity through wind and solar power is subject to seasonal fluctuations. In times of high supply, excess power can be used in Power-to-Gas plants to produce hydrogen which itself can be injected into the already existing natural gas network. Due to the limited acceptance of several plants, compressors and vehicle gas tanks with regard to the presence of hydrogen in natural gas streams, technologies for the separation of these gases are required.

Besides gas separation, methods as cryogenic distillation or adsorption processes as PSA (pressure swing adsorption), membrane systems are an attractive alternative and can also be applied on small fluxes. They show higher selectivities, a low energy consumption as well as a simple functionality, a quick start-up behavior and comparably low investment costs. Membranes can be separated into organic (polymer) and inorganic (ceramic, metallic and carbon) membranes. While polymeric membranes are leading from the financial point of view, inorganic membranes stand out through their thermal and chemical stability.

Hydrogen Separation Membranes

Metallic membranes (e.g. palladium) show the highest H_2 selectivity but they are expensive, highly sensitive to sulphur, chlorine and carbon monoxide, and require high process temperatures. **Carbon membranes** therefore are less cost-intensive than palladium membranes and allow higher selectivity than polymeric or ceramic membranes.

H2-MEM Project

Within the scope of the project „H2-MEM“, carbon molecular sieving membranes (CMSM) will be investigated on their separation performance of H_2/CH_4 and H_2/NG mixes with different hydrogen concentrations. In addition to different gas mixes, various process conditions such as pressure, flux and temperature will be tested. The main target parameters of the project are the following:

- Separation of the gas mixes to a residual H_2 concentration of ≤ 1 vol-%.
- Applicability of the membranes for H_2 contents of at least 60 vol-%.
- Production of a permeate stream with H_2 concentrations of ≥ 95 vol-%.

For further information, please contact the project coordinator Udo Lubenau (udo.lubenau@dbi-gut.de).

Laboratory tests are currently commencing in which the performance of CMSMs with the dimensions of l = 105 mm, d_a = 10 mm and d_i = 7 mm will be tested and compared under different conditions.

The project began in December 2015 and will continue for 36 months. Project partners are DBI GUT GmbH and Fraunhofer IKTS.

SPONSORED BY THE Federal Ministry of Education and Research

Network Topics

Network Topics

We are aiming to spread/exchange knowledge in order to better understand the impact of hydrogen/natural gas blends in pipeline systems. Our core topics comprise

- GAS TURBINES AND ENGINES
- POROUS UNDERGROUND GAS STORAGE
- STEEL CNG1 VEHICLE TANKS
- NATURAL GAS AS WORKING MEDIUM
- CROSS BORDER TRANSMISSION
- SAFETY CHARACTERISTICS OF H2/ NATURAL GAS BLENDS

We additionally keep a minor focus on the general development of power to gas, hydrogen networks, and further topics around the utilisation of (renewable) hydrogen.

HYPOS PROJECT ASSESSMENT WITH THE H2-INDEX-TOOL | GERMANY

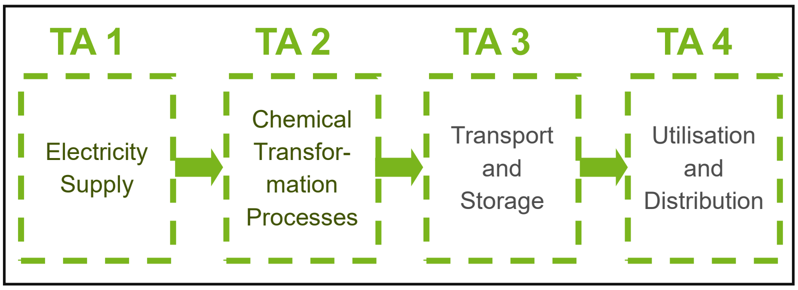
The HYPOS consortium aims to further research and develop hydrogen production from renewable sources in East Germany (see presentation in newsletter #3 page 4). The HYPOS consortium was founded in 2013 and currently has 110 members. The German Federal Ministry for Education and Research (BMBF) proposes to subsidise the consortium until the year 2020 with up to 45 million € within the programme “Twenty20 – Partnership for Innovation”.

The R&D aims to accelerate an economically competitive usage of green hydrogen by:

- researching the production process itself,
- considering scientific research in the fields of
  - ⇒ *storage,*
  - ⇒ *distribution and*
  - ⇒ *utilisation of hydrogen in different industrial sectors e.g. chemicals, mobility, and electricity*

For an efficient management of funds and resources, it is therefore important to gain an overview over the effect of individual innovations and combined research outcomes within each branch of the value chain on the final price of the product. In this evaluation, procedural as well as economic influences of technological innovations have to be considered.

The H2-INDEX-Tool is a model designed to provide said overview over the different value chains associated with the production of hydrogen from renewables. It allows the user to quickly assess the effect of proposed research goals on the economic parameters of the whole value chain. Thus allowing new solutions to be more accurately compared with the state of the art of hydrogen production.



TOPIC AREAS (TA) OF THE H2-INDEX-TOOL (DBI GUT)

The tool serves as an important resource for the objective evaluation of projects and plans and is able to model all combinations of elements of the hydrogen value chain as depicted in the figure below. It was designed to support the HYPOS steering committee in coordinating the project and, in the future, could also be utilised by other members of the HYPOS consortium to optimise innovation strategies.

The H2-INDEX-Tool was programmed using Matlab/ Simulink. This software enables real-time modelling of complicated processes and numerical calculations. The individual elements of the value chain are listed in an element library resembling the structure in the figure below. The user interface enables these elements to be configured and combined in a wide variety of different ways depending on the process involved. The program can process dynamic data as well as static operating parameters (e.g. full load hours). Results, such as specific costs or the amount of produced electricity are averaged over a one-year timespan. It should be noted that a complete modelling of dynamic profiles is not yet possible. It is, however, the focus of current development.

The technical model is reduced to only include general operating parameters (Key Performance Indicators) for the different components of each element in the value chain. This means that the grant applicant has to predict the impact of an innovation on these operating parameters before the application for funding can be evaluated. This process ensures the comparability of results and allows for a maximum in flexibility to adapt to even the most specific innovations. The tool includes a full set of Key Performance Indicators for each element of the chain. This data represents the current technological state of the art in each element.

The results of each assessment represent the direct comparison of the price of the end product (hydrogen, recovered electricity, chemicals) both before and after the implementation of the proposed innovation.

By using the H2-INDEX-Tool, it is therefore possible to assess the individual prosperity of innovations and their impact on the economic viability of the entire value chain.

The assessment with the H2-INDEX-Tool is in not a mandatory requirement to achieve recommendation for funding. The tool is merely intended to support the responsible committees in their evaluation of submitted projects.

For further information, please contact Dr. Martin Pumpa (martin.pumpa@dbi-gut.de).

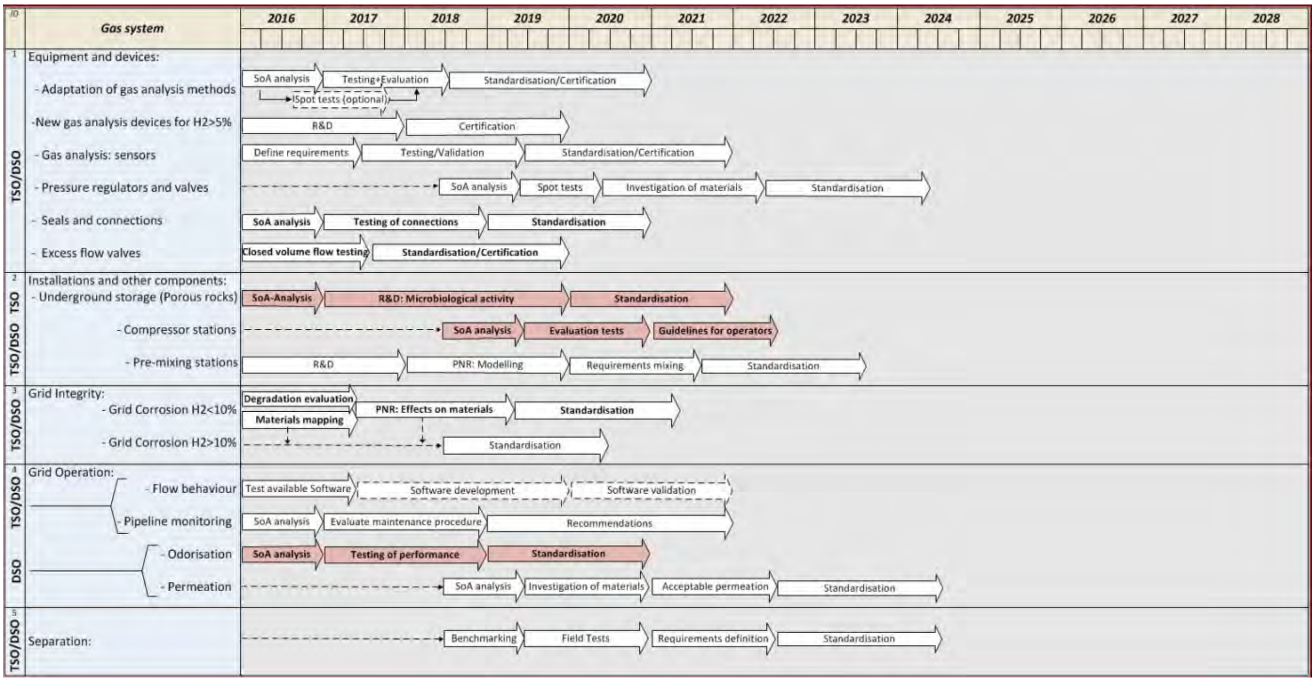
SECTOR FORUM ENERGY MANAGEMENT WORKING GROUP HYDROGEN | POWER-TO-HYDROGEN: CHALLENGES IDENTIFIED (1/2)

AUTHOR: EVELINE WEIDNER | EUROPEAN COMMISSION, DG JRC

In December 2015 we reported in the 7th newsletter on the activities of the CEN/CENELEC Working Group (WG) on Hydrogen under the Sector Forum Energy Management (SFEM). With this article we would like to provide final and mostly additional information on the activities that have been performed in 2015 as well as an outlook on the next envisaged steps.

The WG-Hydrogen took on the task to provide concrete proposals on how to address research and standardization needs in the emerging field of Power-to-Hydrogen. To reach this goal, the group performed a mapping of related hydrogen-energy technologies as well as of existing standardization initiatives, identifying the gaps and challenges in a holistic manner. The main findings of the working group, which successfully concluded its efforts in November 2015, have been published in a report which is available here. A priority roadmap of research and standardization needs for Power-to-Hydrogen and hydrogen admixture in the natural gas system has been developed. Recommended actions include the establishment of a dedicated European standardization technical committee and forum, as well as execution of targeted research and demonstration projects. Based on the advice of the WG hydrogen, CEN has meanwhile decided to create a new Technical Committee, CEN/TC 446 on hydrogen.

A lack of standardization is recognised as a major barrier for deployment of new and innovative technologies. The Europe 2020 Strategy, in particular its Innovation Union Flagship, recognises European and international standardization as a major enabler for technology innovation and states that efforts in this area have to be increased. The Joint Research Centre (JRC) of the European Commission was involved in this effort based on the European Commission Regulation (EU) N. 1025/2012 on European standardisation. The regulation states that the Commission's research facilities shall "provide European standardisation organisations with scientific input, in their areas of expertise, to ensure that European standards take into account economic competitiveness and societal needs such as environmental sustainability and safety and security concerns".



ROAD MAP OF TASK FORCE 3 „GAS SYSTEM“

(E. WEIDNER, M. HONSELAAR, R. ORTIZ CEBOLLA (JRC), B. GINDROZ (CEN/CENELEC), F. DE JONG (NEN) SECTOR FORUM ENERGY MANAGEMENT / WORKING GROUP HYDROGEN FINAL REPORT; EUR 27641 EN; 10.2790/66386, DOWNLOAD HERE)

The SFEM/WG Hydrogen has created momentum for Power-to-Gas, hydrogen and hydrogen natural gas mixtures (H2NG) and most importantly has created a forum in which experts from the natural gas industry, hydrogen industry and power sector exchange knowledge and expertise and can address common issues. Its scope covered the production of hydrogen through electrolysis and the transportation, distribution and use of that hydrogen in pure form or as a natural gas dominant mixture (H2NG) in a number of end-use sectors and applications. In addition, actions in cross-cutting fields such as safety and training of personnel were identified.

SECTOR FORUM ENERGY MANAGEMENT WORKING GROUP HYDROGEN | POWER-TO-HYDROGEN: CHALLENGES IDENTIFIED (2/2)

(continued)

Priority challenges have been determined for the various technical areas and recommendations given on proposed actions and means of implementation. Technical gaps have been identified for new required operational modes of electrolysers, which call for advances in technology related to performance and safety. Partial load, intermittent operation and fast response will be some of the performance requirements for electrolysers when integrated into a power-to-gas plant or for provision of ancillary services to the electricity grid. Interconnection standards to allow physical connection and communication between electrolysers and the grid control systems are needed, in addition to a standardization of the key performance indicators of water electrolysers. Key challenges and early topics for standardization related to the injection of hydrogen into the natural gas grid have been identified. Establishing a European understanding of an acceptable hydrogen concentration in the natural gas system is seen as an overarching theme, which first requires filling a number of knowledge gaps.

In order to develop such a pan-European understanding cooperation with other initiatives e.g. HIPS-NET or Task 38 (IEA/ HIA) is envisaged. Depending on the hydrogen concentration, different components of the gas system or end-user appliances and processes may be affected. The main issues to be addressed before significant concentrations of hydrogen can be achieved include a study of the behaviour of the operating characteristics of gas turbines with admixture of hydrogen and the qualification of steel tanks for CNG vehicles. Roadmaps have been developed to visualise the identified steps on a timeline. An example for the roadmap for challenges related to hydrogen in the natural gas grid is displayed on page 8.

Pre-normative research and standardization challenges and needs related to the hydrogen system and the use of pure hydrogen have been analysed. Hydrogen will have the highest value when used in the mobility sector, therefore the technology can be best supported by first focusing on the issues related to the refuelling infrastructure, which is currently being rolled out across Europe. Cross-cutting key items identified for pre-normative research and standardization actions were safety related topics, certification (Guarantee of Origin) and training of personnel.

The JRC will organize a workshop on the 03.-04.05.2016 at the CEN/CENELEC premises in Brussels to discuss an appropriate follow-up and continuation of the work of SFEM/WG Hydrogen. HIPS-NET members are kindly invited to join the workshop.

Please contact Eveline Weidner (Eveline.WEIDNER@ec.europa.eu).

IEA HIA TASK 38 POWER-TO-HYDROGEN AND HYDROGEN-TO-X: SYSTEM ANALYSIS OF THE TECHNO-ECONOMIC, LEGAL AND REGULATORY CONDITIONS (1/2)

A new task has been proposed by the Hydrogen Implementing Agreement (HIA) of the International Energy Agency (IEA). This task will consider the current and future viability of Power-to-Hydrogen and Hydrogen-to-X projects in different locations around the world. As such, a great focus will be placed on finding and securing the optimal techno-economic, legal and regulatory conditions for the development of Power-to-Hydrogen.

The general aims of this task will be: to provide a comprehensive understanding of the various technical and economic pathways for Power-to-Hydrogen applications in diverse situations; to provide a comprehensive assessment of existing legal frameworks; and to present business developers and policy makers with general guidelines and recommendations that enhance hydrogen system deployment in energy markets. A final objective will be to develop hydrogen visibility as a key energy carrier for a sustainable and smart energy system, within a two or three horizon time frame: 2020, 2030 and 2050, for example.

The task was officially approved by the IEA/ HIA Executive Committee in Sydney in October 2015. Over 20 companies and institutions from more than 10 countries have already confirmed interest in the task. DBI joined the kick-off meeting in Paris in January 2016.

The delegation of tasks among the participants is currently being determined. The project will be take place over a four-year period and will be divided in to different parts (see table on page 10).

IEA HIA TASK 38 POWER-TO-HYDROGEN AND HYDROGEN-TO-X: SYSTEM ANALYSIS OF THE TECHNO-ECONOMIC, LEGAL AND REGULATORY CONDITIONS (2/2)

(continued)

IEA HIA TASK 38 POWER-TO-HYDROGEN - SUB TASKS

Sub Task	Title	Content	Deliverables
1	**Management and communication**	• Task Management and strategy • General methodology • Definition of the different value chains and applications • Interface with other tasks, IEA • Communication management and management tools implementation	• Semi-annual reports • Guidelines for business developers • Recommendations for policy makers • Selection of case studies
2	**Mapping and review of existing demo project**	• Mapping; characterization of projects in terms of maturity, economics and targets	• Projects data base • Report
3A	**Review/ Analyse the existing economic studies on Power to Hydrogen**	• Analysis of studies; harmonization of data and assumption; Identification of key parameters and business indicators for business cases, and comparison with currently available technologies; • "Order of merit" methodology for business cases at 2020, 2030, 2050 - Prioritization and ranking -	• Methodology guide • Intermediate report on economic studies • Intermediate report on state of the art on legal framework • Bibliography and data base of studies
3B	**Review of different existing legal frameworks, policy measures**	• Identification of policy measures to promote Hydrogen. Analyse available public and private financial mechanisms (and actors) for funding energy projects, exploring potential investment opportunities in global markets	
4	**Systemic approach and macro-economic impact analysis**	• Key macro-economic parameters influencing business cases; • Evaluation of positive/ negative effects of hydrogen on macro-economic and systemic point of view	• Inputs, interactions and recommendations for sub-task 3
5	**Specific case studies**	• Evaluation and modelling of business model and value chain assessment of different Power-to-H_2/ H_2-to-X chains • Optimisation methods under constraints	• Report on case studies • Modelling results

Meetings will be organised on a semi-annual basis. Interested companies are still welcome to contribute to the work of the Task 38. The next meeting will take place 21st/ 22nd September 2016 (place tba).
The French CEA/I-tésé, supported by the French ADEME, will coordinate the Task 38. Contributions by interested companies and organisations are welcome.

Contact: Alain Le Duigou (alain.le-duigou@cea.fr), Christine Mansilla (christine.mansilla@cea.fr), Paul Lucchese (paul.lucchese@cea.fr)

LEXUS AND AUDI PROVIDE INSIGHT INTO THE HIGH-END HYDROGEN MOBILITY

At the 2016 Detroit Auto Show, two of the world's top luxury brands introduced their hydrogen-powered cars: The Lexus LF-FC, a car that had already made its world premiere at the Tokyo Motor Show in October 2015 and the Audi h-tron quattro concept.

LEXUS LS LUXURY SEDAN
(LEXUS)

Akio Toyoda, Lexus' chief branding officer, described it as teaser for the first Lexus fuel-cell vehicle arriving around 2020. Lexus parent Toyota saw the fork in the road between battery electric vehicles and fuel-cell electric cars years ago, and chose to follow the hydrogen route without looking back. By 2020, Lexus parent Toyota hopes to have sold 30,000 fuel-cell vehicles globally.

AUDI Q6 H-TRON QUATTRO
(SCOTT OLSON/ GETTY IMAGES)

In comparison, Audi, Volkswagen's luxury brand is embracing both fuel cells and battery electric vehicle technology. Audi said nothing though about production plans for a Q6 h-tron. Fuel-cell vehicles will also probably play a big role in achieving the carmaker's recently-stated goal of reducing emissions 90 percent from 2010 levels by 2050.

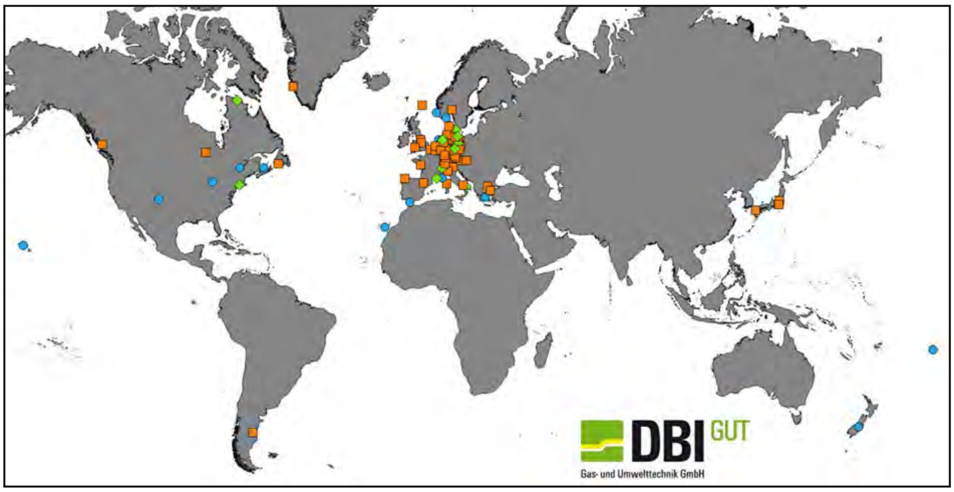
Further information: Lexus, AUDI

OVERVIEW

OVERVIEW OF POWER-TO-GAS PROJECTS | WORLDWIDE

In order to show how fast Power-to-Gas projects are advancing particularly in Europe, we gathered information to create a database of current, planned and completed PtG-projects worldwide (with the focus on Europe) and located the projects on a world map. This map, without detailed project information, is visible for everybody on the starting page of the HIPS-NET website.

The developed PtG-projects database provides basic information and contact details. It might be useful for the design stage of your own PtG-facility as it gives an overview of the state of the art technology for different situations and applications.



MAP OF CURRENT (GREEN), PLANNED (BLUE) AND EXPIRED (ORANGE) POWER-TO-GAS PROJECTS
(DBI GUT)

The PtG-database contains the following information: location, name of project, status, electrolysis power and type, pressure output, H_2 output, power purchase and use paths. Even though a lot of effort was put into the investigation, this list is not exhaustive. Please let us know if you are aware of projects which are not listed and should be added. The list will be updated annually.

HIPS-NET members may access and download the whole PtG-database as table from the Members' area on our website or may request it directly (email to anja.wehling@dbi-gut.de).

Important Events - Workshops - Conferences and Partners

Selection of appointments
(focus on the combination of hydrogen and natural gas)

++ WHEC2016 - 21st World Hydrogen Energy Conference
(13. - 16. June 2016, Zaragoza, Spain)

++ Dena - Annual Conference Power to Gas 2016
(21. June 2016, Berlin, Germany)

++ 3rd HIPS-NET Workshop
(22. - 23. June 2016, Brussels, Belgium)

++ H2Congress - 7th German Hydrogen Congress 2016
(05. - 06. July 2016, Berlin, Germany)

++ EFCF - European Fuel Cell Forum
(05. - 08. July 2016, Luzern, Switzerland)

++ DBI-Fachforum Energiespeicher
(27. - 28. September 2016, Berlin, Germany)

++ World of Energy Solutions
(10. - 12. October 2016, Stuttgart, Germany)

Current partners

Alliander ++ Areva H2Gen ++ DEA Deutsche Erdoel ++ DGC ++ DNV·GL Oil & Gas ++ Enagas ++ Energiforsk ++ Energinet ++ ENGIE ++ EWE Netz ++ Gas Natural Fenosa ++ Gasum OY ++ Gasunie ++ GRTgaz ++ grzi/figawa ++ Infraserv Höchst ++ ITM-Power ++ JRC European Commission ++ KOGAS ++ NAFTA ++ OGE ++ ÖVGW ++ RAG Rohöl-Aufsuchung ++ RWE ++ Shell ++ Solar Turbines Europe ++ SVGW ++ Synergrid ++ Uniper ++ Verband der Chemischen Industrie ++ Volkswagen ++

Interests and wishes

Please let us know if you have special interests/ wishes for the next newsletter. We look forward to your feedback and we aim to provide quality information that is actually needed and wanted to answer the hydrogen core topics.

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DBI GUT
Gas- und Umwelttechnik GmbH

GERG
groupe européen de recherches gazières
the european gas research group

HIPS-NET

“Establishing a pan-European understanding of admissible hydrogen concentration in the natural gas grid”

Newsletter #10 | **June 2016**

Content Newsletter #10

“A network leads to cooperation, cooperation leads to creativity and innovation - this changes the world.“ - Marissa Mayer (CEO Yahoo)

10TH HIPS-NET Newsletter

Dear Partners,
Dear Colleagues,

We welcome you to the latest version of our HIPS-NET newsletter. Once again, we are happy to provide you with new insights into our core topics, and general developments in the fields of power-to-gas and hydrogen. We hope you find the articles interesting and informative. Please feel free to let us know if you are interested in a specific topic, or have heard of any further advances in the state of the art.

The feature articles from our current newsletter include a report on the HyINTEGER and H2STORE projects to assess the viability of storing hydrogen at underground gas storage facilities, and an introduction on the CertifHy project which aims to develop the first guarantee of origin for green hydrogen. The newsletter also introduces a study by DBI and the Fraunhofer Institut analysing the best means to modify infrastructure for the transport of domestic and foreign renewables. In Austria, meanwhile, we report on a project led by OMV to examine the tolerance of hydrogen in the Austrian gas transmission and distribution infrastructure. Just to mention some of the topics, you will find further subjects covered in this 10th edition of the newsletter.

Our next HIPS-NET workshop is just around the corner on 22nd/23rd June. After the success of previous workshops, we look forward to seeing you all at the GERG premises in Brussels and having another chance to exchange ideas and information.

Your HIPS-NET Team

Gert, Anja, Stefan, Josephine & Gideon

The H2STORE and HyINTEGER Projects - Studies on the Effect of Hydrogen Storage in Underground Gas Reservoirs

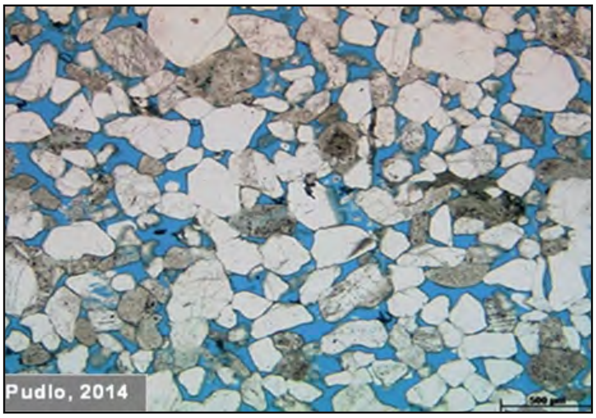
Authors: D. Pudlo and S. Henkel | Friedrich Schiller University Jena | Institute of Geosciences

H2STORE HyINTEGER

As natural gas reservoirs have proven their tightness and capability to store different gas types over millions of years, depleted gas reservoirs might be also appropriate for further utilisation, such as H_2 storage. Studies on the effect of pure H_2 and CH_4/H_2 gas mixtures on the complex system of underground reservoir components (rocks/minerals, formation fluids, biocenosises, residual natural gases) are rare. In this context, two collaborative projects have been carried out to further examine possibilities in this area. The projects have been coordinated by the University of Jena, and are sponsored by the German government with additional support from industrial partners.

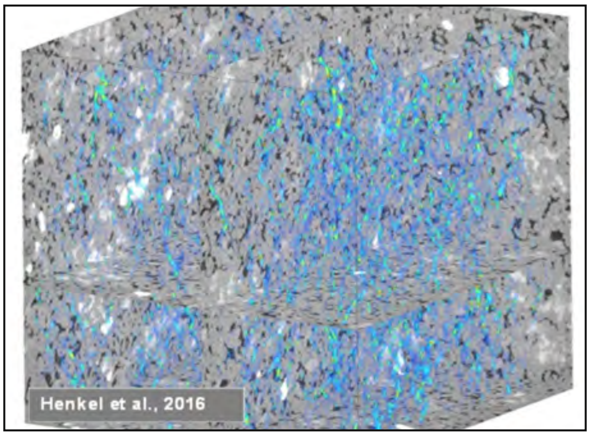
In 08/2012 – 12/2015, the "H2STORE" project conducted laboratory experiments on rock samples of pore storage sites to evaluate potential mineralogical, geo- and hydrochemical, microbiological and geohydraulic reactions induced by pure H_2 at high pressure/ high temperature conditions (p = ~ 4 - 20 MPa | T = ~ 40 - 120 °C | depths = ~ 700 - 3.500 m). The focus was on the evaluation of potential reactions of hydrogen with reservoir components. These experimental studies combined with numerical simulations explored the impact of stored H_2 on the reservoir quality of porous sandstones in depleted gas sites. Numerical simulations (modelling) were realised in the following areas:

- The distribution of injected hydrogen in the underground
- The behaviour of gas mixtures and formation fluids
- The mineralogical and petrophysical alteration of the reservoir and cap rocks
- The interaction of microorganisms and the H_2-bearing formation fluids and reservoir rocks



Microscopic thin section picture of a highly porous reservoir sandstone from N -Germany (depths ~ 3.500 m). The pore space, appropriate for gas storage, is highlighted by blue colour.

One major result of this project is the substantiation of mineral dissolution processes, which led to the modification of petrophysical and geohydraulic reservoir rock features. Moreover, material corrosion of the laboratory equipment, especially of some steel alloys was realised.



High resolution X-ray computer tomographic (µ-CT) figure, showing modelled fluid flow pathways in a porous reservoir sandstone, which are potentially active during gas injection operations. Different colours refer to distinct flow velocities.

From 01/2016 (until 12/2018) these findings are being integrated in the follow-up project "HyINTEGER", which will investigate potential reactions of the natural reservoir components and technical materials used in bore holes during drilling and gas production (e.g. steel alloys, well cementations). As in "H2STORE", potential interactions between all these essential parts of any storage facility are studied by laboratory experiments at well site-specific conditions. However, besides pure H_2, also H_2/CH_4 and H_2/CO_2 gas mixtures will be applied in these tests. The intention of this extended approach is to evaluate the potential effects of such underground gas mixture injections. These findings may have an impact on future developments, like the storage of hydrogen in gas pipelines (H_2/CH_4 mixtures). Additionally the research could be of importance for synthetic methane production. City gas storage facilities with particularly high hydrogen levels have shown in the past the production of methane as part of the reaction between carbon dioxide and hydrogen ($CO_2 + 4H_2 \longrightarrow CH_4 + 2H_2O$). Carbon dioxide may be attained from biomass or CCS projects.

Dr. Pudlo will present these projects and their results in greater detail at the coming HIPS-NET workshop on the 23rd of June in Brussels.

Further information: H2STORE; HyINTEGER

For questions, please contact Dr. Pudlo (dieter.pudlo@uni-jena.de).

Sponsored by the Federal Ministry of Education and Research

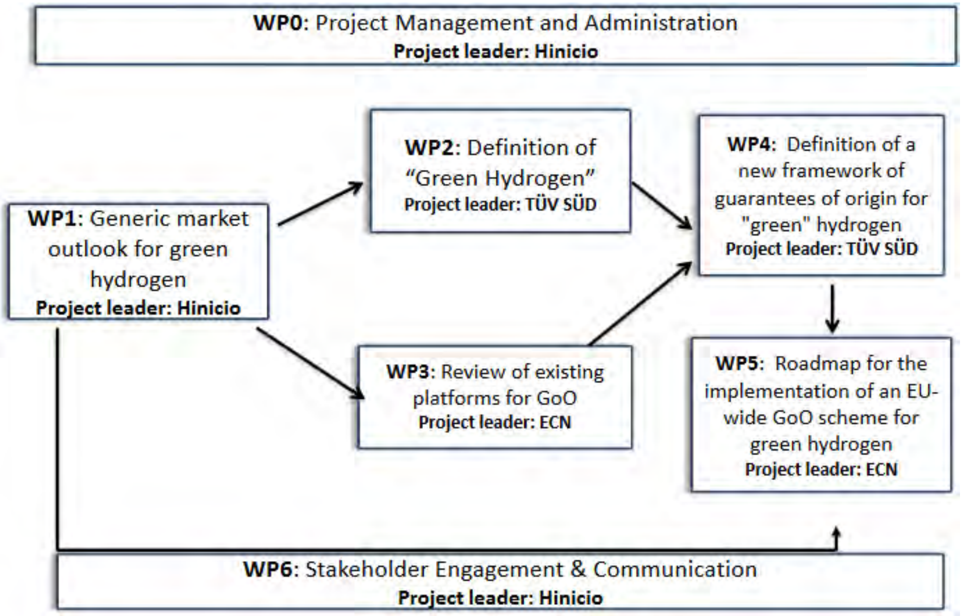
Supported by: Federal Ministry for Economic Affairs and Energy on the basis of a decision by the German Bundestag

CertifHy - Developing Europe's First Guarantee of Origin for Green Hydrogen (1/2)

The CertifHy project is attempting to develop the first Europe-wide Guarantee of Origin (GoO) scheme for green hydrogen. In doing so, it intends to establish a clear definition of green hydrogen and designs a framework for the implementation of a GoO scheme in reference to green hydrogen.

The consortium partners leading the project are Hinicio (as coordinator), TÜV Süd, Ludwig Bölkow Systemtechnik and the Energy Research Centre of the Netherlands (ECN). However, the project is actively seeking involvement from other organisations in the industry in order to facilitate a consensus agreement on the issues of green hydrogen and guarantee of origin. According to the project coordinators, these other organisations would take the position of either "affiliated partner" or "supporting partner" within the project. The costs are projected at 432,000 Euro and will be funded by a grant from the Fuel Cells and Hydrogen Joint Undertaking.

The project is due to take place over a two year period, from December 2014 to October 2016, and has been designed around seven work packages, for which the responsibilities have been divided between the project partners. These work packages are as follows:



Structure of the CertifHy work packages (CertifHy)

The first three work packages have already been completed and results have been made available through the CertifHy website. The remaining work packages have not yet reached completion.

Work Package One - executed by Hinicio - came to the conclusion that the outlook for green hydrogen, based on a CO_2 policy-driven scenario is very positive. They believe the demand for power-to-gas is likely to increase, likewise the demand for hydrogen for mobility purposes. They also feel that European industry would benefit from a GoO scheme, even before 2020. Such a scheme should have the flexibility to provide both proof of renewable origin and proof of a low emission content. They argue that the disconnection between the production site and the demand for green hydrogen through the use of GoO is necessary for an effective use of green hydrogen.

Work Package Two was coordinated by TÜV Süd and intended to develop a definition for "Green Hydrogen" based on industrial consensus. They determined two types of GoO for:

- **CertifHy Green H_2** of renewable origin with low GHG emissions (excluding ancillary use of electricity) and
- **CertifHy Low-GHG H_2** with low level GHG emissions.

Hydrogen from renewable sources is defined as belonging to the share of production equal to the share of renewable energy sources (as defined in the EU RES directive) in energy consumption for hydrogen production, excluding ancillary functions. Both GoO are associated with emissions lower than the defined CertifHy low-GHG-emissions threshold, set at 36.4 gCO_{2eq}/MJ. Any hydrogen produced by this facility that is neither CertifHy Green nor CertifHy Low-GHG must have emissions lower than the benchmark value, set at 91.0 gCO_{2eq}/MJ (refers to steam methane reforming of natural gas). This benchmark ensures that any facility, participating in the GoO scheme, has not excessively high GHG emissions.

Date: CertifHy Workshop "A roadmap for the introduction of guarantees of origin for green hydrogen" Friday, 17th June 2016 in Brussels.

Objective of the workshop:
The focus will be on discussing the draft roadmap and the related actions and responsibilities.

CERTIFHY - DEVELOPING EUROPE'S FIRST GUARANTEE OF ORIGIN FOR GREEN HYDROGEN (2/2)

(CONTINUED)

Work Package Three was coordinated by ECN and analysed previous or currently existing GoO systems - especially those from the renewable energy sector - in order to consider a possible scheme for a hydrogen GoO. They recommend that details of a future hydrogen GoO should be based on the AIB Rules and Principles of the European Energy Certificate Systems (EECS) and, due to the multiple possible uses of hydrogen, a flexible scheme would be necessary including all possible applications for hydrogen. Such a system should cover all possible production routes, including import and export within the EU and with third countries, and should also make a clear separation between the origin of the product and the quality of the product (e.g. as determined by the CertifHy green hydrogen standards or the EU RES Directive qualifications for renewable transport fuels).

In addition, the team uncovered several challenges to the creation of a hydrogen GoO system based on the nature of hydrogen usage. Since hydrogen is created by the process of electrolysation and then often mixed with other gases, a method of analysing and recording the GoO of hydrogen is not always straightforward. Furthermore, hydrogen electrolysis utilises both renewable and non-renewable energy sources, which makes the process of determining the origin yet more complicated.

Further information of the CertifHy project is here available. The full reports on the first three work packages may be downloaded here.

MOVE PROJECT - HYDROGEN ENRICHED METHANE FUEL (HCNG) | SWITZERLAND (1/2)

AUTHORS: URS CABALZAR, THOMAS BÜTLER, CHRISTIAN BACH

Renewable fuels offer great potential for the reduction of CO_2 emissions in the mobility sector. In this context, the Empa is examining the production, dispensing and utilisation of synthetic (electricity based) gaseous fuels. As part of this project, the future mobility demonstration plant "move" was realised consisting of a 0.2 MW Power-to-Gas plant including dispensers for the fuels CNG, H_2 and HCNG (Fig. 1). The facility has been in operation since November 2015.

HCNG is the mixture of CNG and H_2 whereby blending ratios of 2 - 30 vol% H_2 are investigated. This mixture offers numerous advantages regarding the efficiency and emissions of an internal combustion engine. With the increase of refuelling stations for gaseous fuels also HCNG could be made available without major efforts.

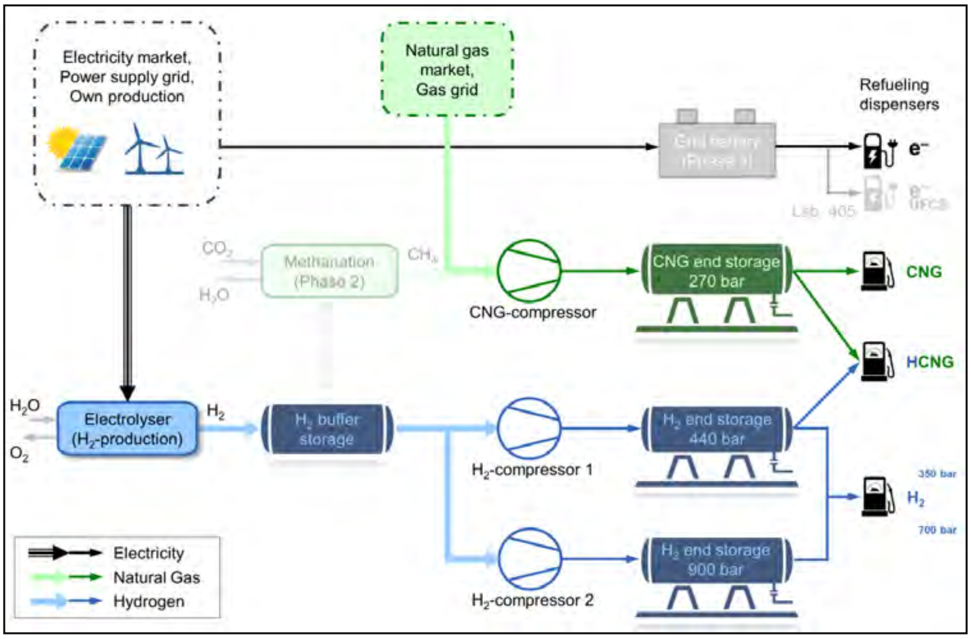


FIG. 1: SCHEMATIC OF THE DEMONSTRATION PLANT „MOVE" INCLUDING FUEL DISPENSERS FOR CNG, H_2 AND HCNG
(MORE INFORMATION: WWW.EMPA.CH/WEB/MOVE)

According to the regulation for automotive fuels (DIN 51624), compressed natural gas is allowed to contain up to 2 vol% of H_2. To quantify the impact of such a low blending ratio, three delivery vehicles were equipped with data logging systems and were then operated for several months with CNG and HCNG with a blending ratio of 2 vol% which was provided by our own fuelling station. The main focus of the field test was the characterisation of the engine start-up behaviour.

MOVE PROJECT - HYDROGEN ENRICHED METHANE FUEL (HCNG) (2/2)

(CONTINUED)

The vehicles were used in the parcel distribution service and therefore had an average of 45 starts a day with a maximum of 102 on one day. Roughly 9,000 engine starts with CNG and with HCNG (2 vol% H_2) with engine coolant temperature above 80°C were evaluated.

The time delay from the first turn of the electric engine starter until the first firing in a cylinder was evaluated for every engine start (Fig. 2a). The engine starts were then classified according to the length of the delay within 4 classes (Fig. 2b).

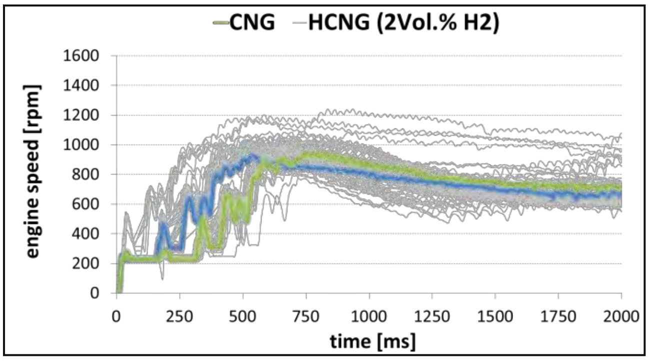


FIG. 2A: ENGINE SPEED TRACES DURING ENGINE START UP (BLUE LINE: TYPICAL HCNG ENGINE START, GREEN LINE: TYPICAL CNG ENGINE START)

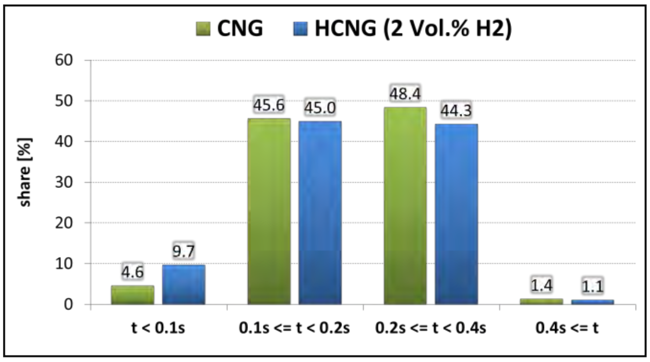


FIG. 2B: DISTRIBUTION OF DELAY FROM ENGINE CRANK TO FIRST FIRE FOR CNG (GREEN) AND HNCG (BLUE) IN 4 CLASSES

It could be determined, that HCNG shows a shift to shorter engine crank durations compared to CNG operation. This can be explained by the higher ignitability caused by the small amount of hydrogen in the HCNG blend. These investigations have been performed in 2014 - 2015, using a provisory H_2 blending system.

As a next step, a project vehicle is in preparation for a one-year field-test starting in autumn 2016 running with higher hydrogen blending ratios up to 30 vol%. To avoid hydrogen embrittlement, all fuel leading parts need to be revised. The fuel lines have to be replaced with stainless steel pipes, the pressure regulator needs to be hydrogen proof and the type I gas cylinders have to be replaced with type IV hydrogen cylinders with appropriate cylinder valves. Maintaining the filling pressure at 200 bar, as is standard for CNG vehicles of today, the volumetric energy density would suffer a significant decrease with the addition of hydrogen. To keep the initial driving range of the vehicle, the target HCNG filling pressure is 350 bar to compensate this effect, which – of course – requires a corresponding type IV hydrogen cylinder.

FIG. 3: PROJECT VEHICLE FOR HIGH H_2-BLENDING RATIOS UP TO 30 VOL% (IVECO DAILY)

Besides the vehicle adaption, the HCNG filling station also offered some challenges. As part of the above mentioned demonstration plant a dispenser for HCNG refuelling was realised between the CNG and the H_2 dispenser. Out of different technical and economic considerations, the refuelling concept was chosen to be of sequential type. Meaning that CNG is refuelled up to 200 bar first, followed by the filling of a predefined amount of hydrogen up to max. 350 bar. The refuelling is fully automatic and takes place through the same nozzle yielding convenient refuelling as known from standard CNG dispensers.

The challenge lies in controlling the gas flows to reach the predefined blending ratio as accurately as possible and to obtain the highest possible filling of the cylinder without exceeding the targeted vehicle tank pressure (350 bar @ 15°C). Furthermore, heat release in the vehicle tank during refuelling is increased in the case of hydrogen blending which needs to be estimated and managed by the refuelling control. To tackle these challenges a model for the refuelling process was developed which forms the basis for implementation of the refuelling control which is currently under way.

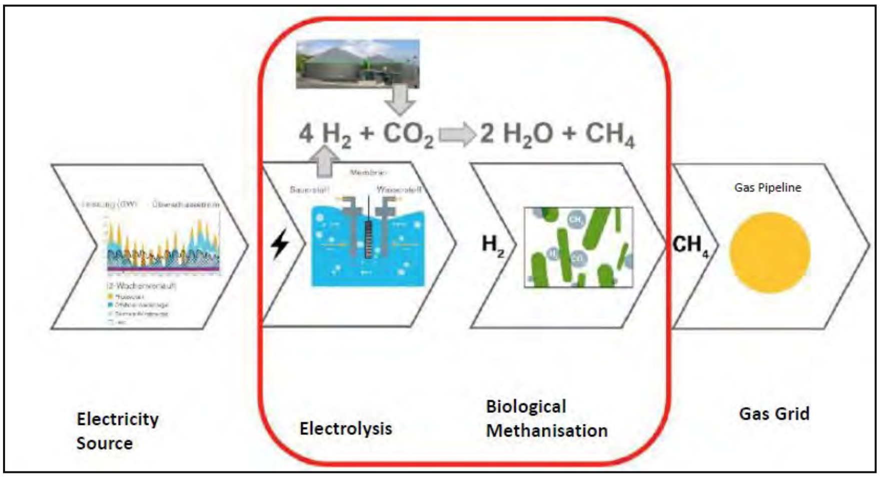
The project is co-funded by the Competence Centre for Energy and Mobility of the ETH-Domain (CCEM), the Swiss Federal Office of Energy (SFoE), the Swiss Gas Association (SVGW/VSG) and several industrial partners (AtlasCopco, Iveco (Switzerland), Swagelok, Mobility Solutions AG, Endress&Hauser).

Source: move

For further information, please contact Christian Bach (Christian.Bach@empa.ch).

VIESSMANN BETS ON BIOLOGICAL METHANATION | GERMANY

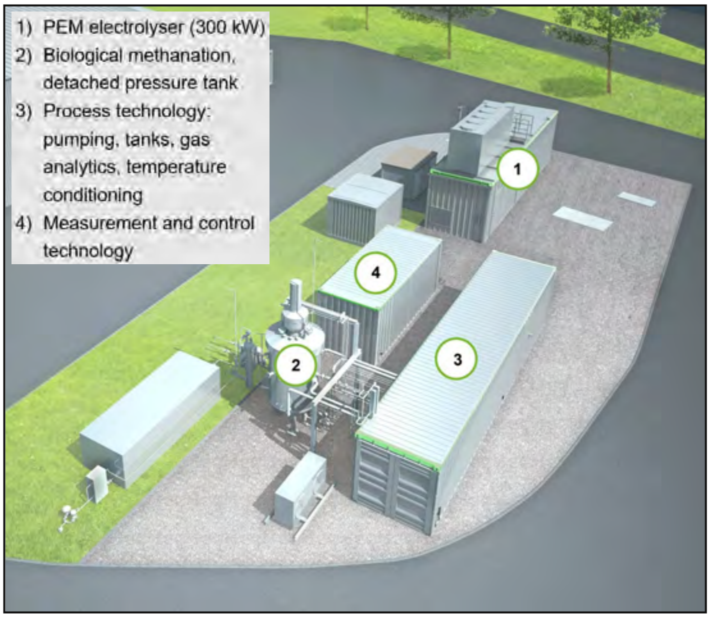
The international heating systems manufacturer Viessmann has installed a methanation facility at its headquarters in Allendorf, Germany. The goal of this facility will be to produce methane by mixing carbon dioxide produced in a biogas unit with hydrogen produced by excess electricity from wind or solar energy. The methane of regenerative origin will then be fed in to the natural gas network or made available for mobility solutions. The project is a part of the wider BioPower2Gas initiative introduced by the German Federal Ministry for Industry and Energy.



PROCESS CHAIN BIOLOGICAL METHANATION (VIESSMANN | TRANSLATION BY AUTHOR)

The initial goals of the project were to explore the biological methanation – with a focus on long term stability and reliability, and to examine the quality of the gas produced (in particular such criteria as temperature, moisture level, and hydrogen content). For the fully automated facility, Viessmann utilises an electrolyser with 2 x 150 kW_{el} capacity and a 500 litre hydrogen storage tank (max. 40 bar). Since spring 2016 the facility has been certified to participate in the German electricity balancing market, allowing it to utilise surplus electricity production from renewable resources such as wind and solar.

Initial results have been extremely encouraging. The project was commissioned in 2015 and produces approximately 400,000 kWh per year (enough to power a CNG vehicle for 750,000 km; assuming vehicle consumption of 3.5 kg of CNG per 100 km). One of the unique characteristics of the facility is the manner in which methane gas is produced. While other methanation facilities regularly use chemical catalysts, the Viessmann plant will use a biological process developed by the company's subsidiary MicrobEnergy. The methane produced is stable with a very high quality (more than 98% methane and less than 1.5% hydrogen). This methane is injected into the local gas grid of Energie Waldeck-Frankenberg GmbH. The gas has been certified by inspection institution TÜV Süd as "e-gas" comparable to the fuel produced by Audi (who also cooperated on this project) for use in road vehicles. The facility has also received certification from REDCert (Biofuels) as suitable for the processing of raw biogas. This certification acknowledges the sustainability of the project and the reduction in greenhouse gases. At the end of 2015, the plant was awarded the "Biogas Partnership of the Year" award by the public-private German Energy Agency (DENA) in recognition of its efficiency and contribution to carbon-neutral transport solutions.



OVERVIEW PTG PLANT ALLENDORF (VIESSMANN | TRANSLATION BY AUTHOR)

Source (German only):
Viessmann, BioPower2Gas

Contact: Thomas Heller
(thomas.heller@microbenergy.com).

Viessmann already has permission to expand this project. In the future, it will be able to use up to 400 Nm³/h of hydrogen for methanation. The company has been able to largely complete the project using its own technologies. In addition to the technological and biological input directly from Viessmann and its subsidiary MircobEnergy, the electrolyser was also largely built by a further subsidiary, CarboTech.

OMV RESEARCH PROJECT WIND2HYDROGEN - TRANSFORMING RENEWABLE ELECTRICITY INTO HYDROGEN | AUSTRIA

A new research project in Austria – wind2hydrogen – is being undertaken to examine the viability of storing and transporting hydrogen produced from wind energy. The project involves the construction of a 100 kW_{el} power-to-gas pilot plant at the OMV compressor station Auersthal in Lower Austria with the capability to feed directly into the natural gas network. Vienna-based OMV Gas & Power is heading the consortium in charge of the project. Fronius, EVN AG, HyCentA Research GmbH and the Energy Institute of the Johannes Kepler University in Linz are also partners.

The expressed goals of the wind2hydrogen project are to examine the hydrogen tolerance of the natural gas transmission and distribution infrastructure, and to examine the hydrogen storage capacity of the Austrian natural gas network. Hydrogen is produced by a state-of-the-art flexible high pressure PEM electrolyser designed specifically for this project. This is then either stored in tanks and transported to existing OMV hydrogen fuelling stations, or fed into the Austrian gas network. The project aims to test the flexibility of the electrolyser technology under different load profiles. More details on the technical characteristics of the project can be seen in the table below.

The hydrogen feed-in to the gas network is of particular significance. After passing through the project pipelines, the hydrogen is injected directly into the high-pressure natural gas network at the OMV compressor station in Auersthal. Due to the small amount of input medium, the hydrogen concentration in the pipeline is below currently measurable limits. This feed-in will aid the optimisation of quality control and control technology.

In addition to network feed-in, the project is also analysing the optimal conditions for the utilisation of hydrogen for mobility in Austria. This analysis will consider the legal, economic, and environmental implications of a large-scale role out in the future and examine the viability of different business models for this scenario.

The potential for this technology in Austria is clear. Network expansion plans in the federal states of Lower Austria and Burgenland alone require an additional electricity storage capacity of up to 2 TWh per year by 2030. Electrolysation of this electricity could provide enough hydrogen fuel for 250,000 vehicles.

W2H pilot plant parameters	
12 PEM modules :	total 100 kW
H_2 production :	14.4 Nm^3/h at 163 bar Hydrogen 5.0 – quality of fuel cells
Daily H_2 production (max.):	31 kg
Water required :	50 l/h water
Electrolysis container :	7 x 2.7 x 2.5 m

PARAMETERS OF THE PILOT PLANT (FACTSHEET OMV)

More information including an image film on this project can be found here and in the factsheet.

Contact: OMV AG public.relations@omv.com

The project has received funding from the Climate and Energy Fund (an Austrian public institution for investment in environmentally-friendly innovations) and is being realised as part of its energy research program. Commissioning of the facility took place in summer 2015 and the project is due to continue until 31st December 2016.

HIPS-NET CORE TOPICS - WHAT ARE OUR AIMS?

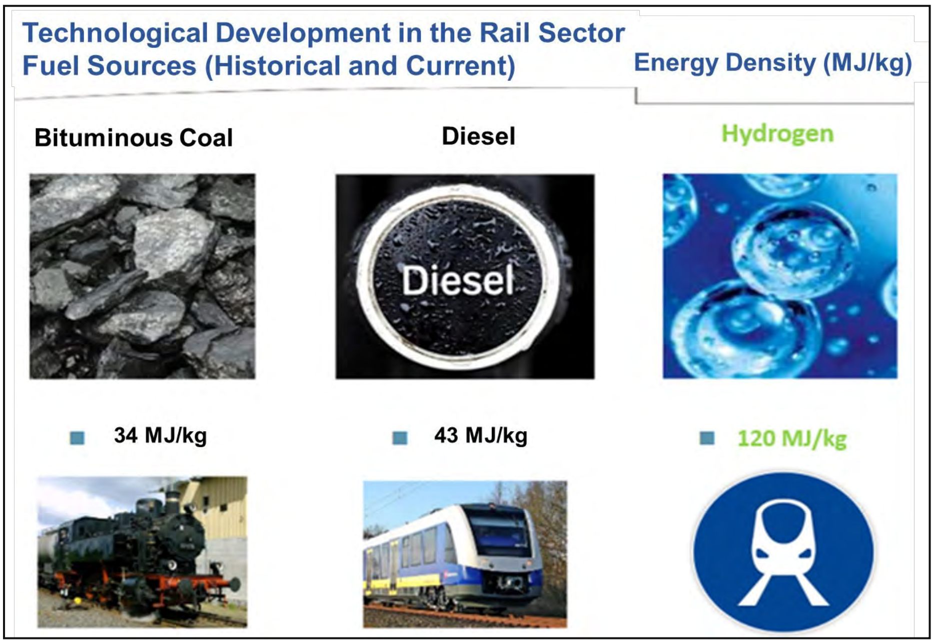
We gather and disseminate the latest available knowledge to improve the understanding of hydrogen/natural gas blends in pipeline systems with emphasis on the core topics:

We additionally keep a minor focus on the general develop-ment of power-to-gas, hydrogen networks, and further topics around the utilisation of (renewable) hydrogen.

Electro Mobility in Rail Transport | Germany

Alstom is currently constructing a new generation of trains powered by fuel cells as part of a larger project to bring hydrogen and fuel cell technology onto the railway tracks of Germany.

At present, the German rail network is approximately 50% electrified. As a result diesel engines are still heavily used, especially on branch lines. The further electrification of these lines is economically inefficient. In this respect, fuel cell technology offers an emission-free alternative that could also be more energy- and cost-efficient in the long run.



Development in the Rail Sector (Alstom | translation by author)

To fund this innovative technology, Alstom has received 8 million Euros from the German Federal Ministry for Transport (BMVI) through the National Innovation Program for Hydrogen and Fuel Cell Technologies (NIP). The first trains are already expected to enter trial operation in 2018. The emission-free regional train has also received enthusiastic support from four federal states within Germany. Together they have signed letters of intent for the purchase of more than 50 hydrogen-powered trains from Alstom by 2021.

Alstom's goal is to prepare fuel cell technology in trains for the market, and to analyse the technical, legal and economic requirements for the hydrogen supply to trains and/or rolling stock.

Alstom sees Germany as the ideal location to start the development of hydrogen-fuelled rail technology due to its well-developed renewables sector, the high potential for hydrogen production, and the country's ambitious goals regarding climate protection. In this respect, it is also looking to expand this technology into other markets such Norway, the Netherlands, Denmark and the UK.

Fuel-cell-powered trains support carbon-neutral railway traffic. However, the success of this technology will depend greatly on the continued expansion of the hydrogen infrastructure. The rail network will require a dynamic and reliable supply of hydrogen in large quantities (approximately 2 tonnes per day for 10 trains), and at prices competitive with conventional fuel sources. This will only be possible as a result of closer partnership between the rail and the gas industry.

Source: NOW

For further information, please contact: Dr. Jens Sprotte (jens.sprotte@alstom.com).

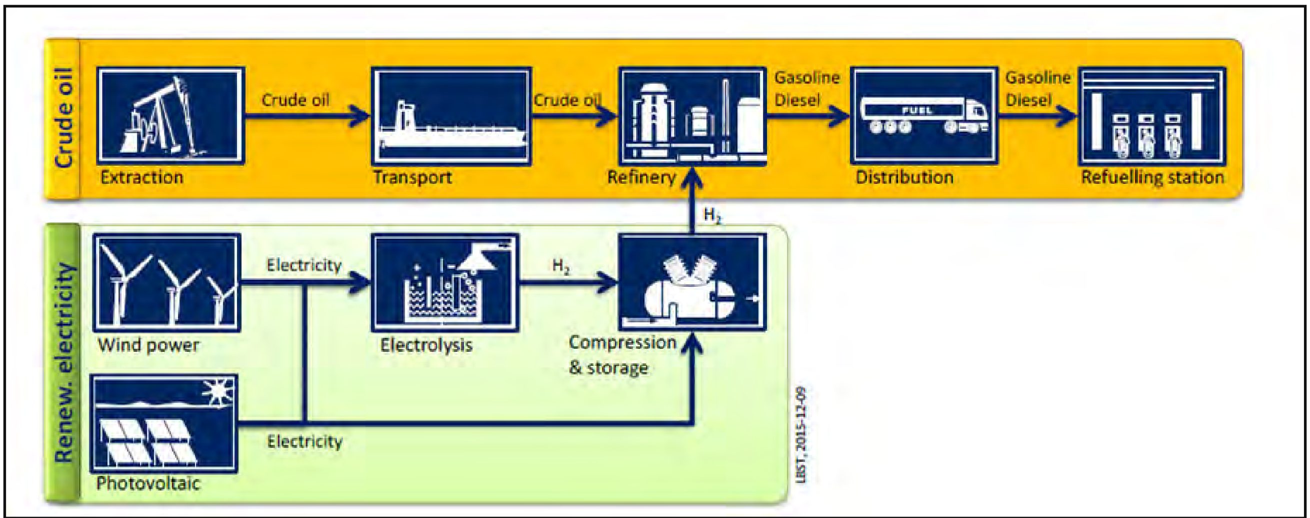
FONDATION TUCK STUDY: OPPORTUNITIES TO LEVERAGE SYNERGIES BETWEEN THE ELECTRICITY AND TRANSPORT SECTORS THROUGH POWER-TO-HYDROGEN | FRANCE, GERMANY

The study was sponsored by the Fondation Tuck and performed by Hinicio S.A. (Belgium) and Ludwig Bölkow Systemtechnik (Germany) and focuses on two possibilities for better implementing the power to gas technology:

- Application of "green hydrogen" in refineries
- "Semi-centralised power-to-hydrogen systems".

The two options are evaluated with framework conditions of France and Germany.

The study argues that Power-to-Gas production could be used to provide the necessary hydrogen for crude oil refineries (figure below). Since refineries currently produce this hydrogen via steam methane reforming of natural gas, this would allow refineries to reduce their greenhouse gas emissions considerably (14 % in France and 7 % in Germany, refers to 'gate-to-gate' emissions of the refinery) and meet the requirements of the EU Fuel Quality Directive this way. The authors assessed the overall costs for producing green hydrogen and came to the conclusion that using green hydrogen is cost-efficient. The GHG mitigation costs are below German infringement costs. Moreover, an implementation in short term would be possible. The authors suggest changing the German regulation to reward the upstream emission reductions for refineries. This is under discussion but has not been implemented yet.



THE PATHWAYS FOR THE SUPPLY OF GASOLINE AND DIESEL INCLUDING HYDROGEN SUPPLY FROM RENEWABLE ELECTRICITY (LUDWIG BÖLKOW SYSTEMTECHNIK)

The second option, semi-centralised power-to-hydrogen systems, is described as a possibility to develop the supply of green hydrogen for fuel cell electric vehicles with co-benefits for local energy systems. Using current French policy and foreseeable costs for installation of semi-centralised power-to-hydrogen systems, the study feels that current conditions in France are conducive to power-to-gas. However, in Germany there are drawbacks because of the grid usage fee.

Finally, the study makes several recommendations on how to develop power-to-gas technology as a key component in energy transition, for example:

- The creation of a feed-in tariff for green hydrogen into the gas grid in France (similar to already existing tariffs for biomethane)
- Provision of similar taxes or grid fee benefits for production of green hydrogen in Germany as in France
- In Europe: Further development of sustainability criteria including green hydrogen in the general frame of the EU Renewable Energy Directive (RED) and the EU Fuel Quality Directive (FQD)

Source: Fondation Tuck
Contact: Wouter Vanhoudt (wouter.vanhoudt@hinicio.com) and Patrick Schmidt (patrick.schmidt@lbst.de)

Congratulations for the ADEME and DENA Franco-German Innovation Award Nomination

LBST and HINICIO are nominated for the ADEME and DENA Franco-German Innovation Award. Both companies are part of the three nominees for the first part of the recently published study on Power-to-Gas financed by the Tuck Fondation and its members Total and Engie. Even though the study did not win the award, the nomination acknowledges the achievements for cross-border co-operation to further the energy transition.

CLIMATE PROTECTION AND RENEWABLY-SOURCED CHEMICAL ENERGY CARRIERS | GERMANY (1/2)

In order to achieve ambitious long-term goals for climate protection, a large share of the energy supply will have to be based on renewable energy sources. Renewable energy carriers produced by power-to-gas and power-to-liquid technology can play an important role for applications across all energy sectors (power, heating, transport, industry). As Germany has only limited potential for renewables, and foreign production of renewable energy could feature economic and energetic advantages, the import of renewable electricity or renewable energy carriers may become necessary in the future. In this regard, the German Federal Environmental Agency (UBA) has commissioned a study to consider the challenges of energy infrastructure in order to incorporate renewably-sourced chemical energy carriers.

LOCATIONS OF POWER GENERATION FROM RENEWABLES (DBI BASED ON BING.DE)

The goal of the study was to gain first insights into renewable chemical energy carriers of regenerative origin produced both domestically and abroad. The study also explores the requirements and restrictions for energy transport created by the existing electricity and gas transport infrastructure. By using a range of international locations, the study is able to determine the feed-in potential of renewable generation technologies such as wind (on-/offshore), photovoltaics and CSP (concentrated solar power). The study also determines the requirements to transport methane and hydrogen in the gas infrastructure. On a national level, the project compared the transport capacity of hydrogen in several power network regions by analysing the effect of spatially occurring power surplus situations. By investigating the development of a hydrogen economy, the project additionally presents national CO_2 reduction potentials as part of the overall transformation process.

Comparison of import routes for renewable gases

The results of the study show a systematic comparison of possible routes for importing renewable energy. They also outline recommendations for the integration of these renewables as part of the transformation process to reduce greenhouse gases in the energy supply system. A list of the considered production locations and technologies is provided in the table below.

Three different import routes are compared:

- **Import of electricity** and the conversion to hydrogen or methane on site (near the place of consumption)
- **Import of natural gas blended with hydrogen** (up to 5 vol%) through conversion of electricity to hydrogen at the site of electricity generation. The hydrogen is subsequently fed into the natural gas grid and transported via gas pipelines.
- **Import of LNG** (liquefied natural gas) through conversion of electricity to synthetic methane at the site of electricity generation. Methane is subsequently liquefied and transported via LNG tanker.

TECHNOLOGIES OF ELECTRICITY GENERATION AND REGIONAL DISTRIBUTION (GERMAN FEDERAL MINISTRY FOR ENVIRONMENT)

Electricity generation by	Country	Location
Wind (on-/offshore)	U.K.	Girvan
	Norway	Stavanger
	Sweden	Bandsjön
Water	Norway	Roskrepp
	Sweden	Hjalta
PV + CSP	Turkey	Aydin
	Spain	Guadix
	Egypt	Samalut

The study came to the conclusion that use of the gas infrastructure for importation would cause the least energetic losses and therefore provides advantages over the utilisation of the electricity grid. The cost of extracting hydrogen from the transported gas blend is not economically viable due to the high energy expenditure required. In cases where pure hydrogen is required, electricity should be imported and utilised to create hydrogen at the site of utilisation. It is therefore advisable to construct production facilities for hydrogen close to the location of its utilisation. Although limited methane loss is observed during transport via the gas grid, the liquefaction of imported LNG involves higher energetic loss. The LNG import route should, therefore, only be considered for particularly remote locations without access to the national gas grid.

CLIMATE PROTECTION AND RENEWABLY-SOURCED CHEMICAL ENERGY CARRIERS | GERMANY (2/2)

(CONTINUED)

Ultimately there are multiple obstacles to be considered for all import infrastructures (electricity, gas grid, and LNG terminal). In order to realise these import routes, it will therefore be necessary to expand the infrastructure and utilisation for renewable energy abroad.

IMPORTANT FACTS OF THE PROJECT (GERMAN FEDERAL MINISTRY FOR ENVIRONMENT)	
Publication	February 2016
Authors	Stefan Schütz (DBI GUT, Leipzig); Philipp Härtel (Fraunhofer Institute for Wind Energy and Energy System Technology, Kassel)
Languages	German only
Client	German Federal Environmental Agency
Project End	July 2015
Funding	German Federal Ministry for Environment, Nature Conservation, Building and Nuclear Safety

Which costs influence the modification of the German gas infrastructure to accommodate hydrogen-blended gases?

The elements of the gas infrastructure, which show an especially low hydrogen tolerance, are process gas chromatographs (PGCs) and natural gas transport compressors. Beyond this, the natural gas grid does not require particular modification for admixtures in lower concentrations. Of the approximately 500 PGCs installed in Germany, only about 10 % could be converted to tolerate a higher concentration of hydrogen. The total costs of converting all PGCs is estimated at 55 million euros (500 PGCs * 110,000 euros = 55 million euros). These costs would, however, be reduced by the installation of hydrogen-tolerant PGC units in the course of ordinary repair and maintenance.

Higher concentrations of hydrogen in natural gas influence the performance of compressors in two ways. Firstly, the heating value of natural gas falls with the increase in hydrogen concentration. In order to fulfil their delivery obligations (i.e. to deliver a certain amount of gas), gas transmission network operators would need to compress their gas to greater extent. A hydrogen concentration of 5 vol% (natural gas quality H, Russia) raises the necessary power consumption of the compressor by 12 %. This can, in most cases, be covered by adjusting the delivery obligations accordingly. Secondly, most turbines used to power the compressors, run on gas and only tolerate minor gas quality changes. Adjusting these turbines to higher hydrogen concentration, will require, in most cases, either refitting or even replacing these turbines. The study gives an overview on investment costs but is reluctant to estimate total costs. With 70 compressor stations (including about 236 compressors) in Germany, any refitting or replacement activities will induce high expenses. Replacement in the ordinary course of maintenance, by new technologies tolerant to hydrogen, is therefore suggested, if higher hydrogen concentrations are expected.

Recommendations of the study are:

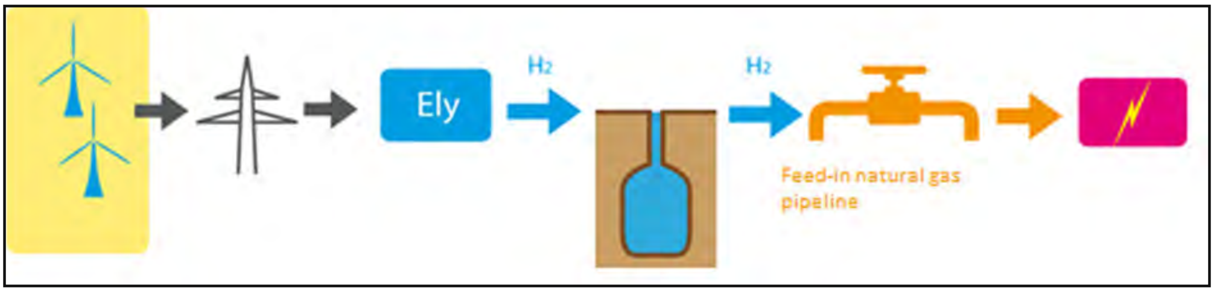
- The gradual integration and substitution of existing fossil hydrogen applications allows synergies and learning effects while efficiently and cost-effectively restructuring the system.
- A simultaneous expansion of renewable energy sources is crucial for this transition.
- Considering the production costs of domestic renewable energy, long-term demands, and in the light of long implementation times, also short-term strategies for international expansion of infrastructure and diversification of import dependencies are to be found and developed.

Please contact for further information Stefan Schütz (stefan.schuetz@dbi-gut.de).

Source in German only: Umweltbundesamt

WESPE PROJECT - SCIENTIFIC RESEARCH ON LARGE-SCALE WIND-HYDROGEN-SYSTEMS | GERMANY

How can surplus wind energy be stored efficiently in the form of hydrogen in a large scale? Scientists validate in the project WESpe different components of wind-hydrogen-systems regarding their technical and operational feasibility. The project has a technical focus and optimises the technical components of wind-hydrogen-systems to enhance durability and performance. The analysis includes a variety of case studies for the value-added chain including electrolysers, underground storage facilities and the connection to gas grids.



ONE OF MANY CASE STUDIES FOR HYDROGEN UTILISATION INVESTIGATED IN WESPE (BTU COTTBUS)

The analysis additionally covers the entire development chain, from the qualification of the prototype through the evaluation of first operational experiences under various conditions and even covers the preparation of future markets (standardisation, education and public acceptance).

Work Packages (WP) of the WESpe Project:

WP1 - Evaluation of the core components: Fundamental investigations on alkaline and PEM electrolysis under the new conditions of dynamic operation.

WP2 - Requirements on underground storages: Identification of methods and designs that allow the construction of technically and economically optimal and reliable gas injection facility for porous rock as well as salt cavern storages. Development of monitoring programmes for hydrogen underground gas storages.

IMPORTANT TECHNICAL FACTS OF THE WESPE PROJECT	
Cavern Storage Capacity	Up to 85 GWh_{H2}
Electrolysers' Power Capacity Layout	0.5 - 20 MW_{el}
Volumetric Energy Density	0.3 kWh_{H2}/litre (@ 100 bar cavern pressure)
Efficiency (AC/$Volume_{H2}$)	< 4.4 $kWh_{el}/Nm^3{}_{H2}$ (alkaline electrolyser), < 4.3 $kWh_{el}/Nm^3{}_{H2}$ (PEM-electrolyser)
Response Time for Provision of Energy	< 10 s (from operating temperature condition)
Project Duration	December 2013 to May 2017

WP3 - Modelling and functional analysis: Development of the electrolysis technology and the entire hydrogen supply chain from wind power to compressed hydrogen. Dynamic modelling of alkaline, PEM electrolysis systems, and other auxiliary components including e.g. annual utilisation rates and efficiency.

WP4 - Environment and climate protection: Studying the effects on climate and environment with greenhouse gas balances, on the avoidance of natural gas imports, on the use of land (avoiding electricity grid expansion) and the environmental relevance of materials from electrolysers.

WP5 - Public acceptance and transparency: Developing and testing of a communication concept.

WP6 - System analysis and macro-economic analysis.

The research consortium closely cooperates with industrial partners to implement future wind-hydrogen projects successfully and thus offers promising opportunities for industrial partners to enter new markets at an early stage.
Project partners are Deutsche Umwelthilfe e.V., Brandenburg Technical University, DBI Gastechnologisches Institut, German Aerospace Center (DLR) and Fraunhofer Institute for Solar Energy Systems (ISE).

Contact for further information: Dr. Ulrich Fischer (ulrich.fischer@b-tu.de).

Source: http://forschung-energiespeicher.info/en/project-showcase/analysen/projekt-einzelansicht//UEberschuessigen_Wind_in_Wasserstoff_zwischenspeichern/
(This link might only work correctly if you copy and paste the URL directly in the address bar of your browser.)

SELECTION OF APPOINTMENTS

++ Dena - Annual Conference Power to Gas 2016
(21. June 2016, Berlin, Germany)

++ 3rd HIPS-NET Workshop
(22. - 23. June 2016, Brussels, Belgium)

++ H2Congress - 7th German Hydrogen Congress 2016
(05. - 06. July 2016, Berlin, Germany)

++ EFCF - European Fuel Cell Forum
(05. - 08. July 2016, Luzern, Switzerland)

++ 2016 International Hydrogen Conference
(11. - 14. September 2016, Moran, Wyoming, USA)

++ DBI-Fachforum Energiespeicher
(27. - 28. September 2016, Berlin, Germany)

++ World of Energy Solutions
(10. - 12. October 2016, Stuttgart, Germany)

CURRENT PARTNERS

Alliander AG ++ Areva H_2Gen ++ DEA Deutsche Erdoel AG ++ DGC ++ DNV GL ++ Enagás ++ Energiforsk ++ Energinet.dk ++ ENGIE ++ EWE AG ++ Gas Natural Fenosa ++ Gasum OY ++ Gasunie ++ GRTgaz ++ grzi e.V. (figawa) ++ Infraserv GmbH & Co. Höchst KG ++ ITM Power ++ EC Joint Research Centre (JRC) ++ KOGAS ++ NAFTA ++ Open Grid Europe GmbH ++ ÖVGW ++ RAG Rohöl-Aufsuchungs AG ++ RWE Deutschland ++ Shell ++ Solar Turbines Europe ++ SVGW ++ Synergrid ++ Uniper Energy Storage GmbH ++ Uniper Technologies Limited ++ Verband der Chemischen Industrie (VCI) ++ Volkswagen AG ++

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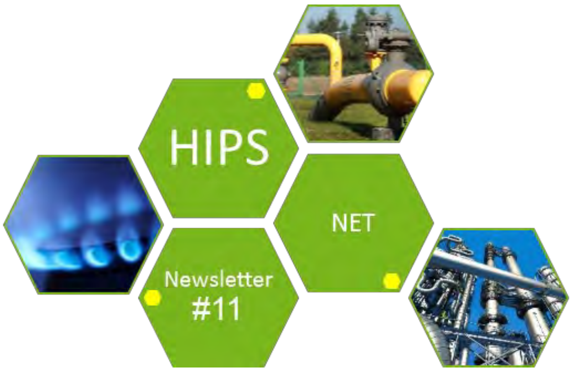
Certified DIN EN ISO 9001:2008

DBI GUT Gas- und Umwelttechnik GmbH

GERG groupe européen de recherches gazières the european gas research group



HIPS-NET

"ESTABLISHING A PAN-EUROPEAN UNDERSTANDING OF ADMISSIBLE HYDROGEN CONCENTRATION IN THE NATURAL GAS GRID"

NEWSLETTER #11 | **September 2016**

CONTENT NEWSLETTER #11

"A network leads to cooperation, cooperation leads to creativity and innovation - this changes the world." - Marissa Mayer (CEO Yahoo)

11TH HIPS-NET NEWSLETTER

Dear Partners and Colleagues,

Welcome to the latest edition of the HIPS-NET newsletter. On 23rd June 2016 the 3rd HIPS-NET Workshop took place in Brussels. Once again the event was a success and we would like to thank all the attendees, especially the presenters, for their enthusiastic participation. This edition of our newsletter focuses in addition to the articles on the presentations given at the HIPS-NET Workshop on 23rd June. We hope that the summaries can provide an overview of key information for members who were unable to attend the workshop. For those of you who attended the event, we hope that the material helps to refresh your memories.

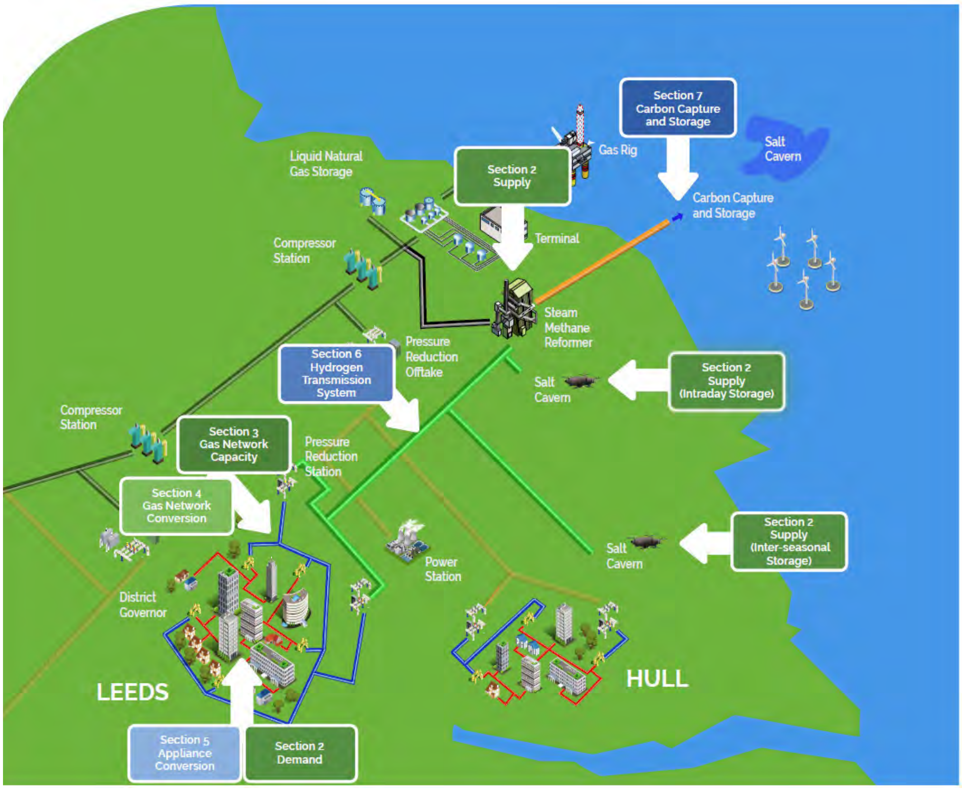
The feature articles from our current newsletter include a U.K. based study how to repurpose gas grids with hydrogen and research on explosion protection for hydrogen and natural gas mixtures. The newsletter also introduces an overview on standardisation for hydrogen applications in Germany. In France, meanwhile, we report about the first French plant to manufacture electrolysers.

We hope you enjoy reading and that you adopt well from the warm late summer days to the current weather conditions!

Your HIPS-NET Team
Gert, Anja, Stefan, Josephine & Gideon

Repurposing the Gas Grids with Hydrogen | U.K.

The **H21 Leeds City Gate project** investigated opportunities to decarbonise the U.K. distribution gas network by specifically focussing on large cities.



System Schematic of the H21 Project (Source: Project Report page 26)

On the example of Leeds, one of the largest U.K. cities, the study suggests that the existing gas network can be significantly decarbonised at minimal cost to consumers and thus contribute to the Paris Agreement commitments (reduction of carbon emissions by 80 % in 2050). The authors argue that the change from natural gas to hydrogen has the potential to provide a very deep carbon emission reduction. The study aims to determine the technical and economic feasibility of converting the existing natural gas networks in Leeds to 100 % hydrogen under the prerequisites of minimal disruption for the customer and heat supply at current costs. The economic feasibility relies on low-cost bulk hydrogen produced by steam methane reforming, fitted with 90 % carbon dioxide capture, which is permanently sequestrated deep under the North Sea (CCS). Hydrogen can also be generated via electrolysis but CCS is regarded as a good bridgehead to enable the demonstration of hydrogen distribution at a predictable price.

	NG (g/kWh)	H_2 (g/kWh)	Reduction
U.K. Carbon budget basis (Scope 1)	184.0	27.0	85 %
Including electricity for sequestration (Scope 1+2)	184.0	49.5	73 %
Including embodied CO_2 from production & importation of NG (Scope 1+2+3)	209.3	85.8	59 %

CO_2 emissions savings achieved by the H21 project (Source: Executive Summary page 5)

The project has shown that:

- The gas network has sufficient capacity for conversion to hydrogen.
- It can be converted incrementally with minimal disruption to customers.
- Minimal new energy infrastructure will be required compared to alternatives.

The existing heat demand for Leeds can be met via steam methane reforming and salt cavern storage using well-proven technology.

You can find the source report and the management summary here.

Partners: Northern Gas Networks, Wales&West Utilities, Kiwa Gastec, Amec Foster Wheeler

EXPLOSION PROTECTION FOR HYDROGEN AND NATURAL GAS MIXTURES | GERMANY

AUTHORS: E. ASKAR, V. SCHRÖDER, T. TASHQIN, K. HABIB (BAM), S. SCHÜTZ (DBI) AND A. SEEMANN (BG ETEM)

Safety characteristics for explosion protection of natural gas and hydrogen are well studied as these are important industrial gases. However, mixtures of hydrogen and natural gas (H_2/NG) are much less well studied especially with standardised determination methods such as EN 1839. Such mixtures become more and more relevant. As regenerative energy technologies are constantly evolving, hydrogen production by electrolysis becomes increasingly important for "storing" the fluctuating green electricity supply. Hydrogen can be easily distributed and stored by using the existing natural gas grid and storage systems. However, the explosion protection concept must be reviewed for this purpose. Considering the safety characteristics for explosion protection, hydrogen is more "critical" in various respects. In previous studies, mainly substantial large-scale tests in open space have been conducted. The scope of this work was:

1) Laboratory tests to determine safety characteristics for explosion protection for H_2/NG mixtures
2) Calculations on the areas with explosive mixtures for H_2/NG mixtures
3) Testing of calculation methods for the safety characteristics of H_2/NG mixtures to reduce the high effort for the experimental determination of safety characteristics prospectively.

The results of the work are presented here in aggregated form.

Explosion regions

In Figure 1 the explosion limits of different H_2/NG mixtures are shown, determined experimentally according to EN 1839–T. Information on the explosion limits are especially necessary for calculating explosion zones. The lower explosion limits (LEL) are very similar for all mixtures. This information is also important for the design of appropriate gas warning sensors. The upper explosion limits (UEL) as well as the limiting oxygen concentrations (LOC) vary strongly. However, the dependency of the UEL and LOC on the composition is clearly not linear. Calculation of explosion limits of such mixtures was conducted with the model of constant adiabatic flame temperatures profiles.

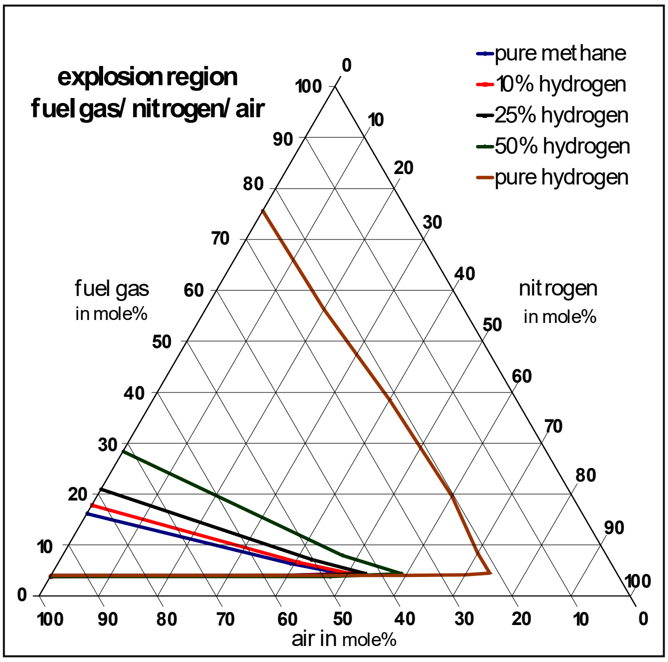


FIGURE 1. EXPLOSION LIMITS OF DIFFERENT MIXTURES OF HYDROGEN AND NATURAL GAS DETERMINED ACCORDING TO EN 1839-T.

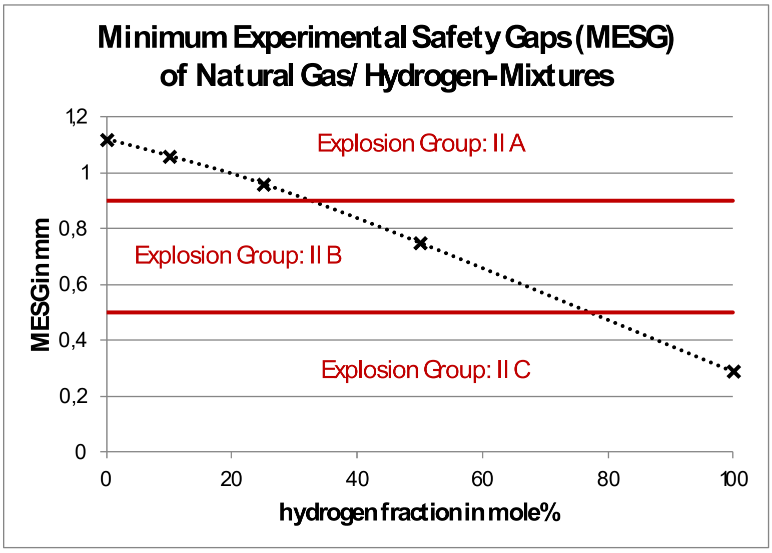


FIGURE 2. MESG OF MIXTURES OF HYDROGEN AND NATURAL GAS AND ALLOCATION TO EXPLOSION GROUPS.

Explosion groups

According to ATEX the gases and vapours are divided into the explosion groups IIA, IIB and IIC according to their Minimum Experimental Safety Gaps (MESG). Natural gas has a rather high MESG and is thus allocated in the least critical explosion group IIA, whereas hydrogen is allocated in the most critical explosion group IIC, because of its very small MESG. In Figure 2 the MESG for H_2/NG mixtures as well as the allocation to the different explosion groups for the mixtures is shown.

EXPLOSION PROTECTION FOR HYDROGEN AND NATURAL GAS MIXTURES | GERMANY

(CONTINUED)

Explosion severity

The explosion pressure p_{max} and the rate of explosion pressure rise $(dp/dt)_{max}$ as safety characteristics for characterising the explosion severity are necessary for designing measures for constructive explosion protection. p_{max} of natural gas and hydrogen are very similar. It was calculated at adiabatic conditions with thermodynamic calculations using the software "GasEq" for "pure" gases as well as for mixtures. $(dp/dt)_{max}$ of hydrogen is much higher compared to natural gas. Similar to most other safety characteristics, the dependency of $(dp/dt)_{max}$ from the composition is not linear for H_2/NG mixtures. For mixtures with hydrogen fractions up to about 25 mole%, $(dp/dt)_{max}$ does only change slightly. At higher hydrogen fractions, $(dp/dt)_{max}$ increases much stronger with increasing hydrogen fraction. The explosion severity parameters for mixtures of hydrogen and nitrogen are shown in figure 3.

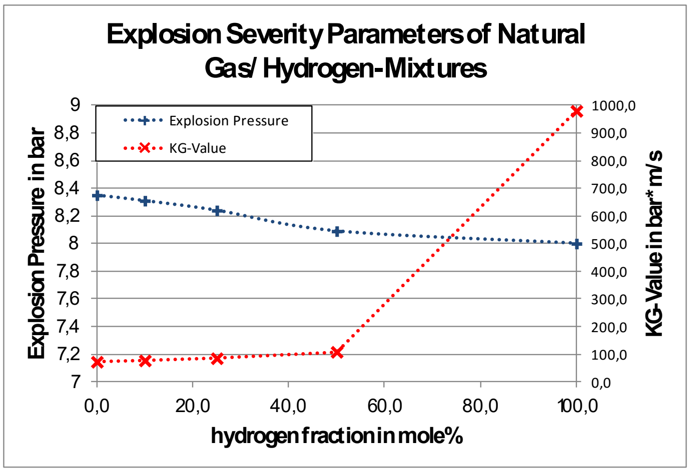


FIGURE 3. P_{MAX} AND $(DG/DT)_{MAX}$ OF MIXTURES OF HYDROGEN AND NATURAL GAS.

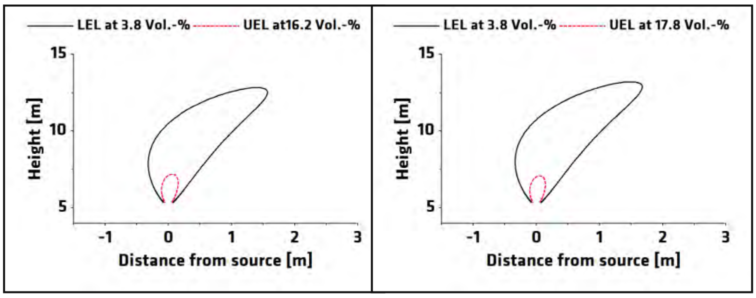


FIGURE 4. CALCULATED AREAS WITH EXPLOSIVE ATMOSPHERES FOR PURE NATURAL GAS (LEFT) AND FOR MIXTURES WITH 10 MOLE% HYDROGEN (RIGHT).

Areas with explosive mixtures

The areas where explosive mixtures with air can occur were calculated with a jet release model for mixtures of 10 mole% hydrogen and 90 mole% natural gas considering different orientations, different flow rates of the fuel gas as well as different wind speeds. No significant difference concerning the areas to pure natural gas was detected for any of the different scenarios. In Figure 4, the calculation results at vertical orientation at a wind speed of 3 m/s and a flow rate of 1 kg/s is shown exemplarily.

Conclusions

An admixture of up to 10 mole% hydrogen to natural gas has very low influence on safety characteristics for explosion protection. With increasing hydrogen fraction, the mixtures become mainly more „critical" considering explosion protection, an substantial influence on explosion protection occurs for hydrogen fractions of more than 25 mole%. A set of data for safety characteristics of natural gas and hydrogen mixtures was obtained for designing measures for explosion protection. Safety characteristics for similar mixtures could be calculated by using appropriate calculation methods.

The project partners are evaluating a follow-up project. Open research issues are:

1) Impact of hydrogen fractions on a possible transition from deflagration to detonation (DDT) at explosions in pipelines
2) Impact of hydrogen fractions on the effectivity of sparks as ignition source
3) Influence of elevated pressure and temperature on safety characteristics of natural gas/ hydrogen blends
4) Development of calculation methods for accurate estimation of explosion limits and other safety characteristics of natural gas/ hydrogen blends
5) Systematic investigation of safety characteristics for further blends with hydrogen, e.g. Syngas

HIPS-NET partners are invited to contribute if they are interested in this topic.

Project partners:

- BAM (German Federal Institute for Materials Research and Testing),
- BG ETEM (Employers Liability Insurance Association Energy, Textiles, Electricity),
- DBI GUT

Funding: BG ETEM

Contact: Dr.-Ing. Enis Askar (enis.askar@bam.de)

Source: Paper

Cross-Sector Cooperation on Standardisation for Energy Storage Technology | Germany

The energy transition addresses increasingly the need for cross-sector cooperation to strengthen the interconnection between the electricity, gas, and heat sector. Four standardisation bodies in Germany have addressed the linkage between the energy sectors; they developed a standardisation roadmap for energy storage ("Deutsche Normungsroadmap Energiespeicher").

The roadmap has been developed and published by DIN (German Institute for Standardisation), VDI (Association of German Engineers), DVGW (German Association for Gas and Water), and DKE (German Commission for Electrical, Electronic & Information Technologies of DIN and VDE).

HIPS-NET colleagues asked us, how does standardisation support the market introduction of power-to-gas? What are you doing in Germany? Even though, this roadmap describes the situation for Germany and only briefly refers to European developments, we decided to include this topic in the newsletter.

The standardisation roadmap addresses five different types of energy storage technologies:

Thermal Storage	Electrochemical Storage	**Chemical Storage**	Electric Storage	Mechanical Storage

The term 'chemical storage' covers so-called power-to-X technologies: renewable gases, liquids and chemicals. The roadmap includes the following parts of the infrastructure for chemical storage: - excerpt -

- Grid connection (e.g. pipelines, electricity network) of the power-to-X facilities
- Technology for gas generation (transformation, storage), gas treatment, gas conditioning, and injection of the generated gases hydrogen and methane
- Storage in (1) gas grids, (2) underground storages, (3) (pressurised) tanks, (4) chemical storage (e.g. metal hydrides)

The rather broad conception of the roadmap is brought down to details, first by a listing all relevant working committees in DIN, VDI, DVGW and explaining their scope (tables 11-13 of the report). At the heart of the section on chemical storage, the report lists existing and drafted technical standards with brief descriptions. We refrain from repeating this overview here, because it spreads over 19 pages; please have a look at table 14 to find needed information. An additional cross-check of the overview revealed further standards such as the DVGW G 292 (dispatching), DVGW G 493 (gas pressure regulation and injection facilities) and DGUV Regel 113-001 (explosion protection). DGUV is the German Social Accident Insurance.

The roadmap briefly emphasises the active standardisation bodies for the hydrogen infrastructure: The ISO/TC 197 covers standardisation activities for hydrogen, which is mirrored in the German DIN-NAGas working committee NA 032-03-06 "Wasserstofftechnologie". Furthermore, the European Industrial Gases Association (EIGA) has technical standards for hydrogen (e.g. hydrogen pipelines, underground storages, reformation). The final report of the CEN-CENELEC SFEM Working Group Hydrogen recommends creating a new CEN/TC "Hydrogen" to support standardisation. This will be established as CEN-CLC/TC 6 "Hydrogen" under the Secretariat of NEN.

Source: Roadmap (German)

Contact:

Olaf Bender (olaf.bender@din.de) for the German Standardisation Roadmap and

Francoise de Jong (Francoise.dejong@nen.nl) or

Jos van Nistelrooij (Jos.vannistelrooij@nen.nl) for the CEN-CLC/TC 6 "Hydrogen"

Invitation to the CertifHy final event

The CertifHy project is about to finalise its work about first EU-wide Guarantees of Origin (GO) scheme for premium hydrogen (green and low-carbon hydrogen) and will present the key project results on Wednesday, October 19th in Brussels. Please see for further information and register here. We described the aims of the project in the June edition #10 (page 3f).

AREVA H_2Gen Launches the First French Plant to Manufacture Electrolysers | France

All-in-one electrolyser ELYTE 120 (AREVA H_2Gen)

AREVA H_2Gen is the leading company in France for the production of Proton Exchange Membrane (PEM) electrolysers and opens its electrolyser manufacturing plant in Les Ulis, France. The site includes office space, a large unit to produce stacks and for system manufacturing and integration (capacity of 30 electrolysers per year) and laboratory space for R&D testing.

AREVA H_2Gen is now building medium-capacity PEM electrolysers ranging from 100 kW to 1 MW up to 35 bars. In the near future, it will be developing large-capacity electrolysers with up to dozens of MW of power storage. The company participated in various projects over the last years such as "GRHYD" Hydrogen injection […] in distribution networks or H2ME "Hydrogen Mobility Europe" or Myrte facility in Corsica.

AREVA H_2Gen Production Facilities (AREVA H_2Gen)

The French political framework supports the company's activities. At present, the "French Hydrogen Territory" RFP, issued in early May 2016 by Mrs Segolène Royal, the French Minister of Environment, Energy and Sea, responsible for international relations on climate change, that is intended to demonstrate that any country, region or land that employs a source of carbon-free hydrogen for a number of uses can drive a profitable and ecologically-sound development.

Contact: Stéphanie Grenault (stephanie.grenault@arevah2gen.com)

Source: AREVA H_2Gen

Summary of the 3rd HIPS-NET Workshop

The subsequent pages provide an overview about the HIPS-NET Workshop, beginning with an evaluation of the workshop based on your feedback and followed by the summaries of the given presentations. The organisational aspects of our network with the outlook for the coming year follow thereafter. Three short project proposals conclude our workshop summary.

In total seven presentations were delivered covering a wide range of topics. Judd, GERG Secretary General, and Gert Müller-Syring opened the event. EU policy was, once again, a major focus of the workshop. Jyri Ylkanen from the European Commission gave an update with his presentation on the key activities within EU energy security strategy and the role that hydrogen technologies will play in this. This was followed by a presentation by Eveline Weidner from the European Commission's Joint Research Centre on the role of standardisation in the formulation of efficient and flexible legislation. Other presentations at the workshop considered the practical utilization of hydrogen or power-to-gas technologies in the present or near future. Dr. Pudlo from the University of Jena presented research into the feasibility of hydrogen storage in underground reservoirs, and Alain Le Digou presented the work of the French Alternative Energies and Atomic Energy Commission to analyse techno-economic, legal, and regulatory conditions for power-to-hydrogen and hydrogen-to-X technologies. The Windgas Hamburg project – one of the few sites in Germany injecting hydrogen directly into the municipal natural gas grid – was presented by Julian Oebel from Uniper Energy Storage. As mobility plays an even greater role in the connection with hydrogen technologies, it was also interesting to hear Juliane Muth from Volkswagen present the carmaker's perspectives for sustainable mobility and its investment in hydrogen fuel-cell technology. Gert Müller-Syring from DBI also presented the latest developments in the HIPS-NET project including the newly-launched website.

SUMMARY OF THE 3RD HIPS-NET WORKSHOP

EVALUATION OF THE WORKSHOP 2016

We would like to thank all workshop participants for the time taken to answer our feedback questionnaire at the end of the event. We will now take this opportunity to summarise the positive feedback and the constructive criticism we received. The feedback includes the opinions of more than 70 % of the participants.

We were pleased to hear that all attendees felt the workshop was worthwhile, either rating the event as "good" or "very good" on our questionnaire. The topics addressed were regarded as "well-balanced" and/or "very interesting", and the selection of speakers was praised as "good" or "very good". In particular, participants stated that they were pleased with the material discussed and also with the opportunity to meet other professionals from across Europe and exchange ideas.

Among the constructive criticism received was the wish to expand the duration of the event. Although the large majority of participants were satisfied with the time provided for the workshop, some attendees would like to have more time to discuss the topics and to get to know new contacts. Since the majority rated the duration as "optimal", we intend to stick to the format of the workshop and appreciate the elevated interest. From an organisational perspective, some participants also requested a brief introduction round at the beginning of the event to establish participants and agenda. Thanks for the good idea; we will include this next year.

Some colleagues asked to meet next time somewhere else but not in Brussels as one of the most expensive city in Europe. We are reluctant to change the place as this gives us the chance to invite DG ENER (Jyri Ylkanen) and opens an opportunity for exchange. As we are a GERG based network, we welcome the support by Robert Judd, Secretary General, who offers the meeting room and catering in the historical GERG building at Palmerston. If you feel nevertheless the place to meet should be discussed, please do not hesitate to suggest this for our next year's agenda. Someone was asking for a list of participants in advance of the meeting. Please refer to the doodle poll we installed in the previous years. We perceived using a doodle poll as effective tool while preparing the workshop. Supplementary, we will distribute the link next year indicating that one might see the planned participation there and disseminate the list of participants right ahead of the meeting.

Several topics were requested for future workshops and newsletters. In particular, the participants mentioned further information on hydrogen production, methanation and real cases of hydrogen injection into the grid. There was also interest in more information on natural gas/ hydrogen blends, and hydrogen storage in underground storage facilities. Most of the suggested topics are covered by the core-topics of our network; they are the main target of the information we are looking for, though not always easy to find it. It is good to read that these questions are still valid to you. In addition to our own search, may we ask you to give us hints if you hear of latest results on the hydrogen tolerance or planned facilities?

Further wishes for the network? We received various suggestions, to mention a few of them:

- New partners —> We, and especially Gert, are promoting the network and constantly looking for new partners. We also welcome suggestions by you.
- Close cooperation with other groups as CEN/CENELEC, IEA —> The cooperation has been established and will be maintained.
- Keep track and do not loose topics. —> Yes, we have been trying and take your suggestion as opportunity to look again for 'lost' topics. Though, to our knowledge, the R&D in the core-topics advances to a different degree and some are not yet sufficiently addressed by projects.
- Newsletters every two months. —> It is good to hear from you, that the work we are doing is in fact useful to colleagues in the network. Researching the topics, writing the articles and typesetting the newsletter is surprisingly time-consuming, which might not be obvious looking at it from the outside. The current available project budget, though, has been calculated for quarterly newsletters. You may look at the status report of year 1+2 for further information (to be downloaded at the website after logging in).

As mentioned before, we will take these comments into consideration as we begin planning for the next HIPS-NET Workshop in 2017. Last but not least: We asked in the questionnaire whether you intend to join the workshop next year again and all answered YES. Thank you for your praise and your trust! We will continue improving the network as well as the workshop and hope to add value to your every-day work in the future.

The most important part of a network is the basis. Please do not hesitate to get in touch with the editorial team @DBI and share your ideas to contribute to the future of HIPS-NET.

SUMMARY OF THE 3RD HIPS-NET WORKSHOP

JYRI YLKANEN - EUROPEAN COMMISSION DG ENERGY OFFICE OF THE PRINCIPAL ADVISOR

Power-to-Gas in EU Energy Policy

Key activities within the EU Energy Security Strategy, which are relevant for Power-to-Gas:

- Development of a new market design
- Strengthening of the European regulatory framework
- Further integration of the energy and transport sectors with a greater emphasis on alternative fuels
- Renewable Energy Package 2016-2017 with a focus on self-consumption, bioenergy sustainability and a post-2020 legal framework for renewables

Energy system investment needs and sources of funding:

- Total investment requirements for the gas and electricity sectors between 2010 and 2020 in excess of 1 trillion euro. This includes approximately 500 billion for energy production and 600 billion for transmission and distribution.
- Funding for sustainable energy available via the Cohesion Policy (approximately 38 billion euro), Horizon 2020 (approx. 5.4 billion), and the Connecting Europe Facility (approx. 5 billion), among others.
- European Fund for Strategic Investments (EFSI) expected to procure 315 billion euro for investment in projects with a higher risk profile.

A flexible system through renewable energy sources:

- Smart energy systems to play a role in a new flexible energy infrastructure
- Creation of strategic energy reserves to make a more robust European energy system
- Diversification of supply and transport routes intrinsically linked to the development renewables
- Greater synergies between renewables and the natural gas grid to support strategic energy reserves

Integration of Power-to-Gas with the natural gas grid and potential issues:

- Standards and safety – possible effects of blending H_2 and natural gas or of transporting H_2 via the natural gas infrastructure
- Possible impact of SNG, biomethane, and hydrogen on the quality of natural gas
- Decarbonised gas infrastructure – reaction of the markets and the impact on objectives
- Securing long-term investment models and a sustainable market structure for all technologies
- Reinforcement of the governance framework to consider emerging energy solutions

Summary of the 3rd HIPS-NET Workshop

Eveline Weidner - European Commission Joint Research Centre

Standards Supporting European Policy and Legislation

European standards such as those adopted by CEN, CENELEC, and ETSI are voluntary. The European Commission does not develop them but the Commission can issue a request (mandate) for a standardisation to be developed.

The Annual Union Work Programme for Standardisation identifies and develops strategies for standardisation. This programme is currently working on new or updated standards, including the following areas related to power-to-gas:

- Use of electrolysers for grid balancing
- Hydrogen admixture to the natural gas grid (safety, quality, etc.)
- Gas-fuelled appliances

Standardisation plays a critical role in connection with EU energy policy

- Developing workable standards for new energy technologies and integration of renewables is at the heart of Horizon 2020 policies
- An upgraded Strategic Energy Technology Plan (SET Plan) was developed, aiming to accelerate the development and deployment of low-carbon technologies to implement the 5th pillar of the Energy Union (research, innovation and competitiveness)
- SET Plan places special focus on the development of standards and interfaces to insert storage technologies into the energy system

The European Commission's Joint Research Centre (JRC) works to support the development of fit-for-purpose performance-based standards to enable smarter legislation

- Established MoU with organisations such as the European Committee for Standardisation (CEN), European Committee for Electrotechnical Standardisation (CENELEC), European Telecommunications Standards Institute (ETSI)
- Supporting an acceleration of the standardisation process by anticipating the needs of industry and focusing on areas where rapid progress is required e.g. eco-innovation
- Greater inclusion of all stakeholders including European Standardisation Organisations (ESO), industry, stakeholders and policy

JRC supports both EU- and global standards

- Liaison with the ISO Technical Committee 197 on hydrogen standardisation
- Cooperation with other stakeholders to produce report on EU harmonized test protocols for PEM fuel cell membrane electrode assembly (PEMFC MEA) testing in single cell configuration for automotive applications

JRC has undertaken pre-normative research in the field of hydrogen safety sensor technology

- Analysed the effect of environmental parameters, the response time, the lifetime and effect of employment conditions, and the related testing methodology
- On going pre-normative research on reliable sensors for hydrogen in natural gas

Summary of the 3rd HIPS-NET Workshop

Dr. Dieter Pudlo - H2STORE and HyINTEGER

Studies on the Effect of Hydrogen Gas Storage in (Pore) Underground Gas Reservoirs

The projects H2STORE and HyINTEGER intend to improve the understanding of potential processes during H_2 storage in depleted gas reservoirs. In addition, HyINTEGER analyses NG/H_2 gas mixtures and well-casing components.

H2STORE research goals:

- Long-term reservoir capacity
- Biocoenosis (variations in species and population growth)
- Gas mixture behaviour
- Fluid transport
- Reactivity of the reservoir rocks

HyINTEGER research goals:

- Alteration of steel alloys, well cements, and elastomers (in combination with the reservoir rocks/fluids)
- The integrity of the reservoirs (cap rock and well leakage)
- Reactivity of the components – e.g. variations caused by different gas mixtures (H_2-CO_2, H_2-CH_4, H_2-H_2S, H_2-$C_2H_4O_2$) and in the order of their addition to the samples
- Gas mixture behaviour and fluid transport

Findings to date: Observed alteration of reservoir rocks through exposure to pure H_2 can lead to an increase in porosity and fluid flow pathways

- Alteration of the rocks and corrosion of well casing materials by pure H_2 are site specific
- Steel alloy corrosion is caused by sulfate reduction or pyrite alteration – different alloys corrode at different rates
- Variations in salinity influence rates of corrosion/dissolution
- Increased porosity modifies the well's storage capacity and recovery rates

The H2STORE and HyINTEGER project were briefly introduced in the 10th version of the newsletter (06/2016).

Support Wanted! - Request by Dr. Pudlo

We are looking for additional materials related to well operations. This includes material used in these operations as well as untapped samples of such material.

The unused samples will be taken for comparison and in the experiments. The provided samples will be investigated by submicroscopic and chemical means, which implies, they will be destroyed during these studies.

Most welcome are

- Steel alloys – stripes of about 4 cm in length, 2 cm in width are preferred (regardless of thickness)
- Well cements – small blocks of about 3 - 5 cm in edge length
- Elastomers (e.g. for sealings) – parts about 5 cm in length of ring-shaped samples
- Samples in any combination of these materials (bonded specimen) are deeply appreciated.

Besides these requests on sample supply, we are looking for further cooperation partners, willing to introduce new ideas and suggestions to our research.

Summary of the 3rd HIPS-NET Workshop

Juliane Muth - Volkswagen AG

Future Trends for Sustainable Mobility

European targets of the EU WHITE PAPER on transport (2011) requires CO_2-reduction until 2050 on a well-to-well basis of 70% in comparison to 2010. This challenging target needs tremendous changes in mobility by:

- Further improvements in efficiency for internal combustion engines
- New drive concepts like battery and fuel cell electric vehicles
- New CO_2 neutral fuels

Development of high energy batteries are one of the core components in electric vehicles:

- Today lithium ion technology is finally established in automotive powertrain applications.
- Reaching energy densities per cell of about 400 Wh/l and more.
- In near future driving ranges up to 500 km are conceivable.
- Next generation batteries could be the solid-state-battery (cell densities of 1,000 Wh/l and driving ranges comparable of today's cars).

Volkswagen AG works since 20 years on the hydrogen and fuel cells technology.

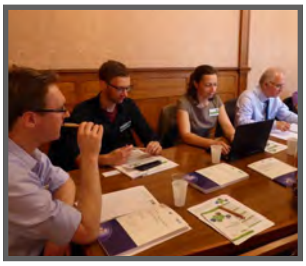
- Latest prototypes are equipped with an in-house developed fuel cell system.
- The next generation will have better ability of cold start, less platinum, prolonged durability and other features.

Pursuing new and innovative approaches for CO_2-reduced fuels like hydrogen, power-to-x fuels, algae based fuels etc. are in an early stage but will be enhanced by

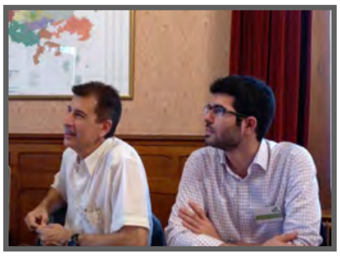
- Necessary financial support to advance beyond demonstration stage
- Political support to reach considerably lower CO_2 abatement costs for hydrogen (via electrolysis) and e-gas (via methanation) until 2020.

Volkswagen Powertrain and Fuels Strategy aims to incorporate e-mobility and highly efficient internal combustion engines both driven with preferably CO_2-neutral energy carriers for a more efficient portfolio, which meets the needs of all customers.

Impressions 3rd HIPS-NET Workshop ...






We uploaded further impressions at the secured members area of the HIPS-NET website. Please respect the right of privacy and do not disseminate the pictures without prior consent of the persons depicted. Thank you.

SUMMARY OF THE 3RD HIPS-NET WORKSHOP 2016

ALAIN LE DUIGOU - CEA

IEA HIA Task 38: Power-to-Hydrogen and Hydrogen-to-X: System Analysis of Techno-Economic, Legal, and Regulatory Conditions

Key facts and figures:

- General state of the art survey involving mapping and review of existing projects, techno-economic studies, legal framework, and business measures
- Detailed case studies including a systemic approach, macro-economic impact analysis, and other specific case studies
- Project began in early 2016 and is expected to last four years
- More than 40 participants from 14 countries

Overview of progress and recent developments:

- Publication of a reference document outlining the structure and goals of the project
- Completion of first methodology sheet and first list of studies for literature review
- Participation at the World Hydrogen Energy Conference in June
- Creation of a secure internet site for documentation – a public site is planned
- Possible cooperation with CEN/CENELEC

An article on this topic was published in the 9th edition of the newsletter (04/2016).

JULIAN OEBEL - UNIPER ENERGY STORAGE

Windgas Hamburg

Project outline:

- 1.5 MW_{el} (stack) facility with PEM electrolyser producing 290 m³/h hydrogen
- Hydrogen output fed directly into local gas grid
- Public funding through German Federal Ministry of Transport and Digital Infrastructure
- Project goals include analysis of PEM technology, analysis of effects of higher levels of hydrogen in the Uniper infrastructure, development of business potential

Results of testing so far have been encouraging:

- Gas grid injection and monitoring technologies according to DVGW (German Association for Gas and Water) standards
- Hydrogen injection into the Hamburg grid in two ways (ring injector, central injector)
- Grid operator tested up to 5 vol% hydrogen in the grid at gas-sensitive industrial customer. No negative impact detected. Regular operation is limited to 2 vol%.

We introduced the Windgas Hamburg Project in the 8th edition of the newsletter (02/2016).

Summary of the 3rd HIPS-NET Workshop

Gert Müller-Syring - DBI Gas– und Umwelttechnik GmbH

HIPS-NET - Organisational Aspects

Fixed responsibilities in the coming year:

- Continued publication of the quarterly newsletter and annual status report
- Addressing open R&D subjects and communication to the EC
- Preparation for the 2017 HIPS-NET workshop (proposed date 21st/22nd June 2017)
- Aim to increase the number of active partners (from 32 to 36)

Partner acquisition supported by the publication of the new HIPS-NET flyer (outlining the project and its goals) in June 2016.

Launch of the HIPS-NET website:

- Public area with a presentation of the network and its partners
- Private area (accessed through username and password) including newsletters, publications, presentations, reports, and a PtG database plus mapping

Additional scope for the coming year (depending on budget):

- Maintaining the HIPS-NET website
- Updating the Power-to-Gas map
- Maintaining cooperation with CEN/CENELEC Sector Forum Energy Management Working Group Hydrogen/TC6
- Establishing closer information exchange with the EC Director General for Energy

HIPS-NET - Project Proposals

The following proposals have been made for projects within the scope of HIPS-NET:

Proposal 1: Turbines and engines in the gas grid

- Aim to develop smooth and cost-efficient change strategies for gas turbines in the gas transmission infrastructure
- Investigate the number and hydrogen tolerance of gas turbines in the gas transmission grid
- Time: 10 months
- Cost: 15,000€
- DBI as performing partner but with support from EU Turbines/EUROMOT

Proposal 2: Natural gas as working medium

- Evaluation of the effects of hydrogen feed-in to the natural gas grid on processes in the chemical industry – hydrodesulphurization catalysts (HDS) tend to reduce in hydrogen-enriched atmosphere
- Evaluate of hydrogen impact on HDS through literature research and thermodynamic calculations
- Experimental test of HDS catalysts under elevated hydrogen content in the feed gas
- Time: 12 months
- Cost: 80,000€ funded by DBI and HIPS-NET partners

Proposal 3: Safety aspects

- Determination of properties related to safety technologies of gas mixtures with hydrogen under non-atmospheric conditions (amongst others, properties will include explosive range, ignition point as a function of temperature and hydrogen content, pressure, and oxidation)
- Determination of safety parameters of gas admixtures of H_2 with various natural gases
- Relevant gas conditions will be identified with the help of public/private institutions and literature research
- Results of experimental studies will be used to examine computational models
- Time: 36 months
- Cost: 75,000€ (estimated for current scope of project)
- Initiated by German Federal Institute for Materials Research and Testing and DBI GUT

Please contact us if you are interested to support these proposals technically and/or financially.

SELECTION OF APPOINTMENTS

++ 2nd International Workshop on Material Challenges for Fuel Cell and Hydrogen Technologies (19-21 September 2016, Grenoble, France)

++ DBI-Fachforum Energiespeicher (27-28 September, 2016, Berlin, Germany)

++ World of Energy Solutions (10-12 October, 2016, Stuttgart, Germany)

++ Biological Methanation - OTTI-Fachforum (25 October, 2016, Regensburg, Germany)

++ 6th Nordic Hydrogen and Fuel Cell Conference (26-27 October 2016, Sandviken, Sweden)

++ 2nd HYPOS-Forum - academic course of lectures (8-9 November, 2016, Bitterfeld-Wolfen, Germany)

++ IRES-Symposium - policy framework for storage technologies (1 December, 2016, Berlin, Germany)

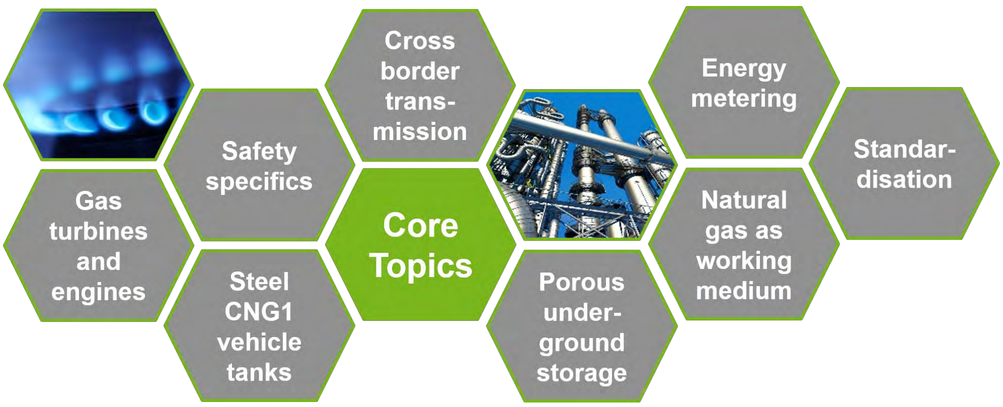
CURRENT PARTNERS

Alliander AG ++ Areva H_2Gen ++ DEA Deutsche Erdoel AG ++ DGC ++ DNV GL ++ Enagás ++ Energiforsk ++ Energinet.dk ++ ENGIE ++ EWE AG ++ Gas Natural Fenosa ++ Gasum OY ++ Gasunie ++ GRTgaz ++ grzi e.V. (figawa) ++ Infraserv GmbH & Co. Höchst KG ++ ITM Power ++ EC Joint Research Centre (JRC) ++ KOGAS ++ NAFTA ++ Open Grid Europe GmbH ++ ÖVGW ++ RAG Rohöl-Aufsuchungs AG ++ RWE Deutschland ++ Shell ++ Solar Turbines Europe ++ SVGW ++ Synergrid ++ Uniper Energy Storage GmbH ++ Uniper Technologies Limited ++ Verband der Chemischen Industrie (VCI) ++ Volkswagen AG ++

HIPS-NET CORE TOPICS - WHAT ARE OUR AIMS?

We gather and disseminate the latest available knowledge to improve the understanding of hydrogen/natural gas blends in pipeline systems with emphasis on the core topics:

We additionally keep a minor focus on the general development of power-to-gas, hydrogen networks, and further topics around the utilisation of (renewable) hydrogen.



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Certified DIN EN ISO 9001:2008

GERG groupe européen de recherches gazières the european gas research group

DBI GUT Gas- und Umwelttechnik GmbH

HIPS-NET

"ESTABLISHING A PAN-EUROPEAN UNDERSTANDING OF ADMISSIBLE HYDROGEN CONCENTRATION IN THE NATURAL GAS GRID"

NEWSLETTER #12	January, 2017

CONTENT NEWSLETTER #12

"Coming together is a beginning; keeping together is progress; working together is success."
(Henry Ford)

12TH HIPS-NET NEWSLETTER

Dear Partners, Dear Colleagues,

Welcome to the latest edition of the HIPS-NET newsletter.

Our feature articles in this edition will look to the future as we present several projects focused on the long-term development of hydrogen infrastructure and technologies. We report on the creation of a road-map for the future development of Power-to-Gas technologies and the challenges this process faces. We will also present a project analysing potential convergence in the electricity and gas grids and the creation of a fully-automated gas and electricity distribution network. Meanwhile we will also focus on the impact of hydrogen on gas turbine operation, and on the development of a design, monitoring, and analysis system for natural gas pipelines transporting hydrogen or natural gas/hydrogen blends.

POWER-TO-GAS - THE INVISIBILITY OF THE NATURAL GAS GRID (USCHI DREIUCKER - PIXELIO.DE)

We hope you enjoy reading!

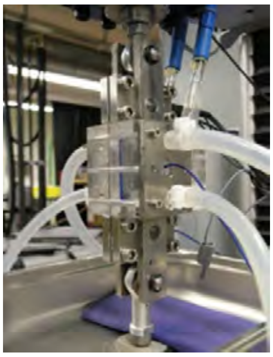
Your HIPS-NET Team

Gert, Anja, Stefan, Josephine & Gideon

H_2-PIMS - SAFE TRANSPORT OF HYDROGEN IN THE NATURAL GAS NETWORK | GERMANY

Development of a pipeline integrity management system for further utilization in existing natural gas infrastructure intended to convey shares of hydrogen

Gas network operators are applying pipeline integrity management systems (PIMS) to continuously maintain pipeline integrity and sustain risk reduction. These software based systems meet the security needs while finding optimised strategies for cost-efficient maintenance. The successful conversion of the existing natural gas infrastructure for the transportation of natural gas/hydrogen (NG/H_2) blends or pure hydrogen needs to satisfy the currently applied integrity level of natural gas transportation systems. Hydrogen exposure can increase the risk of embrittlement for metallic materials, reducing their durability and life-expectancy. The H_2-PIMS project aims to develop an innovative analysis system incl. material property data, which can support the safe operation of pipelines for the transport of hydrogen-rich gas blends.



MATERIAL TESTING
(SOURCE: FRAUNHOFER IWM)

Work Packa-	Scope of Activities
1	Together with material producers and pipeline operators: Collation and evaluation of existing knowledge of gas/hydrogen blends and pure hydrogen tolerance. Focus: pipeline materials and further elements such as fittings and joints as well as monitoring and maintenance systems. Including recommendations for gas/ transport and pure hydrogen by the European Industrial Gas Association (EIGA).
2	Action plan containing necessary technical and legal adjustments to use gas grids with higher concentrations of hydrogen. Recommendations for the testing and preparation of the infrastructure prior to conversion. Providing testing parameters for later work packages (WP 3). Defining operating parameters for the converted infrastructure.
3	Degradation testing on basic materials and welding seams including slow strain rupture tests, fracture mechanics testing, notched bar impact tests at room temperature and at -20°C.
4	Testing of leakage monitoring and detection systems. Cost efficiency of implementation.
5	Modelling the results of material degradation for integration into the PIMS system. Extensive testing of PIMS application.

The project was initiated in July 2016 and will run until 2019. H_2-PIMS is a cooperation between DBI GUT, TÜV SÜD, ONTRAS, Veenker, Fraunhofer Institute for Mechanics of Materials IWM und SZMF coordinated by DBI. The budget of approximately 3 million euro will be funded by „Hydrogen Power Storage & Solutions East Germany“ (HYPOS) – a project supported by the German Federal Ministry for Education and Research (BMBF) as part of the “Zwanzig20-Partnership for Innovation”.

Contact:
Marco Henel
E-Mail: marco.henel@dbi-gruppe.de

HYPOS - Hydrogen Power Storage & Solutions East Germany “The revolution of the hydrogen economy initiated in East Germany”

The HYPOS project is funded by the German Federal Ministry for Education and Research (BMBF) with up to 45 million Euro. It aims to produce green hydrogen from renewable sources on a large scale and forms the roof for various R&D projects. The HYPOS project connects the economic and scientific expertise of over 110 partners principally across eastern Germany. See HIPS-NET newsletter #3 (October 2014) for a short description of HYPOS.

RECENT LAUNCH OF R&D BY THE GERMAN GAS INDUSTRY ASSOCIATION

The German Association for Gas and Water (DVGW) pursues research & development with its 'Innovations Circle Gas'. The innovations circle is divided in four clusters, (1) gas production and energy system, (2) smart grids, (3) CHP and appliances, as well as (4) LNG and mobility. Following an intensive process of prioritising R&D needs inside the DVGW, a new wave of projects received funding in 2016. Power-to-Gas remains, as in the previous years, an import topic for the German gas industry. Selected recently launched projects are introduced in the following three articles.

POWER-TO-GAS POTENTIAL FOR INTERLINKING ELECTRICITY AND GAS NETWORKS

One of the recent keywords in German energy policy is "Sektorkopplung". It may be translated with 'sectoral interlinking' and describes the interlinking of different industrial sectors (gas, electricity, mobility, chemical, etc.). By linking the sectors, the advancing decarbonisation of the electricity sector can be used to decarbonise other sectors, simply by using renewable electricity or alternatively hydrogen and methane from Power-to-Gas applications. The sectoral interlinking could also be used to stabilise the electricity grid (i.e. balancing volatile electricity production).

Previous DVGW projects explored the utilisation of Power-to-Gas in connection with smart grids, and the potential for Power-to-Gas to support the 110 kV electricity grid (110 kV project – for details see newsletter #6 p. 10). The KonStGas project had already examined network interlinking of electricity and gas transmission networks.

"Power-to-Gas Potential" - the newly-launched project - will analyse the potential for utilisation of Power-to-Gas technology in distribution networks in Germany on a national scale. It will explore possible utilisation scenarios within the electricity and gas networks on a distribution level (network convergence).

The project Power-to-Gas Potential will be broken down into six work packages:

Work Packages	Scope of Activities
1	Analysis of current and future supply situations in the electricity and gas networks. Evaluation of current and forecasted load profiles utilising information from previous studies and demographic data.
2	Analysis of the electricity and gas distribution networks. Identification of typical gas and electricity structures and potential for interlinking of both networks.
3	Selection of suitable network structures for project purposes. These network structures should be representative of the entire German network.
4	Evaluation of the potential for Power-to-Gas technologies on the selected network structures. Determination of optimal location and utilisation of Power-to-Gas technologies in the context of target network planning.
5	Evaluation of the potential for Power-to-Gas technologies on a national scale. Plausibility assessment for estimations and assumptions made in Work Package. Mapping of a potential nationwide Power-to-Gas network.
6	Review and analysis of results, derivation of recommendations.

What is the hydrogen tolerance of the gas network in the present project? The experts assumed for the finalised 110 kV project that technical limitations for hydrogen injection would be solved up to 10 vol% in 2035 and up to 15 vol% in 2050. Beyond these limits, methanation was the preferred strategy. A similar approach might be followed in the new project.

The project aims to provide the first complete overview of the potential for Power-to-Gas in distribution networks on a national level. The first phases of the project began in August 2016 and the final results are expected in January 2018.

The project partners are EVT, GWI, DBI GTI and IAEW. The project is being funded by DVGW and will cost approximately 500,000 €.

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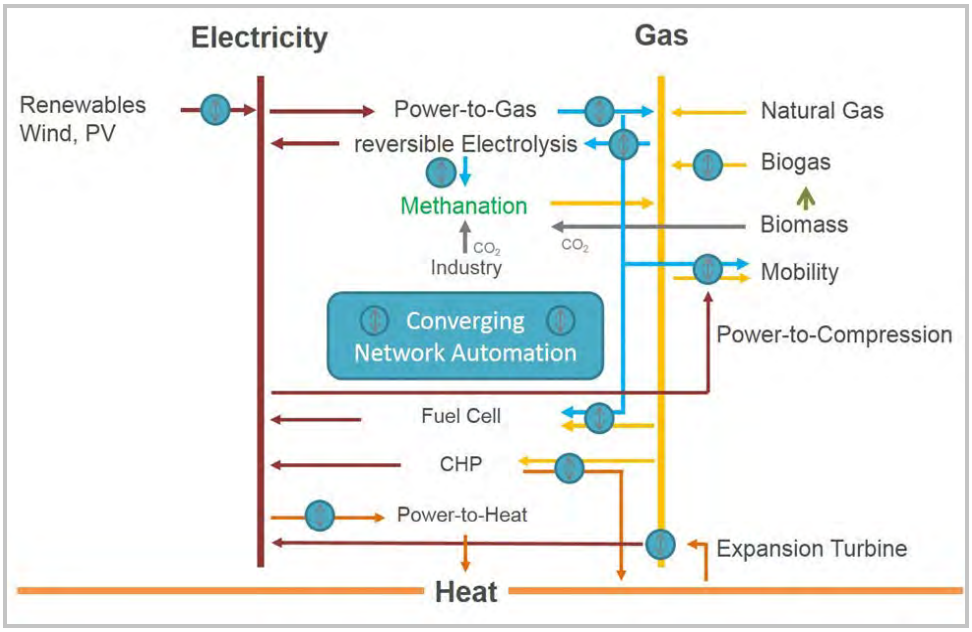
GAS AND ELECTRICITY DISTRIBUTION NETWORK AUTOMATION | GERMANY

The **GuStaV** project will explore the development of convergent, automated gas and electricity networks. Increasing utilisation of interlinking technologies such as combined heating and power (CHP) and Power-to-Gas offer the opportunity for greater convergence of gas and electricity networks. This convergence will reduce investment costs for network renewal and expansion and encourage the utilisation of renewable energy. In addition, synergies with telemetry (remote measurement) and data-management technology will enable greater automation of both the gas and electricity network.



NETWORK AUTOMATION INTERLINKING THE ELECTRICITY AND GAS DISTRIBUTION NETWORKS (SOURCE: GWI)

Previous DVGW projects and the project KonStGas considered the possibilities for greater interlinking of the gas and electricity networks. GuStaV will take this research further by analysing the distribution networks regarding the challenges and benefits of an automation of the gas network structure, considering e.g. the injection of hydrogen from Power-to-Gas and an optimised biomethane injection.

The project has been divided into four work packages which have been delegated to different project partners. The work packages are as follows:

Work Packages	Scope of Activities
1	Definition of research parameters. Evaluation of the current state of the distribution network infrastructure and level of automation as well as forecast of its future development. Description of additional utilisation of the infrastructure (e.g. network services, leak monitoring etc.).
2	Development of a concept for optimal grid automation and convergence. Definition of necessary technologies and their interaction based on Smart Grid Architecture Models (SGAM).
3	Simulation of the developed concept. In the first instance this will involve a hydraulic simulation on a selected network. The convergence points between the gas and the electricity distribution networks will then be modelled using Modelica. Parameters of the gas and electricity networks and interconnectivity will be examined in a sensitivity analysis.
4	Review of results. Presentation of the potential benefits for network convergence. Creation of a road-map for further research topics.

The project partners coordinated by EVT are, GWI, DBI GTI and EBI. It began in August 2016 and is due to be completed in July 2018. Its costs are forecasted at approximately 450,000 € and will be funded by the DVGW.

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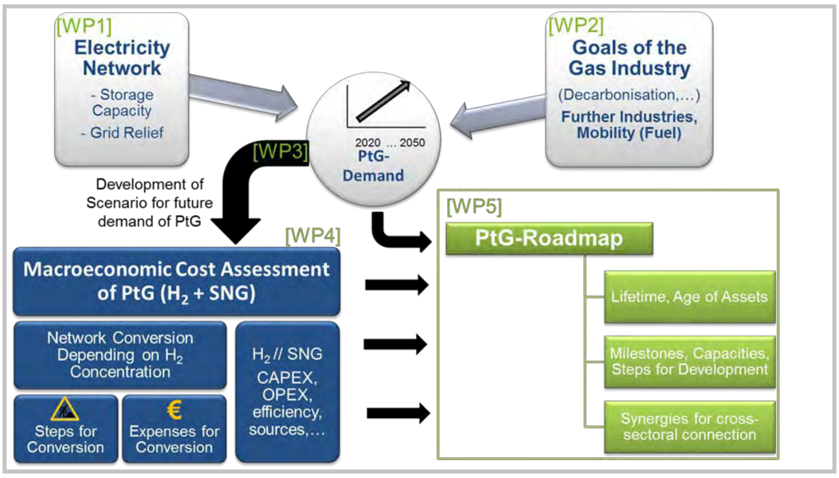
Strategy Road-Map Power-to-Gas | Germany



Project work packages strategy road-map Power-to-Gas
(Source: DBI)

Coordinating and integrating different industrial sectors will be crucial in order to realise the development of Power-to-Gas (PtG) technology within the framework of the current energy transition towards renewable energy sources. In doing so, PtG technology enables the interlinking of different industrial sectors and furthers decarbonisation beyond electricity-based applications by using renewable hydrogen and methane. This project aims to develop a viable road map outlining the future integration of PtG while considering the rising challenges it faces as PtG facilities are established as cross-cutting network elements.

The Strategy Road-Map Power-to-Gas aims to give answers to the following questions:

- Which energy demand for electricity storage, the chemical industry, and to fuel vehicles can be covered with renewable gases produced by electrolysis and methanation?
- Which technical adjustments of the gas infrastructure are necessary, including the conversion of existing appliances in the gas grid, to improve their tolerance to hydrogen and natural gas/hydrogen blends?
- What is a cost-efficient (macroeconomic) approach to enable the gas network to transport limited concentrations of hydrogen and/or set up methanation facilities?
- At what concentration does the adjustment of the grid (CAPEX) outrun the additional expenses of SNG production (CAPEX and OPEX) in comparison to hydrogen?

The project is funded by the DVGW and started in August 2016. Final results are expected at the end of March 2018. The total costs of the project amount to approximately 200,000 €. A key element in the development of the road map is the creation of a viable database and the development of a model. The model shall enable the simulation of multiple scenarios (e.g. considering different H2-concentration and durations for implementation) aiming to find feasible and cost effective ways for accommodating renewable gases in the gas infrastructure. The partners aim to complete data collection by spring 2017. The project partners are University of Wuppertal (EVT), EBI and DBI GUT.

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Impact of Hydrogen/Natural Gas Blends on Gas Turbine Operation | U.K.

Author: Stuart James, Uniper Technologies

Throughout Europe, a significant proportion of the electricity supplied is generated from natural gas. For example, in 2012, around one sixth of the total electricity generated was from natural gas (*ENTSOG Ten Year Network Development Plan2015*). Under many scenarios, this proportion is expected to increase. The majority of this natural gas generation is likely to be through the use of gas turbines. In addition to their use in power generation, gas turbines are also used extensively as prime movers for gas compression stations on the transmission networks.

Modern gas turbines utilise lean premixed combustion in order to minimise levels of NO_x emissions, and most of the engines considered above will be of this type. Whilst such combustion systems are successful in their principal aim of minimising NO_x emissions, this is achieved at the expense of a much smaller window of stable combustion. It is for this reason that all original equipment manufacturers (OEMs) insist that the natural gas to be used as the fuel complies with strict composition requirements.

Impact of Hydrogen/Natural Gas Blends on Gas Turbine Operation | U.K.

Author: Stuart James, Uniper Technologies

(continued)

Of particular interest to HIPS-NET partners is the allowable quantity of hydrogen in the fuel. The standard fuel specifications of existing gas turbines shows a limit of anywhere between 'trace' and 5% (by volume). Taking these at face value, an operator who ran their gas turbine with a fuel exceeding the relevant hydrogen level would be liable for any damage that was sustained by the gas turbine. Therefore, for a risk adverse operator, operation with hydrogen levels in excess of those specified by the OEM would be unacceptable.

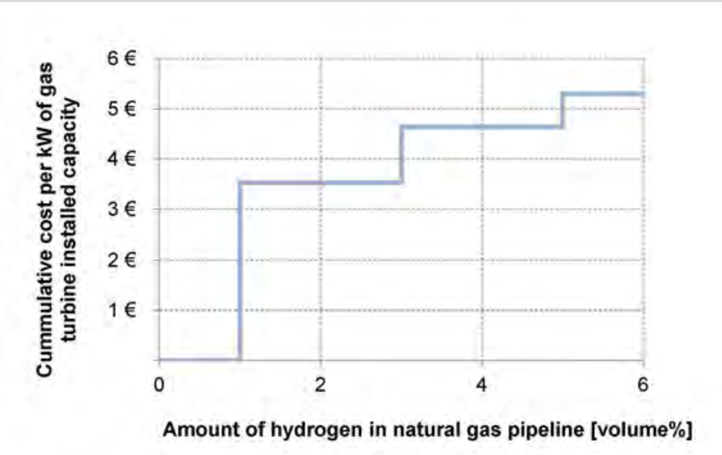
Work is being undertaken by OEMs to increase the amount of hydrogen that they would underwrite in their combustion systems. However, until this is confirmed, operators are effectively limited in the proportion of hydrogen they can use in the existing gas turbine hardware. Operation with higher levels of hydrogen might be possible, but this would require modifications to the existing hardware, with associated cost.

Uniper has carried out an internal study in order to estimate the magnitude of this cost. Given the limited information, a number of assumptions had to be made. Selected assumptions are listed below:

- For a given gas turbine type, the maximum allowable hydrogen content was as specified in their fuel specifications. However, if the OEM had published papers demonstrating that higher levels of hydrogen have been demonstrated, then the higher level was taken to be possible.

- For the cases of higher levels of hydrogen, some OEMs are currently recommending the use of diffusion combustion systems. These will result in an increase in NO_x emissions. The cost of retrofitting post-combustion NO_x reduction technologies, such as selective catalytic reduction (SCR) was not considered in this study.

Even with more modest amounts of hydrogen addition, where the existing lean premixed combustion systems could be used, some increase in NO_x emissions might be expected. Again, no consideration of the cost required to mitigate this was made.



Estimated costs for adjustment in relation to hydrogen concentration (Source: Uniper)

From this work, it was possible to construct a basic chart of total cost to the operator as a function of the amount of hydrogen in the natural gas supply. By normalising this to MW of installed gas turbine capacity, the chart shown below was produced.

The above chart was based broadly on the gas turbine types installed in the UK, and therefore represents the cost to the UK gas turbine operators as a whole as a function of the stated allowable hydrogen concentration in the natural gas pipeline. If the cost to a particular company or country is to be inferred, then some caution should be exercised as it is only strictly applicable if the distribution of gas turbine types is the same as in the UK. Nevertheless, it does provide a useful indication of order of magnitude costs.

The above study shows that even levels of hydrogen of 1% by volume in the natural gas grid could incur significant costs. However, it is hoped that further development by OEMs will increase the hydrogen percentage at which the first step in costs occurs. A realistic expectation, but not one that has been demonstrated yet, is for existing gas turbines to be able to safely and reliably utilise fuel containing up to 3-5% by volume hydrogen.

Beyond this level, there are concerns over the requirement for a separate start-up fuel to be used. Concerns in this area are not clear, but are believed to be due to flashback risks, or concerns over an explosive mixture in the gas turbine exhaust. Therefore, based on the current understanding, Uniper's conclusion is that hydrogen levels greater than 5% by volume in natural gas pipelines is unacceptable. This is based on taking a very conservative approach, based on the very limited amount of information in the public domain. If it could be demonstrated that there is no risk to starting a gas turbine containing hydrogen levels above 5%, then a relaxation of this limit could be acceptable. This would require more detailed modelling and calculations than has been possible in the study reported here. In practice, it is likely to require a consortium of partners to carry out the work, with the results being shared with affected stakeholders. It is recommended that such a study be encouraged by the HIPS-NET group.

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HyDeploy Project - Raising the Hydrogen Limit | U.K.

Keele University in England will be the site of a major project to evaluate the potential for natural gas/hydrogen blends in the UK gas grid. The HyDeploy project, conducted by National Grid Gas Distribution Ltd in cooperation with several other partners, represents the first practical deployment of hydrogen into a live gas network in the UK since 1977 (when the UK gas network was converted from town gas to natural gas). The goal of the project is to demonstrate that natural gas containing levels of hydrogen beyond those in the GS(M)R specification (General Safety (Management) Regulations) can be distributed and utilised safely and efficiently in a representative section of the UK distribution network.

HyDeploy sample gas network for the testing of natural gas/hydrogen blends
(Source: ITM Power)

National Grid Gas Distribution Ltd believes that the utilisation of greater volumes of hydrogen in the natural gas network can unlock up to 29 TWh of decarbonised heat energy for the UK market. These volumes could be greatly significant for UK energy security in the future as reserves of natural gas in the North Sea are depleted. The project aims to receive approval from the Health and Safety Executive (HSE) for an exemption to GS(M)R which currently limits hydrogen to 0.1 vol%. In particular, the project is seeking clearance to test gas/hydrogen blends with staged increases in the hydrogen content, beginning at 0.1 vol% and increasing to 20 vol%, while remaining with the Wobbe limits.

Hydrogen feed-in will take place on Keele University's gas network. The network is ideally suited to such testing as it is a closed private network servicing only the university and its facilities. It comprises a network and appliances typical of UK gas distribution systems, domestic & commercial users including a CHP.

The project is due to begin in April 2017 and will take three years. Three project phases have been defined:

Phase 1	Activities to be undertaken to secure exemption from the GS(M)R. These include customer engagement, baseline survey, provision for appliance/network element replacement, engagement with health and safety authorities.
Phase 2	Construction of on-site equipment for hydrogen production, injection, and measuring.
Phase 3	Testing phase and analysis. Hydrogen injection trials will take place over an 18-month period from late 2018.
Next Steps	Identifying suitable public networks for a subsequent project.

The main project partners are: National Grid Gas Distribution (as funding licensee and project sponsor); Northern Gas Networks; Keele University; ITM Power (which will provide a 0.5 MW electrolyser for the production of hydrogen); the Health and Safety Laboratory (HSL), and Progressive Energy. Further information on the project can be found here.

The project is expected to cost GBP 7.6m. GBP 6.8m of this budget has been granted by the Gas Network Innovation Competition (NIC). This is an annual competition organised by the Office of Gas and Electricity Markets in the UK (OFGEM) to provide funding for projects "which help all network operators understand what they need to do to provide environmental benefits, cost reductions and security of supply as Great Britain (GB) moves to a low carbon economy".

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Power-to-Gas Hydrogen Market Prices | U.K.

ITM Power has signed fuel contracts, selling hydrogen at £10/kg, with Anglo American, Europcar, Hyundai, Toyota, Commercial Group, Arcola Energy, and Arval. ITM Power is currently rolling out a network of 10 hydrogen refuelling stations in the UK of which 3 are now open for public access. The refuelling network has been financially supported by Innovate UK, Office for Low Emission Vehicles (OLEV) and the Fuel Cells and Hydrogen Joint Undertaking (FCH JU).

ALSTOM UNVEILS ITS ZERO-EMISSION TRAIN | GERMANY

FUEL CELL POWERED TRAIN CORADIA ILINT
(SOURCE: ALSTOM)

Quicker than expected, Alstom presented its zero-emission train – Coradia iLint – in September 2016. Coradia iLint is a new CO_2-emission-free regional train and alternative to diesel power. It is powered by a hydrogen fuel cell, its only emission being steam and condensed water while operating with a low level of noise. To make the deployment of the Coradia iLint as simple as possible for operators, Alstom has worked together with its partners to offer a complete package, consisting of the train and maintenance, as well as the extensive hydrogen infrastructure for its implementation.

Didier Pfleger, Vice President of Alstom Germany and Austria says: „We will set up a hydrogen supply system, cooperation partners already exist“. The iLint has a range of 600 to 800 km and runs with maximum speed of 140 km/h. The construction is based on the service-proven diesel train Coradia Lint with only the drive system newly developed. The train is expected to shuttle between Buxtehude and Cuxhaven (Germany) beginning in December 2017 (regional transport; approx. 120 km one-way). The first iLint trains were completed and the licensing process began in autumn 2016 and will presumably take about one year.

At present, the German rail network is approximately 40% electrified. Hydrogen powered trains are perceived as a solution to serve parts of the railway system without overhead electricity lines and may replace diesel powered engines. For further general information see HIPS-NET newsletter #10, June 2016.

Image film and information in English and in German.

Contact: presse@alstom.com

FCH JU CROSS-CUTTING PROJECTS | EUROPE

Two coordination and support actions related to cross-cutting activities have been selected by the Fuel Cells and Hydrogen Joint Undertaking (FCH JU) under its 2016 call for proposals.

HyLAW

Project HyLAW, coordinated by Hydrogen Europe in Belgium, aims at mapping all legislation and administrative processes applicable to fuel cells and hydrogen (FCH) technologies both at EU and at national level with the aim of identifying related barriers to deployment, possible best practices future development strategies for the sector

A major issue to the development of FCH technologies are the legal framework and administrative processes which differ from country to country. As these are usually formulated for application on incumbent technologies, they often hinder the progress of new technologies such as hydrogen fuel cells. In order to overcome this issue, HyLAW will create an online database describing discrepancies between the processes in 18 different countries across Europe. This database will allow the analysis of best and bad practices. The results of this analysis will be made available through the online database and via a series of workshops to national authorities and investors.

In addition to identifying barriers to progress for FCH technologies. HyLAW will establish a Europe-wide umbrella organisation, the National Association Alliance, with the intention of increasing communication and cooperation between national associations and other organisations active in the development of hydrogen fuel cell technologies.

The project began on 1st January 2017 and is expected to take two years. The project received a funding grant of €1.14 million from FCH JU. Further information on this project including a full list of project partners is available here.

NET-Tools

The European project NET-Tools, coordinated by the Karlsruher Institute of Technology, develops e-Tools and an online platform to provide support and materials for education and training on FCH technologies for students as well as professionals and engineers. NET-Tools lays a special focus on the development of an e-education tool as well as an e-laboratory for scientific cooperation and exchange of knowledge via the online platform. A library of educational materials, e-tool, specific text books and also scientific knowledge shall get developed and/or collected to be provided to stakeholders under open access to enable data- and computer-intensive research and teaching opportunities online. To face also industrial demands on education and training, NET-Tools incorporates an industrial advisory board and arranges several work-shops and testing lessons to harmonise necessities during the project lifetime. The project will start on 1st March 2017 and last three years. The project receives a funding grant of €1.6 million from FCH JU. Further information on this project is available here.

Contact HyLAW:
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Contact NET-Tools:
Olaf Jedicke
(olaf.jedicke@kit.edu)

SELECTION OF APPOINTMENTS

++ 7th Int. Conference on „Fundamentals & Development of FC's"
(31 January - 03 February, 2017, Stuttgart, Germany)

++ Energy Storage 2017
(08-09 February, 2017, Paris, France)

++ FC Expo 2017
(01-03 March, 2017, Tokyo, Japan)

++ European Fuel Cell Car Workshop
(01-03 March, 2017, Orléans, France)

++ 13th International Hydrogen and Fuel Cell Conference
(14 March, 2017, Birmingham, U.K.)

++ 6th Int. Conference on Fuel Cell & Hydrogen Technology 2017
(11-13 April, 2017, Putrajaya, Malaysia)

++ 19th Int. Conference on Hydrogen Production and Storage
(21-22 May, 2017, Berlin, Germany)

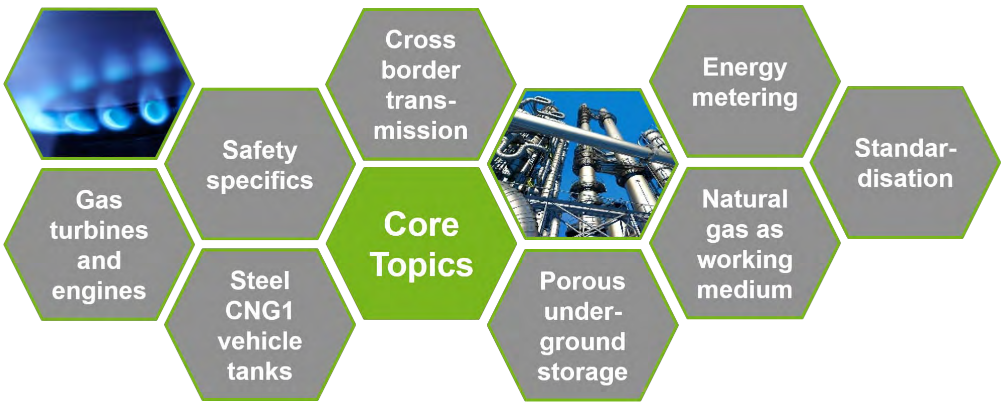
CURRENT PARTNERS

Alliander AG ++ Areva H_2Gen ++ DEA Deutsche Erdoel AG ++ DGC ++ DNV GL ++ Enagás ++ Energiforsk ++ Energinet.dk ++ ENGIE ++ EWE AG ++ Gas Natural Fenosa ++ Gasum OY ++ Gasunie ++ GRTgaz ++ grzi e.V. (figawa) ++ Infraserv GmbH & Co. Höchst KG ++ ITM Power ++ EC Joint Research Centre (JRC) ++ KOGAS ++ NAFTA ++ Open Grid Europe GmbH ++ ÖVGW ++ RAG Rohöl-Aufsuchungs AG ++ RWE Deutschland ++ Shell ++ Solar Turbines Europe ++ SVGW ++ Synergrid ++ Uniper Energy Storage GmbH ++ Uniper Technologies Limited ++ Verband der Chemischen Industrie (VCI) ++ Volkswagen AG ++

HIPS-NET CORE TOPICS

We gather and disseminate the latest available knowledge to improve the understanding of hydrogen/natural gas blends in pipeline systems with emphasis on the core topics:

We additionally keep a minor focus on the general development of power-to-gas, hydrogen networks, and further topics around the utilisation of (renewable) hydrogen.



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GERG groupe européen de recherches gazières the european gas research group

DBI GUT Gas- und Umwelttechnik GmbH

groupe européen de recherches gazières
the european gas research group

HIPS-NET

"Establishing a pan-European Understanding of Admissible Hydrogen Concentration in the Natural Gas Grid"

Newsletter #13	May, 2017

Content Newsletter #13

13th HIPS-NET Newsletter

Dear Partners,

Welcome to the 13th edition of the HIPS-NET newsletter. This is our 4th network year and we are thankful and proud at the same time, to run such a stable network. We will do our best to maintain that base and hope to provide benefits for your work. Please support HIPS-NET and its future development by giving feedback to us and sharing recent project information from your country or industry.

Change of Partners: Energiforsk (Sweden) terminated its membership last year. Three further organisations joined the network for the fourth year. We welcome ONTRAS (Germany), INERIS (France) and Storengy (France) as new partners! The network is constantly growing and we are now 34 partners across Europe.

Our feature article in this edition will look to the role of Power-to-Gas (P2G) for the energy storage strategy of the European Commission. We continue to report on the upcoming projects of HYPOS, this time about hydrogen distribution networks. An exciting project has started to test the hydrogen tolerance of well-worn gas infrastructure element – the gate valves, on sole initiative of Innogy. Meanwhile we also focused on the final results of the CertifHy project and Flanders in Belgium with their own P2G roadmap. We are curious how methanation in underground gas storages will develop and introduced the Underground Sun Conversion project. Just to mention some of the topics.

Enjoy reading!

Your HIPS-NET Team

Gert, Anja, Stefan & Josephine

NEW DATE!

HIPS-NET Workshop

June 2017

13th/14th

Please register here.

EUROPEAN COMMISSION WORKING PAPER: ENERGY STORAGE - THE ROLE OF ELECTRICITY

The European Commission has released a working paper outlining and evaluating the role of electricity in different energy storage methods. The paper considers the high volatility of energy output from renewable energy sources and the possible advantages and disadvantages of different storage solutions. These solutions include mechanical (such as pumped hydro-storage or compressed air storage), thermal, chemical (includes hydrogen storage and SNG), electro-chemical (such as lithium-ion, and lead acid batteries), and electrical storage via super-capacitators.

In addition to analysing the technological effectiveness of different storage solutions, the paper also considers the long-term development goals for these technologies and the effect that these developments will have on the electricity grid (in terms of volume, infrastructure and cost) in the future. Likewise, it also considers the regulatory framework for energy storage.

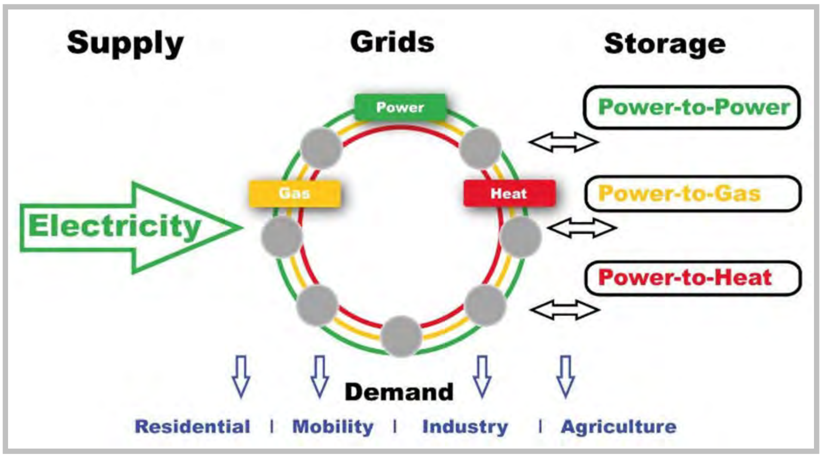
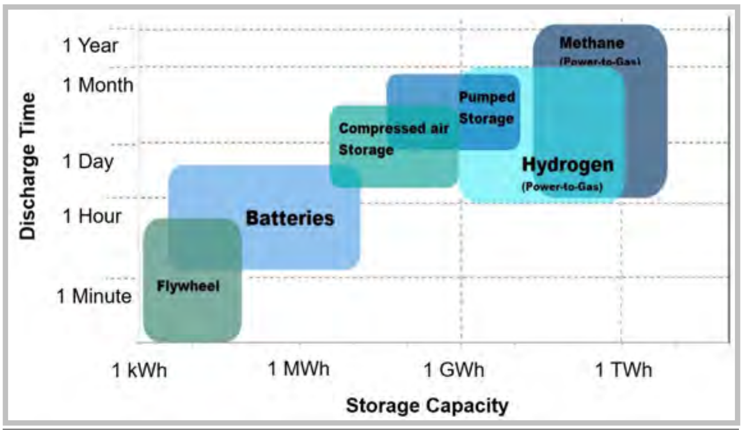


ILLUSTRATION OF FLEXIBILITY COMPONENTS IN THE ELECTRIC SYSTEM (SOURCE: EC)

The working paper pays attention to the use of hydrogen from renewable energy sources for greater sectoral integration. In particular, it sees the potential for greater integration between energy production and other sectors with large hydrogen requirements such as agriculture, chemicals, and transport. The paper argues that green hydrogen could be used to replace the massive amount of hydrogen from fossil fuels when producing chemicals such as fertilizers. The realisation of greater sectoral integration via green hydrogen would increase the profitability of hydrogen as a fuel source and make it a logical medium for energy storage via underground storage facilities.

In its final assessment, the working paper draws four conclusions for the development of energy storage solutions:



AVAILABLE STORAGE TECHNOLOGIES, THEIR CAPACITY AND DISCHARGE TIME (SOURCE: SCHOOL OF ENGINEERING, RMIT UNIVERSITY)

1. **Energy storage should be allowed to participate fully in electricity markets** – Greater participation in the electricity system encourage investment in energy storage technologies. The report also argues that electricity systems with a large share of renewable energy sources are themselves more cost- efficient when combined with storage technologies.

2. **Energy storage should participate and rewarded for services provided on equal footing to providers of flexibility services (demand response, flexible generation, and adaptation of transmission and distribution infrastructure)** – The electricity system will have to become more flexible to deal efficiently with larger amount of electricity from renewable energy sources. Energy storage solutions would increase this flexibility.

3. **Energy storage as an enabler of a higher amount of variable RES could contribute to energy security and decarbonisation of the electricity system or of other economic sectors** – Sectoral integration would create storage solutions with greater flexibility than electricity-only solutions. Chemical storage options (such as hydrogen storage) could provide large-scale storage potential in the same way that underground storage facilities support the natural gas network. Use of renewable energy sources for feedstock would help the transport sector to decarbonise.

4. **The cost-efficient use of decentralised storage and its integration into the system should be enabled in a non-discriminatory way by the regulatory framework** – Centralised and decentralised storage solutions would greatly improve flexibility and should, therefore, be rewarded as such in order to incentivise investment. Increased scope of balancing responsibility, scarcity pricing and dynamic supply contracts would help in this respect. Network charges should also be adapted to these storage solutions. These incentives were outlined in the EC's Market Design Initiative in 2015.

Further information on the working paper can be found here or by contacting **Robert Judd** at robertjudd@gerg.eu.

H_2-NETZ - DEVELOPING AN INFRASTRUCTURE FOR LOCAL HYDROGEN SUPPLY | GERMANY

H_2-NETZ

H Y P O S

The H_2-Netz project is developing an innovative hydrogen distribution infrastructure to function alongside the existing natural gas network. The project will realise the construction of a pure hydrogen distribution grid at a selected test location and, in doing so, will connect local independent producers of green hydrogen with the end user.

The principal goal of the project is the technical evaluation of a hydrogen distribution network whilst also considering economic, ecological and safety factors. H_2-Netz will achieve competitive means for providing hydrogen and maintain the high safety standards of the current natural gas network. In particular, this will be achieved through careful and efficient selection and utilisation of innovative pipeline materials and technologies. The project will encompass all elements of the distribution network including gas governor stations, monitoring and measurement technologies for permeation and flow as well as an odorisation system.

The project partners for H_2-Netz are DBI GUT (acting as co-ordinating partner), Leipzig University of Applied Sciences (HTWK), MITNETZ GAS, REHAU and TÜV SÜD. H_2-Netz will receive support from the HYPOS project, a partnership of corporations and institutions in Eastern Germany dedicated to the development of green hydrogen solutions.

The specific objectives of the project have been further divided into the following tasks, which will be delegated amongst the different project partners:

- The development of an innovative and sustainable concept for a hydrogen distribution infrastructure which can be competitive in price with conventional distribution network solutions. This infrastructure will connect an existing hydrogen pipeline with a selected test location referred to as the “Hydrogen Village”.
- The evaluation and inspection of specifically designed polymer piping systems for interior building construction.
- The realisation of distribution infrastructure, including required safety technology, for the supply of hydrogen to individual customers.
- The realisation of a research model for distribution grids.
- The monitoring of infrastructure.
- The evaluation and optimisation of all systems including safety and communications concepts.
- The creation of a simulation model for the technical and economical evaluation of the infrastructure for the supply of hydrogen.

INNOVATIVE TECHNOLOGY - PLOUGHING OF A COMPOSITE PIPING SYSTEM (SOURCE: REHAU)

Contact: **Marco Henel** at

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The project began in November 2016 and will last until the end of December 2019. Costs of the project are calculated at 3.78 million Euro; they will be borne by the project partners depending on involvement and by funding from the German Federal Ministry of Education and Research (BMBF).

HYPOS - Hydrogen Power Storage & Solutions East Germany “The revolution of the hydrogen economy initiated in East Germany”

H Y P O S

The HYPOS project is funded by the German Federal Ministry for Education and Research (BMBF) with up to 45 million Euro. It aims to produce green hydrogen from renewable sources on a large scale and forms the roof for various R&D projects. The HYPOS project connects the economic and scientific expertise of over 110 partners principally across Eastern Germany. See HIPS-NET newsletter #3 (October 2014) for a short description of HYPOS.

zwanzig20
PARTNERSCHAFT FÜR INNOVATION

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

Gate-Valve Hydrogen Tolerance Testing | Germany

Innogy SE and its distribution system operator Westnetz contracted a technological research team from DBI GUT to undertake extensive testing on the tightness of gate valves with different natural gas/ hydrogen blends.

The purpose of the examinations is to establish differences in the tightness of gate valves depending for natural gas/ hydrogen blends. To this end, five different blends will be utilised in the testing process, ranging from 100 vol% natural gas to 100 vol% hydrogen (see table 1 for details).

Of particular importance for these tests is the use of new and old gate valves; the latter had previously been installed on gas pipelines. By using such valves instead of newly manufactured equipment, the tests will more realistically due to the natural wear and tear, which occurs on pipeline materials.

Eight previously installed gate valves with differing widths will be examined as part of the test and compared with three new ones (benchmark). The widths are standardised according to German industrial standards and range from 80 mm to 250 mm width.

Concentration	Natural Gas [vol%]	Hydrogen [vol%]
Test Gas 1	100	0
Test Gas 2	95	5
Test Gas 3	90	10
Test Gas 4	80	20
Test Gas 5	0	100

Table 1: Natural gas - hydrogen blends for Westnetz gate valve tolerance testing
(Source: DBI GUT)

Two methods will be applied to examine the tightness. For a precise measurement of possible gas leakage, the valves will be examined within a measurement cell. Using a gas chromatograph, it will be possible to establish, not only the amount of gas escaping from the valve, but also possible differences in the leakage rate between different blends of natural gas and hydrogen. The valve will be tested to evaluate internal (figure 1) and external tightness (figure 2). The tightness testing with test gases 1 to 5 is planned in weekly intervals.

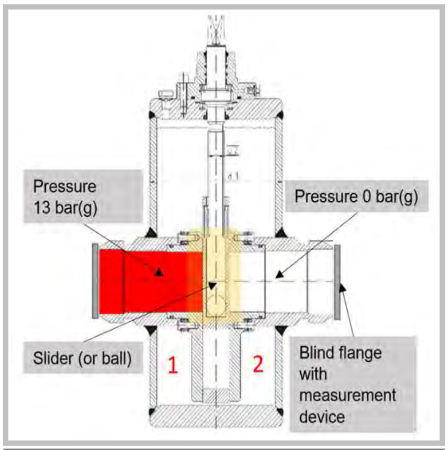


Fig. 1: Internal tightness testing of gate valves; closed valve
(Source: Westnetz (figure) , DBI (text))

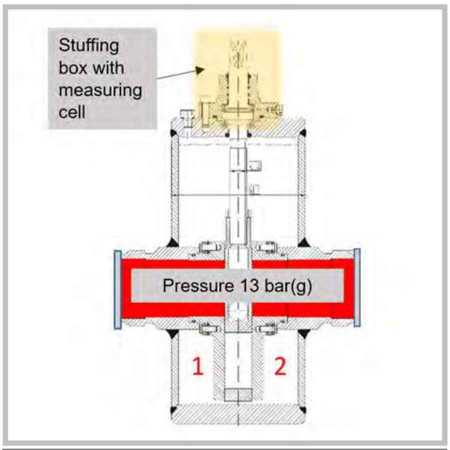


Fig. 2: External tightness testing of gate valves; open valve
(Source: Westnetz (figure), DBI (text))

Figure 1 is a simplified illustration of internal tightness testing for all leakages around the slider. After the valve is closed, the chamber on side 1 is filled with the test gas, raised to a pressure of 13 bar(g) and monitored. At the same time, the chamber on side 2 will be flushed with nitrogen. In this way, it is possible to perform pressure differential measurements. In case of internal leakages, the gas in chamber 2 is analysed with a gas chromatograph.

Figure 2 is a simplified illustration of external tightness testing for all leakages around the stuffing box. The valve is opened and both sides (1 & 2) are filled with the test gas to a pressure of 13 bar(g) and monitored. In case of external leakages, the fugitive gas is analysed with a gas chromatograph.

For each gate valve DBI constructed an unique measuring cell, because there are large differences between the valves, especially new and old gate valves. Two of these measuring cells are shown in figure 3.

The test gas 5 (pure hydrogen) will remain for 6 months in the gate valves and the week-long testing with the measurement cell will be repeated at the end of this period. This experimental setting allows comparing the results of the first and the second testing and proves the impact of hydrogen exposure on the valve seals. After completion of these tests, the valves will be placed in water for further tightness testing. In this case, possible leakage will be observed by the formation of bubbles (referring to DIN EN 13774 “Valves for gas distribution systems with maximum operating pressure less than or equal to 16 bar”).

Fig. 3: Unique measuring cells for each gate valve (Source: DBI)

The examination is due to begin in February 2017 and will take approximately nine months to complete including an initial six-month period in which the valves will be conditioned to hydrogen for testing purposes.

Contact: **Carsten Stabenau** at carsten.stabenau@westnetz.de and **Stefan Schütz** at stefan.schuetz@dbi-gruppe.de

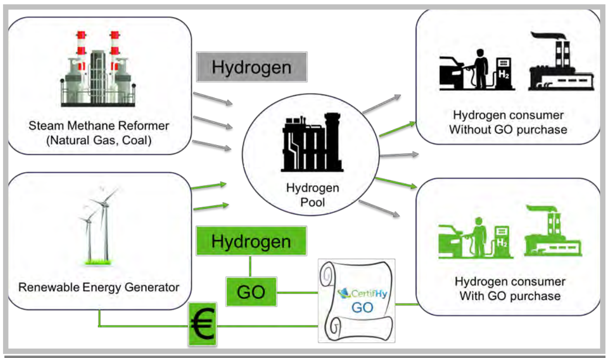
CertifHy - Developing Europe's First Guarantee of Origin for Green Hydrogen

Global demand for hydrogen is foreseen to reach 50 million tons by 2025 mainly used in industry and transport. It is predicted to grow 3.5 % per year. Today 95 % of all hydrogen is produced from fossil resources. For hydrogen to become a climate-friendly alternative to fossil fuels, it is necessary to ensure minimal impact on natural resources in the whole life cycle. It is expected that 50-60 % of all hydrogen for the growing market of transportation will originate from renewable or low-carbon sources by 2030.

The CertifHy project identified a framework for the first EU-wide guarantees of origin (GO) for premium hydrogen including

- a definition for green and low-carbon hydrogen,
- a detailed proposal for a GO system and
- a roadmap for implementation.

In order to allow premium hydrogen to be traded, a tracking system ensuring the quality of hydrogen is necessary. The proposed GO for premium hydrogen decouples the green attribute from the physical flow of the product and makes premium hydrogen available EU-wide, independently from its production sites.



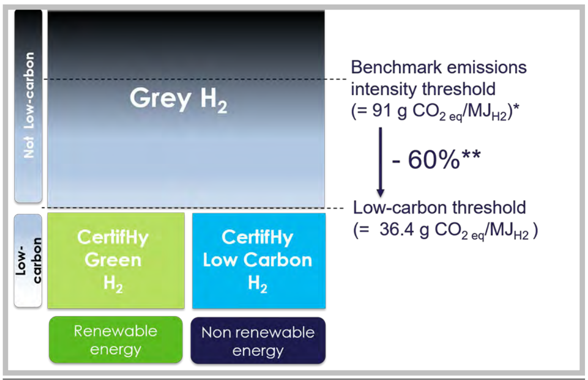
Green hydrogen guarantee of origin (Source: CertifHy)

The authors suggest the following definitions for CertifHy premium hydrogen (see figure below):

CertifHy Premium Hydrogen is hydrogen produced with low carbon emissions and includes CertifHy Green Hydrogen and CertifHy Low Carbon Hydrogen. It refers to hydrogen with carbon emissions 60 % below the benchmark emissions intensity threshold. The benchmark is determined by the greenhouse gas emissions of hydrogen produced by steam reforming of natural gas (SMR) representing 95 % of current merchant market. This is equivalent to 36.4 g_{CO2eq}/MJ, produced in a plant where the average emissions intensity of the 'grey' hydrogen production since sign-up or in the past 12 months, does not exceed the emissions intensity of the benchmark process (91.0 g_{CO2eq}/MJ, SMR of fossil natural gas).

CertifHy Green Hydrogen is hydrogen generated by renewable electricity with low carbon emissions.

CertifHy Low-Carbon Hydrogen is hydrogen created from non-renewable energy with low-carbon emissions.



Definition of premium hydrogen: green hydrogen and low carbon hydrogen (Source: CertifHy)

We described in HIPS-NET newsletter #10, page 3, 4, the results of the first three work packages and summarise here the results of the remaining two.

Work Package Four – project leader TÜV SÜD, joint work of TÜV SÜD, ECN and LBST – seeks to elaborate on the scope of the GO scheme, the main principles, the different protagonists, and the rules and obligations of the GO scheme, in terms of requirements, methodologies, certification process and registration of GO. It defines the compliance system and the registry detailed for the different stakeholders and processes.

Work Package Five – project leader ECN, joint work of ECN, Hinicio, LBST, TÜV SÜD – develops a roadmap for the establishment of a well-functioning EU hydrogen GO system. The goal – the concrete outcome of the Roadmap - are the necessary steps to introduce the GO scheme until 2020. As last step, the project asked for endorsement and the recent results (March 2017) show: The CertifHy project is strongly supported by the industry, standardization and issuing bodies, international organizations and individuals by showing commitment to support the implementation of the first EU-wide GO scheme for premium hydrogen.

The Future of Premium Hydrogen GOs - After having developed the framework for premium hydrogen and a roadmap for implementation, the next steps are strengthening the momentum by building a supervisory board, assuring legal safeguard and creating buy-in for the scheme. At the same time, it is necessary to build the GO infrastructure and test it by pilot projects. "*It is an ambitious, but realistic roadmap. It will require a lot of energy and funding to realize it.*", as Philip Good from the European Commission stated during the panel discussion at the CertifHy event in Brussels.

Consortium partners: Hinico (coordination), ECN, TÜV SÜD, LBST

Affiliated partners: Air Liquide, Air Products, AkzoNobel, Areva H2Gen, BMW, Colruyt Group, EDF, Group Machiels, Hydrogenics, Linde, OMV, Shell, Total and Uniper

Contact: **Vanessa Wabitsch** at vanessa.wabitsch@hinicio.com
For further information see here.

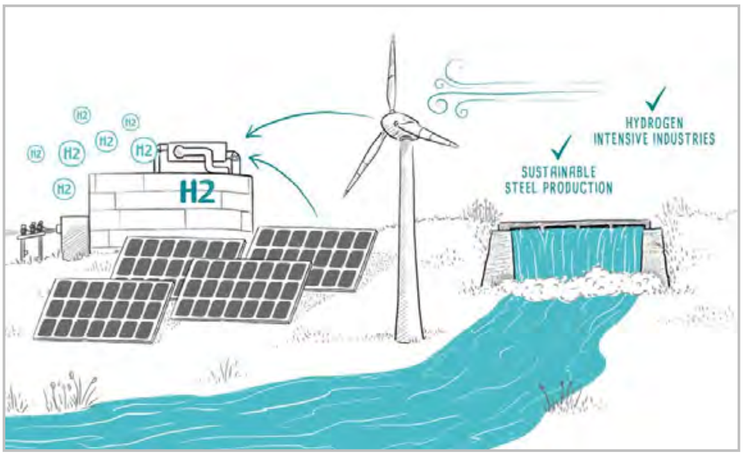
H2FUTURE - DEMONSTRATION PEM ELECTROLYSIS FOR STEEL PRODUCTION AND GRID SERVICES

H2FUTURE
Green Hydrogen

HYDROGEN MEETING FUTURE NEEDS OF LOW CARBON MANUFACTURING VALUE CHAINS

H2FUTURE is a 4.5-year cooperative project, implemented by VERBUND (coordination), voestalpine, Siemens, APG, K1-MET, and ECN. The aim of H2FUTURE is to deploy a large-scale PEM electrolysis plant and use the green hydrogen produced in the steel production process. The 6 MW_{el} PEM electrolyser will also be used to provide electricity grid services.

The demonstration is split into five pilot tests and quasi-commercial operation to show that the PEM electrolyser, operated with electricity from renewable resources, is able both to use timely power price opportunities (in order to provide affordable green hydrogen for current uses of the steel making processes) and to attract additional revenues from grid services. ECN analyses the replicability of the experimental results on larger scales for the European steel industry. This involves a technical, economic and environmental assessment of the experimental results using the CertifHy tools. Commercial operation of the Linz pilot plant will start immediately after the demonstration. Dissemination targeting the European stakeholders of the electricity, steel and fertilizer value chain actively supports the preparation of the practical implementation of the results in the 10 years after the end of the demonstration.



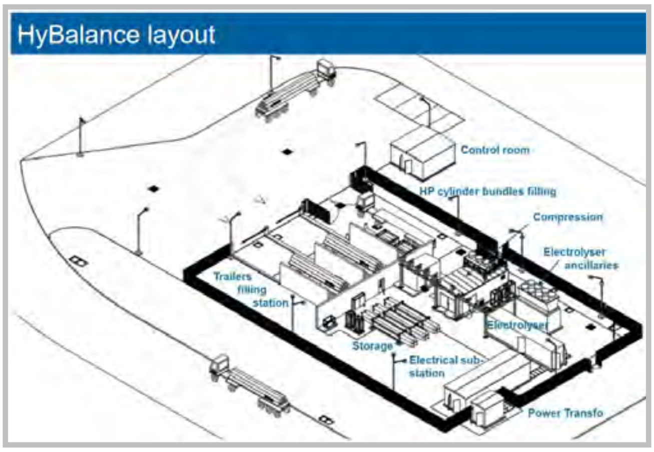
H2FUTURE PROJECT | RENEWABLE HYDROGEN FOR STEEL PRODUCTION AND GRID SERVICES (SOURCE: FOTOCREDIT © VERBUND)

Further information and image film: http://www.h2future-project.eu/project
Contact: **Rudolf Zauner** at rudolf.zauner2@verbund.com

Project cost are about 18 Mio €. This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking under grant agreement No 735503. This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme and Hydrogen Europe and N.ERGHY.

HYBALANCE PROJECT | DENMARK

One of Europe's most advanced hydrogen facilities is currently being established in Denmark. Air Liquide, Hydrogenics, LBST, Neas Energy, Hydrogen Valley/CEMTEC and the European Joint Technology Initiative are building one of Europe's largest facilities for production of green hydrogen.



(SOURCE: HYBALANCE)

Hydrogenics, partner in the HyBalance project and developer of the new 1.2 MW_{el} PEM electrolyser, announced that the electrolyser has successfully produced hydrogen during the first stage of factory acceptance testing at Hydrogenics facilities in Oevel, Belgium. The new, state-of-the-art 1.2 MW_{wl} PEM electrolyser will be delivered to Hobro, Denmark in the coming weeks for the HyBalance project. The production of green hydrogen is expected to start in fall 2017.

The electrolyser will produce hydrogen from wind-generated energy and also enable grid balancing services. The green hydrogen will be used in multiple high value markets such as industry (merchant hydrogen) and clean transportation (fuel cell electric cars and possibly buses). Thus, the HyBalance project will not only validate highly dynamic PEM electrolysis technology and innovative hydrogen delivery processes involved but also demonstrate these in a real industrial environment by applying the latest high pressure hydrogen production and delivery equipment.

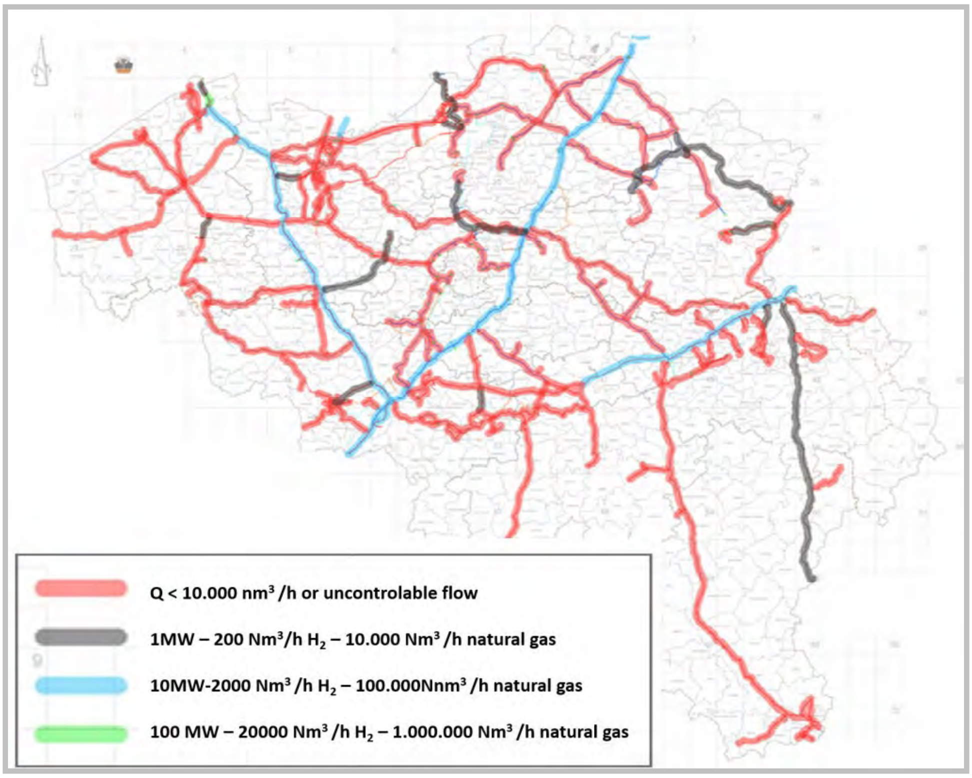
The overall project budget is 15.2 M€, supported by FCH JU with 8 M€ and ForskEL in Denmark with 2.6 M€. It is scheduled for 5 years (October 2015 until September 2020).

Contact: **Marie-Louise Arnfast**, arnfast@hydrogenvalley.dk
For further information: http://hybalance.eu/

P2G ROADMAP FOR FLANDERS | BELGIUM

As part of the drive towards the realisation of climate change targets, Belgium, is in the process of instituting short and long-term goals for the decarbonisation of its society. The P2G Roadmap for Flanders, developed by a range of partners (see below) and released in October 2016, aims to clarify the role of hydrogen and "power-to-gas" in the achievement of these goals. The document represents not only a combination of previous and current knowledge and research, but also sets out to create the opportunity for further cooperation in the future.

The roadmap analyses the potential for different possible uses of power-to-gas or power-to-x technologies based on a selection of realistic business cases. This analysis considers the present situation, medium-term (2030), and long-term developments (2050). In addition, the roadmap evaluates different business models for the successful implementation of power-to-gas/ power-to-x technologies and provides a set of recommendations specifically for these technologies in the Belgian market.



POTENTIAL OF DIRECT HYDROGEN INJECTION IN THE BELGIUM TRANSPORT GAS INFRASTRUCTURE BASED ON 2 VOL% LIMITATION (SOURCE: FLUXYS)

The roadmap draws several interesting conclusions for the development of **power-to-gas** in Belgium. It concludes that at present hydrogen produced from electrolysis can already be competitive with hydrogen delivered from tube trailer trucks for use in small industrial projects. Hydrogen injection into the natural gas grid is also already economically viable if hydrogen is able to profit from similar feed-in tariffs to those applied for biomethane in Germany and France. The roadmap therefore argues for the adoption of a more supportive regulatory structure, including the authorisation of hydrogen injection into the natural gas grid at a level of at least 2 vol%. The methanation of hydrogen is seen as favourable in the long term and the increase of hydrogen production in Belgium should be accompanied by a methanation demonstration project to showcase the potential of this process.

The implementation of **power-to-mobility** projects will also soon become economically competitive and has been identified as one of the most attractive applications of hydrogen technologies in the country. The roadmap seeks to develop the necessary regulatory framework and also a business case for the nationwide roll-out of hydrogen refuelling stations. A government-based incentive program for these stations will be sought to make the project more competitive in its initial phases.

Power-to-fuel projects focus on the partial substitution of diesel with bio-methanol produced from electrolytic hydrogen and carbon dioxide. In Belgium these projects will aim for the medium-term development of green hydrogen as a replacement for fossil-based hydrogen in industrial processes. Efforts in this respect should comprise of the creation of a consortium for a specific project in the Port of Antwerp. The creation of a supportive regulatory framework based on existing European regulations (such as the Fuel Quality Directive and the Regional Entrepreneurship and Development Index) is of particular importance.

One of the principal results of the creation of this document has been the accompanying creation of the **Power-to-Gas Cluster**. This is a collaboration of 20 leading companies with active interest in the development of power-to-gas technologies. The cluster will help to coordinate research and promote the goals outlined above.

Project partners in the P2G Roadmap Flanders are Hydrogenics, WaterstofNet, Umicore, Sustesco, Colruyt Group, Fluxys, Elia, and Eandis.

Further information on the P2G Roadmap Flanders can be found here, or by contacting **Isabel Francois** at isabel.francois@waterstofnet.eu

Sun Storage Project Final Results | Austria

The Sun Storage Project is its final phase; the successful completion is followed by the next innovative project – the Underground Sun Conversion Project (see below). Following the tradition of the past years, Stephan Bauer (RAG) will present – this time final – results of the Sun Storage Project at the HIPS-NET workshop in Brussels.

Underground Sun Conversion Project | Austria

UNDERGROUND SUN.CONVERSION

Geological history in fast motion: renewable natural gas produced from solar power and water, 1,000 metres underground

Have you ever heard of **organic natural gas**? The successful Underground Sun Storage project advances its research – for the first time the Underground Sun Conversion project will enable production of natural gas directly within a gas reservoir using a microbiological process initiated specifically for this purpose by RAG, and to store it in the same reservoir.

This innovative method is unique worldwide, and recreates the natural process by which gas originates, but shortens it by millions of years – geological history in fast motion.

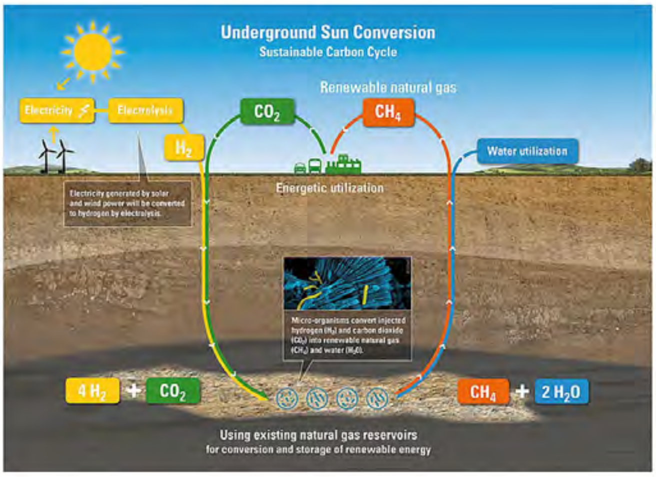
First, hydrogen is produced from solar or wind energy and water in an above-ground facility, and then injected into an existing gas (pore) reservoir, together with carbon dioxide – creating a sustainable carbon cycle. At a depth of over 1,000 metres, in a relatively short time naturally occurring microorganisms convert these substances into renewable natural gas which can be stored in the same reservoir, withdrawn as needed at any time, and transported to consumers via the existing pipeline network.

This environmentally friendly process has three major advantages:

- Carbon neutral thanks to carbon cycle
  Renewable natural gas is carbon-neutral, if carbon dioxide that originates, for example, from burning biomass – is utilised for the production process. This creates a carbon cycle.
- Renewable energy becomes storable
  The problem of storing fluctuating renewable energy from wind and sun is solved by converting it into renewable natural gas.
- Existing infrastructure is used

Research facility in Pilsbach Lower Austria
(Source: RAG)

The aim of the RAG-initiated project, implemented in collaboration with partners, is to carry out research into the principles for producing large quantities of renewable natural gas using a carbon-neutral process, and storing it in environmentally friendly, naturally formed reservoirs, which will in turn provide urgently needed flexibility for renewable energy.



Sustainable carbon cycle
(Source: RAG)

Initial laboratory tests conducted as part of the forerunner project Underground Sun Storage – which is also supported by the Austrian Climate and Energy Fund – show that hydrogen injected into the reservoir with carbon dioxide is converted into methane by microbiological processes. This enables the creation of a sustainable carbon cycle. Laboratory tests, simulations and scientific field tests at an existing RAG reservoir will be carried out in collaboration with project partners. A further objective is to test whether the outcomes can also be achieved at many other reservoirs all over the world.

The project has been designated a flagship project by the Austrian Climate and Energy Fund and granted 4.9 million Euro as part of the fund's energy research programme. The Austrian consortium is managed by RAG. The total cost of the project amount to 8 million Euro.

The project partners are the University of Leoben; the BOKU - University of Natural Resources and Life Sciences, Vienna (Department of Agrobiotechnology, IFA-Tulln); acib - Austrian Centre of Industrial Biotechnology; the Energy Institute at Johannes Kepler University Linz; and Axiom Angewandte Prozesstechnik.

The project is scheduled to be completed by the end of 2020.

Further information: www.underground-sun-conversion.at/en.html.

Contact:

Press Relations Officer **Elisabeth Kolm** at elisabeth.kolm@rag-austria.at

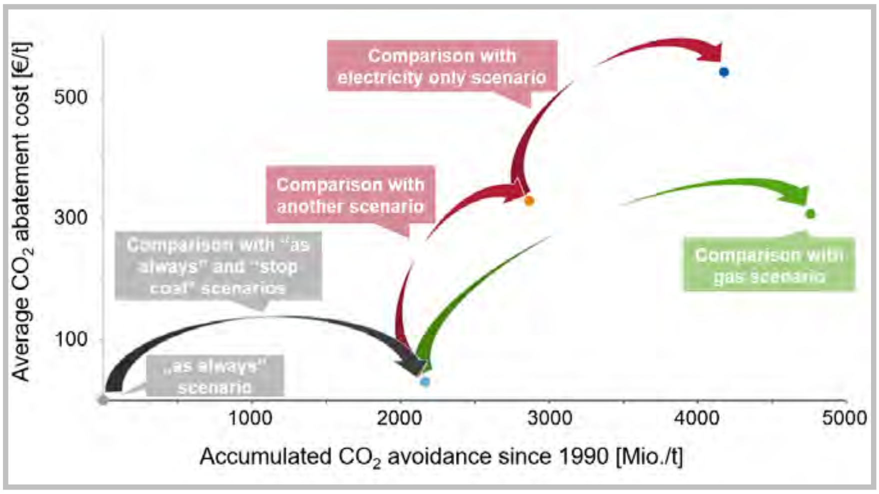
Project Manager **Stephan Bauer** at stephan.bauer@rag-austria.at

STUDY: CLIMATE PROTECTION BY SECTORAL INTERLINKING | GERMANY

As explained in our previous newsletter: One of the recent keywords in German energy policy is “Sektorkopplung”. It may be translated with ‘sectoral interlinking’ and describes the interlinking of different industrial sectors (gas, electricity, mobility, chemical, etc.). By linking the sectors, the advancing decarbonisation of the electricity sector can be used to decarbonise other sectors, simply by using renewable electricity or alternatively hydrogen and methane from Power-to-Gas applications.

A recently released study addresses the German heating and electricity sector and compares different approaches to decarbonise it (80% and 95% greenhouse gas emission reduction until 2050 compared to 1990’s levels of primary energy demand). The authors conclude:

1. Decarbonising the heat and power sector efficiently – to meet the national emission reduction aims – requires an accelerated coal phase-out.
2. At least until 2040, natural gas will still constitute the most cost-efficient CO_2-abatement option for the heating sector. At least until 2050 and most likely beyond, natural gas will remain a cost-efficient low-carbon energy source for back-up power plants.
3. To achieve Germany’s long-term climate goal efficiently, it is less expensive using power-to-gas technology to tab into the flexibility of gas infrastructure.



AVERAGE CO_2 ABATEMENT COST - SCENARIO COMPARISON
(SOURCE: ENERVIS, PAGE 54)

Development of the heat market | 95 % emission reduction

A decrease in CO_2 emissions by 95% instead of 80% results in a massive increase in the required amounts of renewable energy: This is largely due to high temperature heat demand. This may be covered by electric direct heating or, alternatively, by large amounts of synthetic and CO_2 neutral gas (500 TWh/yr).

Demand of electricity | 95 % emission reduction

The deployment of the Power-to-Gas technology increases the electricity demand rapidly, especially beginning in 2025. Until 2050, electricity demand increases to 1,450 TWh/yr. (In the electricity only scenario, it amounts to approximately 790 TWh/yr in 2050.) While the electricity demand is higher when using synthetic and CO_2 neutral gas in comparison to a electricity only scenario, the residual peak load is approximately 50 GW_{el} lower when using gas. Furthermore, the (potential) electricity production is similar, about 1,600 TWh/yr in the electricity only scenario and in the gas scenario. The surplus electricity (about 810 TWh/yr) in the electricity only scenario is either exported or curtailed.

Backup capacities | 95 % emission reduction

Gas power plants play a major role for providing backup capacity. Peak power requirements in the electricity only scenario are 109 GW_{el} and in the gas scenario 56 GW_{el}.

System cost for rebuilding the energy system | 95 % emission reduction

The electricity only and gas scenarios have system costs of similar magnitude, though there is a slight advantage for the gas scenario. Both scenarios show impressive system costs with about 30 milliard Euro/yr ($30*10^9$ Euro/yr) in 2050. This equals for the entire period to rebuild the energy system in the electricity only scenario about one billion Euro (10^{12} Euro) and in the gas scenario 0.86 billion Euro ($0,86*10^{12}$).

The study was released by enervis in March 2017 on behalf of DEA, EWE, Gascade, OGE, Shell, Statoil, Thüga, VNG.

Contact: **Julius Ecke** at julius.ecke@enervis.de

Download in German with Executive Summary in English (page 9-13) click here.

SELECTION OF APPOINTMENTS 2017

May, 12	**German-Japanese Symposium: H_2 Technology as a Solution?** (Herten, Germany)
May, 21-22	**19th Int. Conference on Hydrogen Production and Storage** (Berlin, Germany)
June, 05-06	**Hydrogen + Fuel Cells 2017** (Vancouver, Canada)
June, 27-28	**International Hydrail Conference 2017** (Graz, Austria)
July, 04-07	**6th European PEFC & Electrolyser Forum** (Lucerne, Switzerland)
July, 09	**7th World Hydrogen Technology Convention & Czech Hydrogen Days** (Prague, Czech Republic)
Aug., 28-30	**2nd China International Hydrogen & Fuel Cell Conference & Exhibition, CHFCE** (Beijing, China)
Sept., 10-13	**Solarpower International 2017, Hydrogen + Fuel Cells North America** (Las Vegas, USA)
Sept., 26-27	**DBI-Fachforum Energiespeicher** (Berlin, Germany)

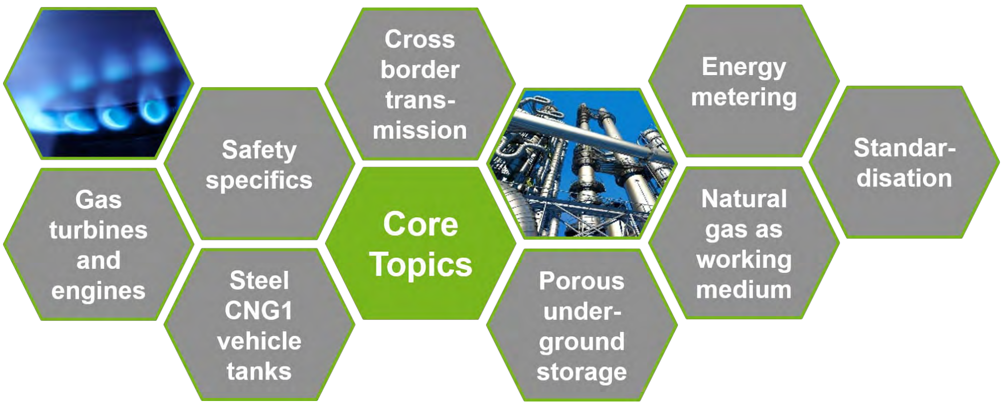
CURRENT PARTNERS

Alliander AG ++ Areva H_2Gen ++ DEA Deutsche Erdoel AG ++ DGC ++ DNV GL ++ Enagás ++ Energinet.dk ++ ENGIE ++ EWE AG ++ Gas Natural Fenosa ++ Gasum OY ++ Gasunie ++ GRTgaz ++ grzi e.V. (figawa) ++ Infraserv GmbH & Co. Höchst KG ++ INERIS ++ ITM Power ++ EC Joint Research Centre (JRC) ++ KOGAS ++ NAFTA ++ ONTRAS ++ Open Grid Europe GmbH ++ ÖVGW ++ RAG Rohöl-Aufsuchungs AG ++ RWE Deutschland ++ Shell ++ Solar Turbines Europe ++ Storengy ++ SVGW ++ Synergrid ++ Uniper Energy Storage GmbH ++ Uniper Technologies Limited ++ Verband der Chemischen Industrie (VCI) ++ Volkswagen AG ++

HIPS-NET CORE TOPICS

We gather and disseminate the latest available knowledge to improve the understanding of hydrogen/natural gas blends in pipeline systems with emphasis on the core topics:

We additionally keep a minor focus on the general development of power-to-gas, hydrogen networks, and further topics around the utilisation of (renewable) hydrogen.



HIPS-NET CONTACT

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Certified DIN EN ISO 9001:2008

GERG groupe européen de recherches gazières the european gas research group

DBI GUT Gas- und Umwelttechnik GmbH

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the european gas research group

HIPS-NET

"Establishing a pan-European Understanding of Admissible Hydrogen Concentration in the Natural Gas Grid"

Newsletter #14	**June, 2017**

Content Newsletter #14

"Coming together is a beginning; keeping together is progress; working together is success."
(Henry Ford)

14th HIPS-NET Newsletter

Dear Colleagues,

Welcome to the 14th edition of the HIPS-NET newsletter.

We are approaching a period of power-to-gas technology demonstration after having proven technical viability in the past; various larger projects are underway and we are presenting a selection from Denmark, France and Switzerland in this edition. Interesting results were produced by the HyHouse project, showing a comparable level of safety risks for low pressure hydrogen leaks in domestic settings as for natural gas. Another project is aiming to separate the hydrogen from a hydrogen/natural gas stream; an approach for using the gas infrastructure and allowing multiple distribution paths for hydrogen. An uptake for the power-to-gas technology may originate in hydrogen demand for mobility, even though there are various open questions connected with the introduction, the activities are divers; we picked two to give an impression. Enjoy reading!

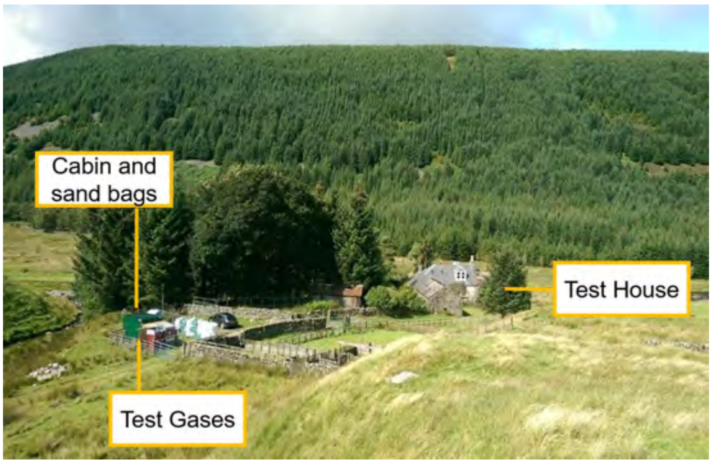
Final preparations for the HIPS-NET workshop are underway, we are looking forward to seeing many of you on Tuesday and Wednesday in Brussels! As usual, we will prepare minutes of the workshop and share them in the 15th newsletter for all HIPS-NET partners.

Your HIPS-NET Team

Gert, Anja, Stefan & Josephine

HyHouse Project Results | U.K.

What is the risk associated with a low pressure gas leak, as can happen in a domestic environment, when using either 100% hydrogen or after blending hydrogen into natural gas? The HyHouse project has successfully demonstrated that hydrogen is a safe replacement for natural gas in a domestic setting. Even though the project was concluded two years ago in 2015, the outcome may be useful to colleagues launching hydrogen projects, and reacting to concerns about the safety of hydrogen. Here, in a nutshell, is an account of the project and its findings:



HyHome Test Site (Source)

The project was designed to identify whether accidental leaks from a pure hydrogen or hydrogen and natural gas mixture supply would have more or less risk attached than a leak from a natural gas supply.

The study involved simulating realistic leaks using five test gases (100% H_2, 100% natural gas, and three different mixtures of the two). The scientists conducted tests in an empty, remote two storey farmhouse in Scotland. The project was jointly funded by the UK Government, Kiwa and SSE.

First, the farmhouse windows would be shut and the doors locked. Then, retreating to a cabin 200ft away, Kiwa Gastec's environmental scientists would release test gases into the property to simulate gas leaks of up to 200kW. Taking samples at 15 locations within the house, they tracked how the gas had distributed, and calculated how likely it would be to catch fire in presence of an ignition source.

The outcome was reassuring because hydrogen is very much lighter than natural gas and the H_2 molecule has a high rate of diffusion. Proportionately, it is actually less likely to accumulate in dangerous amounts. Overall, it would appear hydrogen (although clearly a flammable gas) presents about the same risk as natural gas. Detailed explanations of the experimental setup and the results may be found in the technical project report.

Contact: **Mark Crowther** at mark.crowther@kiwa.co.uk

Source: here

GreenLab Skive | Denmark

What is Skive, one may ask? Skive is a municipality in Denmark with the declared aim to become completely CO_2-neutral by 2029. One key instrument to achieve this is the development of the GreenLab Skive energy initiative – a business development park – with a power-to-gas plant as core element.

The future energy chain consists of photovoltaics, wind turbines, electrolysis, biogas, upgrading, methanation, the natural gas grid, landfill gas, CHP engines and energy system balancing. The already existing infrastructure with the heart of global wind turbine industry, a leading business cluster biomass, and leading universities form a sound basis to develop a unique infrastructure to allow testing, demonstration and development of new full-scale products in a large-scale symbiotic setup.

Sketch of Energy Park (Source: GreenLab Skive)

Contact: **Steen Harding Hintze** at shhi@greenlabskive.dk

Source: www.greenlabskive.dk and more detailed information in Danish

2 MW_{EL} POWER-TO-GAS HYBRID POWER PLANT | SWITZERLAND

LITTLE SISTER—BIOLOGICAL METHANATION IN ALLENDORF | GERMANY (MICROBENERGY)

Combining sewage treatment plant with PEM electrolysis and biological methanation process saves up to ten percent primary energy and about twenty percent greenhouse gas emissions. The intelligent coupling of the processes advances the energy efficiency by using almost the entire energy of the sewage gas in comparison to state of the art electricity generation by combined heat and power plants (CHP).

Ten energy utilities in Switzerland are taking the initiative and planning to install a 2 MW_{el} power-to-gas hybrid power plant in Dietikon. In addition to electricity generation, more than 18 GWh/yr renewable gas will be injected into the natural gas network to enhance the share of renewable gas.

The power-to-gas plant combined with biological methanation is a scale up of the proven technology of Viessmann installed in Allendorf, Germany.

Jonas Klückers of MicrobEnergy explains "The electricity price in Switzerland is not burdened with the Renewables Energies Act levy (EEG-Umlage) as in Germany. We will produce the regenerative methane for 12 ct/kWh and even though the regulator does not remunerate the injection of renewable gas, the energy utilities agreed to purchase the gas to advance the decarbonisation of gas to realise a greenhouse gas reduction potential of about 95 percent in comparison to natural gas."

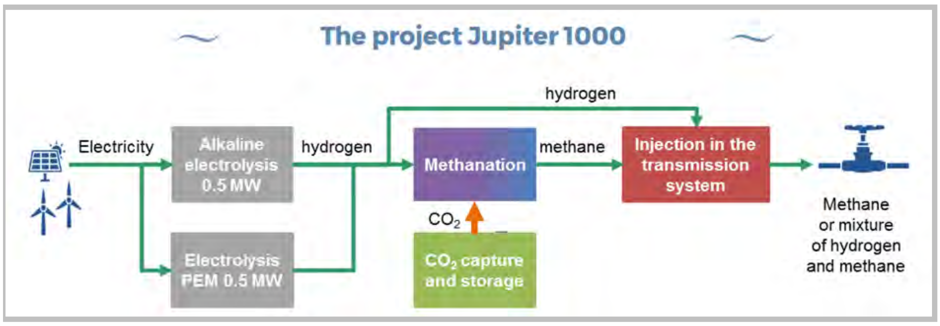
Contact: **Eva Sonnleitner** at
eva.sonnleitner@microbenergy.com
Study (in German only)
Source (German)
Source (French)

The subsidiary company of Viessmann, MircrobEnergy received the Rudolph-Diesel medal for the "Sustainable Innovation" for its technological achievements to advance the energy transition, especially for developing energy storage with the power-to-gas technology in combination with biological methanation in April 2017. Congratulations!

1 MW_{EL} POWER-TO-GAS PLANT - JUPITER 1000 | FRANCE

GRTgaz and its partners are involved in the "Jupiter 1000" project at the Fos sur Mer harbour nearby Marseille on a platform dedicated to demonstration projects devoted to the energy transition. The project is located at the intersection of gas and electrical networks and close to an industrial source of CO_2.

GRTgaz is currently designing to build a power-to-gas plant of 1 MW_{el}. The project implements two technologies of electrolysers: PEM (Proton Exchange Membrane) and alkaline. The CO_2 will be captured from industrial flue gas. The electricity will be provided from renewable energy. The injection / mixing unit will be used to ensure in all circumstances the injected gas satisfies the specifications of the natural gas grid. French regulation permits 6 vol% of H_2 in the natural gas networks.



PROJECT JUPITER 1000 (SOURCE: JUPITER 1000)

Contact: **Laurent Clisson** at
Laurent.clisson@grtgaz.com

Feasibility analysis (in French only)

Source: www.jupiter1000.com/en/accueil.html

Project partners are GRTgaz, ATMOSTAT, cea, CNR, L&L, Marseille Fos, McPhy, TIGF, RTE and is co-financed by the European Union under the FEDER funds, by the government as part of the "Investissements d'Avenir" program entrusted to ADEME and the Provence-Alpes-Côtes d'Azur regional council.

Green Gas Initiative | Europe

Green vision and commitment for Europe

Seven independent gas infrastructure companies form GGI (Green Gas Initiative): Energinet.dk (Denmark), Fluxys Belgium, Gasunie (the Netherlands), Gaznat (Switzerland), GRTgaz (France), ONTRAS (Germany) and Swedegas (Sweden). They have committed themselves to achieve the joint objective of reaching CO_2 neutral gas supply by 2050. The GGI members currently consider the combination of using biomethane, power to gas (P2G) solutions and using gas as an alternative fuel for road and maritime transport as the most promising solutions for curbing climate change. GGI is also urging to create a regulatory framework at European level to develop (economically viable) markets for synthetic natural gas and hydrogen.

Their cross-border cooperation seeks to achieve benefits for all parties involved through knowledge-exchange and targeted communication on both national and European levels. One of the missions of GGI is to raise awareness among market players, politicians and the public at large of the benefits of P2G.

GGI members therefore encourage and welcome any research aiming at making P2G products compatible with natural gas infrastructure or making infrastructure fit for P2G products – at reasonable costs.

Contact: **Gilles Verdan (Gaznat SA)** at g.verdan@gaznat.ch

Feasibility Study for Hydrogen Use in Mobility, Industry and Heating Market | Germany

Schleswig-Holstein is a region in North-West Germany with a huge rise in surplus RES electricity. A recently published feasibility study on behalf of the GP JOULE demonstrates the interlinking of electricity, heating and mobility through renewable surpluses in the joint project called “Acceptance through added value – hydrogen as a connective link between the heating, electricity, industry and transport sectors” (“Akzeptanz durch Wertschöpfung – Wasserstoff als Bindeglied zur Kopplung des Wärme-, Strom-, Industrie- und Verkehrssektors”).

The joint project exists among others of five PEM electrolysers installed in North Friesland, converting RES electricity into hydrogen. The heat incurred in the process is fed into pre-existing local heat networks and thus contributes to the heat transition, i.e. the decarbonisation of the heat supply. Further, the hydrogen is stored and subsequently dispensed via two H_2 filling stations in Husum and Niebüll to two fuel cell buses, which operate public transport routes. In this way, the public transport in the north can gradually be made emission-free, cost-effective and economical, as the study proves.

Sketch of the Project Idea
(Source: GP JOULE)

To validate the joint project, seven reputable institutions, including Fraunhofer ISI, Fraunhofer ISE and the Foundation for Environmental Energy Law (Stiftung Umweltenergierecht), have developed a comprehensive feasibility study on behalf of GP JOULE.

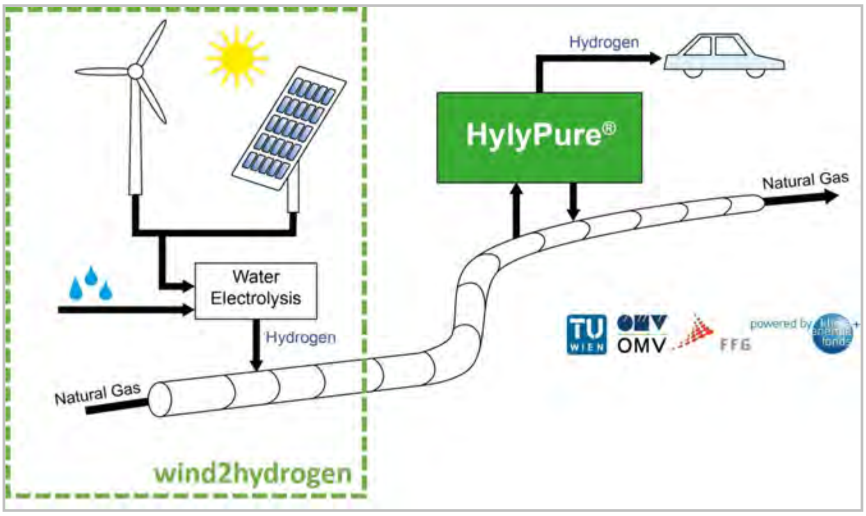
“The results of the study are something to be proud of – our joint project proves that hydrogen from renewable energies can create competitive costs and be used as a CO_2-free fuel for the mobility sector. There are no significant hurdles for the joint project from a technical, legal consent or economic perspective”, explains Ove Petersen, founder and general manager of GP JOULE. The study considered injecting hydrogen into gas networks but postponed it due to low market prices of competing energy carriers. The consortium is now aiming to apply for funding to enter the basic engineering phase and gaining legal permission. Inauguration is scheduled for 2018. In the beginning of 2027, the project intends to continue its operation without further external funding, thus having reached economic viability.

Contact: **Timo Bovi** at t.bovi@gp-joule.de
Source: here

HylyPure - Hydrogen Recovery from Natural Gas | Austria

Recovering green hydrogen without wasting energy

The Wind2Hydrogen strategy involves storing hydrogen in the natural gas grid and delivering it (mixed with natural gas) to individual consumers at low cost. For the hydrogen to be available as a feedstock in the chemical industry, or for transport applications in fuel cell quality, it is essential to recover it in pure form from the mixture.



System Sketch (Source: HylyPure)

In the HylyPure project, scientists of the Vienna University of Technology, in collaboration with OMV, are developing and testing a compact facility, which recovers hydrogen in three stages in an ecologically and economically efficient way. In stage one, membrane gas permeation, the hydrogen concentration is increased at minimum energy cost and the quantity of gas drastically reduced. In stage two, pressure-swing adsorption (PSA), the hydrogen concentration is increased further. Depending on requirements, the hydrogen stream can then undergo further adsorptive purification in an optional stage three, to ensure the desired product quality.

Contact: **Dr. Michael Harasek** at michael.harasek@tuwien.ac.at

The residue is brought back to the original pressure and fed back into the natural-gas line. Provided that the electricity needed comes from renewables, the separation process is carbon-neutral.

Research Activities for Hydrogen Tolerance of Turbines | Germany

Tests of the Leibniz University Hannover
(Source: here)

Gas and steam turbines are technically optimised for full-load operation and not for switch-on and switch-off operation to limit the natural tear and wear. The future electricity network demands conventional electricity generation to balance the fluctuation of wind and PV. The technical layout of turbines, therefore, has to be more robust, improved for part-load operation, increased stability for frequency variations, and alternating fuels while keeping today's efficiency and emission level. The aim is to adjust existing turbines and newly-developed ones. Of significant importance is an increased hydrogen tolerance of minimum 10 vol% to serve as key element for power-to-x conceptions.

In the research network „Flexible Energy Transformation", founded in February 2017, OEMs and research institutions are addressing these questions, and one of the focuses is the use of hydrogen in electricity generating processes under the roof of the German Federal Ministry of Economic Affairs and Energy (BMWi). The first network meeting takes place at 30th June; registered experts are welcome in Jülich, Germany.

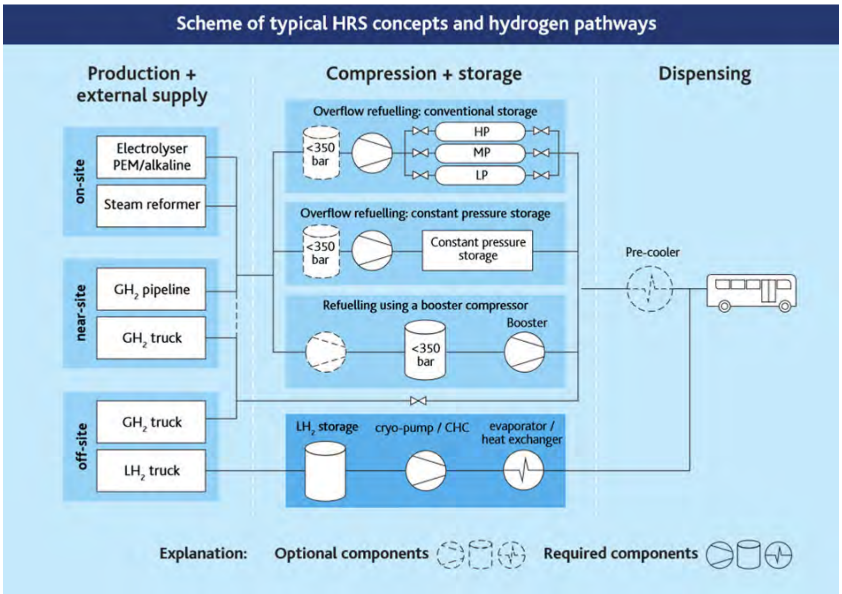
Contact: **Sabrina Costantini** (AG Turbo) at sabrina.costantini@dlr.de

Source: here

Stabilisation of the Power Grid by Flexible Turbines
(Source: here)

LARGE-SCALE HYDROGEN REFUELLING ECONOMICALLY VIABLE | EUROPE

FCH JU project NewBusFuel has just finished and its conclusions demonstrate that hydrogen refuelling in large-scale bus depots is not only technically feasible, it is also commercially viable. 10 of Europe's leading technology providers of hydrogen production and refuelling equipment worked with 12 bus operators in Europe to develop designs for large scale refuelling systems for their bus depots. In each location, a suitable design was developed in consultation with the bus operators and the local regulators. As a result, a wide range of engineering solutions was developed, involving different supply modes (liquid/gaseous trailer delivery and on-site production from electrolysis and methane reformation) covering hydrogen demands between 1,000 and 5,000 kg per day, corresponding to depots of 50-260 hydrogen buses. Each of these technical solutions was able to meet the original design requirements defined within the case studies, demonstrating that hydrogen refuelling at these large scales can be affordable and reliable.



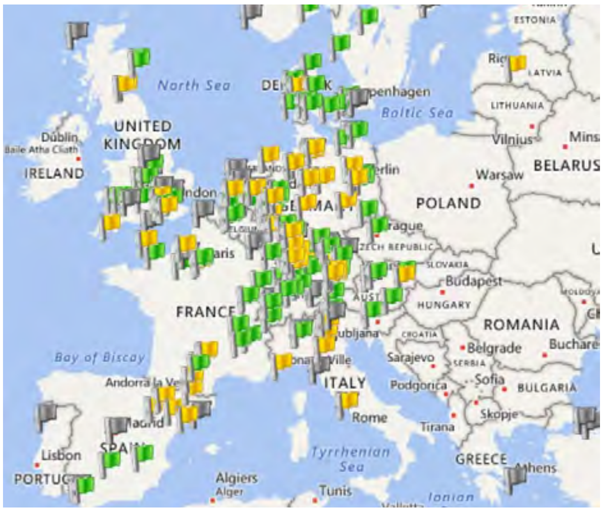
SCHEME OF TYPICAL HYDROGEN REFUELLING SYSTEM (HRS) CONCEPTS AND HYDROGEN PATHWAYS
(SOURCE: HERE, P. 15)

Project duration	June 2015 – March 2017
Project costs	2.48 Mio €
Funding	2.44 Mio €
Coordinator	Element Energy Limited U.K.

Contact: **Dr. Benjamin Reuter** at benjamin.reuter@thinkstep.com

Study: here

Within the project, two central publications were developed: the first is a guidance document, which contains a variety of useful information for bus operators who consider the use of hydrogen fuel cell buses and the related necessary infrastructure. The second is the project's summary report, which analyses the developed designs and gives recommendations for different stakeholder groups of how to further improve the technical and economic performance of hydrogen refuelling stations.



EXCERPT OF THE INTERACTIVE MAP
(COPYRIGHT LUDWIG-BÖLKOW-SYSTEMTECHNIK)

DATABASE OF HYDROGEN FILLING STATIONS WORLDWIDE

A Database of hydrogen filling stations worldwide with 760 (!) entries gives an impression of the efforts to build up a new infrastructure. Have a look for the efforts and achievements in Europe and click the interactive map at www.h2stations.org.

SELECTION OF APPOINTMENTS 2017

June, 20	Annual Conference Power to Gas 2017 (Berlin, Germany)
July, 04-07	6th European PEFC & Electrolyser Forum (Lucerne, Switzerland)
July, 09	7th World Hydrogen Technology Convention & Czech Hydrogen Days (Prague, Czech Republic)
July, 29-31	8th International Conference on Hydrogen Production (Brisbane, Australia)
Aug., 28-30	2nd China International Hydrogen & Fuel Cell Conference & Exhibition, CHFCE (Beijing, China)
Sept., 10-13	Solarpower International 2017, Hydrogen + Fuel Cells North America (Las Vegas, USA)
Sept., 11-13	7th International Conference on Hydrogen Safety (ICHS 2017) (Hamburg, Germany)
Sept., 11-13	International Conference on Hydrogen Energy (University of Surrey, Guildford, U.K.)
Sept., 26-27	DBI-Fachforum Energiespeicher (Berlin, Germany)

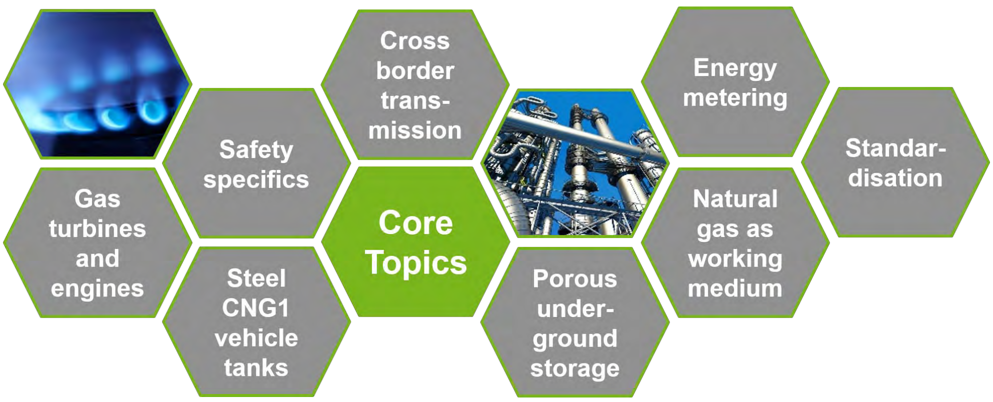
CURRENT PARTNERS

Alliander AG ++ Areva H_2Gen ++ DEA Deutsche Erdoel AG ++ DGC ++ DNV GL ++ Enagás ++ Energinet.dk ++ ENGIE ++ EWE AG ++ Gas Natural Fenosa ++ Gasum OY ++ Gasunie ++ GRTgaz ++ grzi e.V. (figawa) ++ Infraserv GmbH & Co. Höchst KG ++ INERIS ++ ITM Power ++ EC Joint Research Centre (JRC) ++ KOGAS ++ NAFTA ++ ONTRAS ++ Open Grid Europe GmbH ++ ÖVGW ++ RAG Rohöl-Aufsuchungs AG ++ RWE Deutschland ++ Shell ++ Solar Turbines Europe ++ Storengy ++ SVGW ++ Synergrid ++ Uniper Energy Storage GmbH ++ Uniper Technologies Limited ++ Verband der Chemischen Industrie (VCI) ++ Volkswagen AG ++

HIPS-NET CORE TOPICS

We gather and disseminate the latest available knowledge to improve the understanding of hydrogen/natural gas blends in pipeline systems with emphasis on the core topics:

We additionally keep a minor focus on the general development of power-to-gas, hydrogen networks, and further topics around the utilisation of (renewable) hydrogen.



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HIPS-NET

"Establishing a pan-European Understanding of Admissible Hydrogen Concentration in the Natural Gas Grid"

Newsletter #15 | **October, 2017**

Content Newsletter #15

15th HIPS-NET Newsletter

Dear Colleagues,

Welcome to the 15th edition of the HIPS-NET newsletter.

This newsletter comprises new developments in four European countries: The recently released conceptual study for the Liverpool-Manchester region in the U.K., with similar ideas as the Leeds City Gate project but deviating approaches as it favours hydrogen admixture to the natural gas grid. The Danish TSO energinet started research to determine possible hydrogen concentration levels to path the way into a carbon free future. A huge research proposal by Dutch stakeholders was accepted to support the connection of the electricity and gas infrastructure. We added furthermore a short information about an electricity and heating system using the power to gas technology with a closed cycle for carbon dioxide, which is entering the market for larger buildings.

You will find in the second part of this newsletter the summary of the HIPS-NET workshop with shortened overviews about the given presentations. In case you missed the download period given after the workshop via e-mail with all presentations, please access the HIPS-NET website members' area to retrieve further information.

We hope you find the described developments and the workshop summary interesting to read!

Your HIPS-NET Team

Gert, Anja, Josephine & Stefan

Please save the date!

HIPS-NET Workshop

2018

14th June

LIVERPOOL-MANCHESTER HYDROGEN CLUSTER PROJECT | U.K.

INITIAL CONCEPTUAL STUDY RELEASED

The use of hydrogen in place of natural gas could offer a route to widespread decarbonisation of gas distribution networks. In addition to the Leeds City Gate (H21) concept, presented at the HIPS-NET workshop in June this year, a second region in the U.K. is preparing for hydrogen use in gas pipeline systems. The main driver for the concept is widespread carbon abatement at lower cost than alternative strategies.

The Liverpool-Manchester Hydrogen Cluster project is a conceptual study to develop a practical and economic framework to introduce hydrogen into the gas network in the Liverpool-Manchester area. It proposes converting natural gas into clean-burning hydrogen gas, by steam methane reforming. The process removes carbon dioxide from the gas, which can then be captured and stored in depleted offshore gas reservoirs (CCS). The hydrogen gas would then be supplied to a core set of major industrial gas users in Liverpool-Manchester and fed into the local gas distribution network as a blend with natural gas (potentially up to 20 vol%).

The project prefers hydrogen admixture because the associated Capex amount to about 30 % (0.6 b£) for the same level of carbon dioxide reduction in comparison to full hydrogen supply (Capex 2.1 b£) and avoids the replacement of thousands of boilers and creation of underground salt cavern hydrogen stores. The Opex is estimated around 57 M£/annum. The cost of carbon abatement (CoA) is estimated around 90-104 £/t_{CO2}. The use of air source heat pumps would cause higher CoA and is suggested for rural areas, including those not served by gas (see table).

Approach to Decarbonisation	CoA (£/tCO_2)
Proposed L-M Hydrogen Cluster Project	90 - 104
Nuclear	125
Offshore Wind	131
H21 Project	292
Air Source Heat Pumps	768

COMPARISON OF COST OF ABATEMENT (CoA) WITH ALTERNATIVES
(SOURCE: CADENT GAS, SUMMARY REPORT, P. 16)

Source: http://cadentgas.com/About-us/Innovation/Projects/Liverpool-Manchester-Hydrogen-Cluster

One of the mentioned key risks relate to the missing market framework for low carbon hydrogen in the U.K.. The authors therefore argue that a support mechanism must be designed to socialise the costs across all gas users in the region or possibly in the wider U.K.. The study was released in August 2017.

POWER-TO-GAS FOR HEAT AND ELECTRICITY SUPPLY IN BUILDINGS | GERMANY

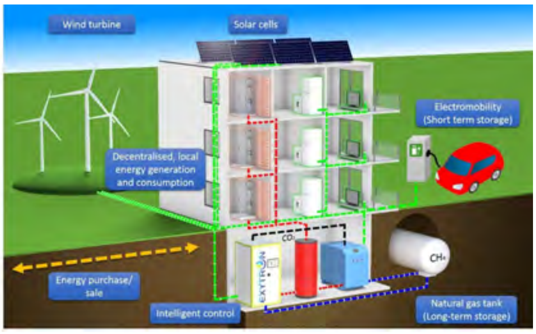


IMAGE OF ENERGY SUPPLY FOR AN APARTMENT BUILDING (SOURCE: EXYTRON)

SmartEnergyTechnology is the first fully closed ‘power to gas’ system in the world. It does not emit any carbon dioxide and enables carbon-free heat and electricity supply for several solutions, from housing projects of some kW up to gas power plants of many MW. The decentralised system combines an electrolyser with a catalytic methanation process. The strongly exothermic reaction of hydrogen and carbon dioxide produces heat, which is used for heating purposes. The methane is burned e.g. in a CHP unit (combined heat and power) in a modified combustion with oxygen, to prevent all nitric oxide emissions. The burning process leaves especially clean carbon dioxide that is subsequently used for methanation (closed carbon capture and use process loop). Additionally, the unit is complemented by an intelligent control system, which forecasts future electricity production from PV and the needs for power and heat. The process of methanation was developed with the renowned Leibniz Institute for Catalysis (LIKAT) at the University of Rostock and will soon cover the energy supply for hotels in a decentralised system as pilot project. The process aims at 90 percent efficiency. The methane is not reliant on an injection in the gas grid, but can use it as storage system in big applications.

The electricity and heat supply in the two existing projects in Alzey and Augsburg are already today economically viable for end customers.

Image film and trailer: https://exytron.online/EN/
Contact: Klaus Schirmer kschirmer@exytron.com

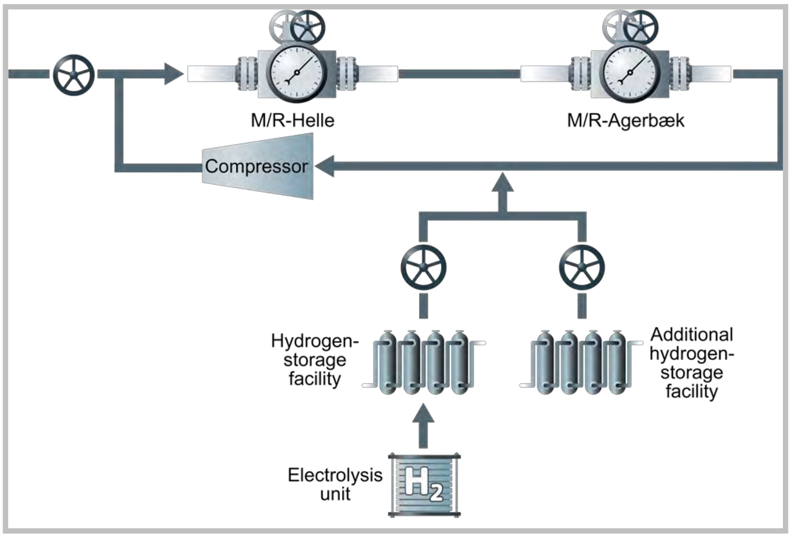
How Much Hydrogen Can the Danish Gas Infrastructure Handle?

Authors: Jesper Bruun, Julie Just Krebs (Energinet)

The Danish gas TSO Energinet is currently testing the Danish natural gas infrastructure to see whether it is ready to handle hydrogen. The test was started in June 2017 and is running for two years.

The goal is that by the year 2050 Denmark should be supplied with 100 % renewable energy. This means that it will be necessary to find out how to deal with energy from windmills on days with no wind. Hydrogen from electrolysis may be the key to solve this.

Therefore, Energinet has established a test facility between the two meter and regulator (M/R)-stations in cooperation with three Danish partners Danish Gas Distribution, Danish Gas Technology Center and EWII Fuel Cells. With the project, the partners want to obtain knowledge about how much the existing system can handle as it is and how much it will cost to prepare the Danish natural gas system for future challenges.



Sketch of project testing facility (Source: Energinet)

In June 2017, Energinet and partners added the first 2 vol% hydrogen to the closed test facility and in August the next 2 vol%. So far, there are good results, as the system did not lose the added hydrogen.

The test facility uses the same infrastructure and contains the same components as the rest of the Danish natural gas system. Therefore, it is possible to transfer the results of the test in the entire system and on longer term use the system for managing and transport wind power in the form of hydrogen. The aim is to test what the system can handle in the range 0 - 15 vol% hydrogen.

Contact: **Jesper Bruun** at jbr@energinet.dk

The preliminarily good results bring Energinet and partners one step closer to being able to supply Denmark with 100 % renewable energy in 2050.

TSO 2020 Project | Netherlands

Towards Synergised Infrastructures in the EU

COBRA interconnection cable and TSO 2020 (pilot) locations (INEA, © PLATTS for power grids)

TSO2020 project will use existing power cable networks to dispatch the electricity flows, expected from the interconnecting COBRA cable, to a nearby major gas network facility. Existing gas storage facilities (salt cavern) and the national gas pipeline network (power to gas) will be unlocked to absorb the hydrogen. Local businesses will provide hydrogen distribution via road transport in the Netherlands and the western part of Germany. The activities combine studies, two pilot activities and a business plan for the scale up of grid management solutions. TSO2020 is the largest action approved in the first so-called synergy call of proposal launched as part of the EU Connecting Europe Facility (CEF). The COBRA cable is an international project aiming to interconnect Denmark and Netherlands for electricity supply.

The pilot locations will test the impact of storage and grid balancing equipment on the electrical and gas networks (Zuidwending pilot) and develop a hydrogen distribution hub (Delfzijl pilot) to efficiently distribute hydrogen to various end customers. The project will provide further a comprehensive business and financing outlook for the scale up of hydrogen production to supply hydrogen fuel stations on the TEN-T network. The injection in the national gas pipeline network is also considered an option.

Project duration: February 2017 until December 2019

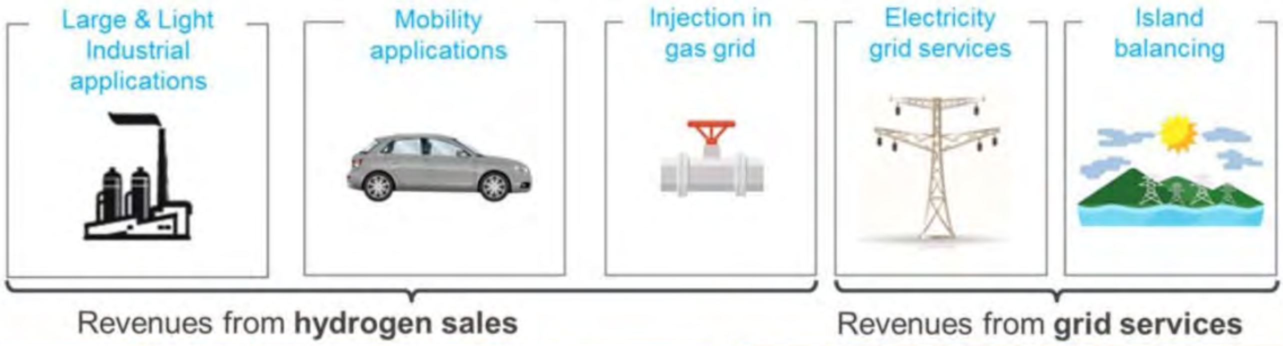
Project budget: about 12 M€, co-financing by EU 7 M€

Source: www.tso2020.eu, https://ec.europa.eu/inea/en/connecting-europe-facility/cef-energy/projects-by-country/netherlands/2016-eu-sa-0012

STUDY ON EARLY BUSINESS CASES FOR HYDROGEN RELEASED | EUROPE

Hydrogen is widely recognised as a promising option for storing large quantities of renewable electricity over longer periods. Its need in the long-term appear to be generally acknowledged. The key challenge today is to identify concrete short-term investment opportunities, based on sound economics and robust business cases.

This study identifies early business cases and to assesses their potential replicability in Europe from now until 2025. In short, a market of 2.8 GW of electrolysers with a value of 4.2 b€ was identified for Europe until 2025, covering regional hydrogen mobility, light industry and refineries. An essential part and innovative approach of this study is the detailed analysis of the power sector including its transmission grid constraints. This is of key importance for hydrogen business cases, for at least two reasons. First, because of revenues via the provision of balancing services. Second, because operating expenses are mainly determined by the price of electricity and local grid bottlenecks and RES curtailment may be reflected by lower procurement costs, depending on the national electricity market design.



PtoH application	Potential revenues [k€/MW/year]
Refineries, without carbon penalty	237 – 512
Refineries, with carbon penalty*	792 – 1068
Light industry market (delivery by trailer)	499 – 1235
Mobility (delivery to the HRS)	526 – 920
Hydrogen injection into gas grid based on national biomethane injection tariff[1]	171 – 350*

PtoH application	Potential revenues [k€/MW/year]
Balancing services	2 -17
Frequency control services	70 - 224
Distribution grid services	< 1

Primary value streams
Secondary value streams (combinable with primary applications for little extra cost)

*Carbon penalty of 470€/tCO_2 is based on German law of emission intensity reduction requirement on conventional fuel production (§37c BImSchG), if H_2 was recongnised in the carbon intensity calculation.

[1]Biomethane injection tariff can vary significantly depending on injection capacity and feedstock. The study considers a realistic lower revenue for hydrogen gas grid injection.

OVERVIEW OF POTENTIAL VALUE STREAMS (SOURCE: HINICO, FULL REPORT, P. 56)

The authors conclude robust business cases upon an electricity price of 40-50 €/MWh including (!) grid fees, taxes & levies. The payback time of the best located business cases varies from 3 to 11 years depending on the primary application, conditional on a gas grid injection tariff of 90 €/MWh_{LHV}. Analysed markets for the short- and medium-term involve mobility and industry as primary applications, such as regional hydrogen mobility deployment, refineries and cooking oil production, complemented by gas grid injection.

The study selected five power systems for in-depth modelling, Germany, France, Denmark, U.K. and Sardinia. The three best short-term business cases are in Albi (France) as semi-centralised production for mobility, in Trige (Denmark) for the food industry, and Lübeck (Germany) in the refinery.

Gas grid injection and electricity grid services, represent a short-to-mid-term a de-risking instrument. As a matter of fact, gas grid injection can boost cash flows at low marginal cost towards breakeven during the ramp-up phase of mobility applications, when the risk of expected demand not materialising remains high (“valley of death”).

The over 200 pages long study was released in June 2017, written by Tractebel, Engie and Hinicio with the support of a large advisory board, funded by the FCH JU and supported by the European Commission.

Source: http://www.fch.europa.eu/publications/study-early-business-cases-h2-energy-storage-and-more-broadly-power-h2-applications

Summary of the 4th HIPS-NET Workshop

Jyri Ylkanen (European Commission Energy)

Energy Storage in EU Energy Policy

Further development of the electricity market design (excerpt)

- Credo remains: transparent, non-discriminatory, flexible
- Upcoming storage legislation includes: improving short term markets + service products to be defined and procured by TSO & DSO + network planning including energy storage
- Unbundling prevails: External storage ownership; cost of acquired storage services by the network to be included in the grid fees
- Power-to-Gas included in storage definition as suggested ‘energy storage’ means, in the electricity system, deferring an amount of the electricity that was generated to the moment of use, either as final energy or converted into another energy carrier
- Recognises the need to decarbonise the energy system; instead of focussing solely on electricity: SECTORAL INTEGRATION

Francoise de Jong (NEN)

European Standardisation of Hydrogen and H2NG

Where did we start? – CEN/CENELEC SFEM WG Hydrogen

- Participation of about 80 experts from more than 60 European companies, organisations and institutes
- Establishment of a dedicated European standardisation technical committee (CEN/CENELEC TC 6)
- Result of SFEM WG Hydrogen is a final report and a roadmap of near term action items for every task force. (connection to electricity grid, electrolysers, gas system and usage, hydrogen technologies) … see also summary in newsletter #9 page 8, 9

Where are we now? CEN-CLC/TC 6 and CEN/TC 234

- Scope: standardisation in the field of systems, devices and connections for the production, storage, transport and distribution, measurement and use of hydrogen from renewable energy sources and other sources
- **WG 1 – Terms and definitions**: do we all use the same language (PtG, PtX, …)
- **WG 2 – Guarantee of origin**: for the GoO standardisation is very important, because of the question how to define blue and green hydrogen
- **WG 3 – Hydrogen safety**: main topic
- **Decision**: extend the existing standards and implement new standards for hydrogen (from 0% to 100% concentration) in the gas infrastructure

Next Step: EC standardisation request on hydrogen for interoperability between grids, on safe admixture of hydrogen to the gas grid, on gas quality and on compatibility with end-use appliances

Participation welcome: get in contact with Francoise de Jong or Eveline Weidner

Summary of the 4th HIPS-NET Workshop

Carsten Krause (Areva H2Gen)

Power-to-X – Short Overview about Activities and Projects in Germany

Kopernikus Project – Power-to-X (PtX)

- Main focus: application of PtX for sectoral integration of energy, transport and chemistry
- Budget of 40 Million € for 1st period (2017-2020) with over 60 project partners
- Further funding periods follow; total duration: 10 years

Power-to-X – Energy transition in the transport sector: sector coupling

- Focus: sectoral integration of energy, transport and maritime industry
- 130 Million € funding by the German Federal Ministry of Economic Affairs and Energy
- Focus on electricity-based liquid fuels passenger vehicles, lorries, sea-faring vessels, construction equipment or stationary industrial engines

Stephan Bauer (RAG)

Results of Underground Sun Storage Project

Research on effects of 10% hydrogen admixtures in existing gas storage facilities

Geochemistry and reactive transport modelling (WP 2)

Laboratory experiments on cap rock permeability, reservoir alteration and H_2 transport in reservoirs

- no increased H2 permeability even with 100 vol% hydrogen at 100 bar
- no significant reservoir alteration after 1 year at 25 vol% hydrogen

Microbial processes in hydrogen exposed reservoirs (WP 3)

- Hydrogen induces microbial metabolism in the reservoir and there are different reactions possible.
- It was observed that there are microbes in the reservoir but no significant H_2S reactions were detectable.
- Abiotic reactors did not deliver decline in hydrogen concentration.

Material and corrosion (WP 5)

- steel alloys experiments with alloys, which are used by RAG
- fracture elongation stays the same until you add H_2S
- no hydrogen related alteration of cementation detectable

In-situ field experiment construction and operation (WP 7 & 8)

- after the selection of a suitable reservoir, the first injection took place and then the shut-in period started with two month testing
- 82 % of H_2 retrieved, rest dissolved in reservoir fluids, migrated into cushion gas some hydrogen was transformed into other gases (e.g. methane) by microbial metabolism

+++ new project +++ Underground Sun Conversion Project (2017 – 2021)

- methane production: sustainable carbon cycle in a reservoir - decline of H_2 and CO_2 and increase in methane

Summary of the 4th HIPS-NET Workshop

Dan Sadler (Northern Gas Networks)

H21 Leeds City Gate Project

"If you can proof Leeds, you can proof the entire system!"

- Redesigning the gas network for Leeds into a 100% hydrogen network

Energy Demand Requirements (Heat)

- District governor: 3,180 MW
- 260,000 m² area with an annual demand of 6 TWh
- Steam methane reformer: 1,025 MW
- 2 salt caverns to store hydrogen; together 706 GWh
- 4 GWh of intraday storage
- 80 % carbon reduction

Selected results

- Complete impact assessment of the gas appliance population within Leeds based on a hydrogen network
- Complete impact assessment on the existing gas network within Leeds of the introduction of hydrogen, based on international trials and best practice
- Assessment on the potential use of a hydrogen delivered via a network on road vehicles
- Re-model the Leeds Gas Network based on hydrogen conversion including costs and customer impact

More information: http://www.smarternetworks.org/Project.aspx?ProjectID=1630 | Dan Sadler (DSadler@northerngas.co.uk)

Gert Müller-Syring (DBI GUT)

Organisational Aspects HIPS-NET

Fixed responsibilities in the coming year

- Continued publication of the quarterly newsletter and annual status report
- Addressing open R&D subjects and communication to the EC
- Preparation for the HIPS-NET workshop in 2018
- Aim to increase the number of active partners (from 34 to 38)
- New partners are ONTRAS (Germany), INERIS (France) and Storengy (France)

Additional scope for the coming year (depending on budget)

- Maintaining the HIPS-NET website
- Updating the Power-to-Gas map
- Maintaining cooperation with CEN/CENELEC SFEM WG Hydrogen/ TC6
- Establishing closer information exchange with the EC Director General for Energy

Discussion for future development of HIPS-NET

- Workshop next year: discussion round to find gaps and identify open regulatory issues and how to solve them?
- Roadmap for harmonisation across different countries (differences across Europe in regulatory especially for hydrogen)?

Summary of the 4th HIPS-NET Workshop

Isabelle Alliat (ENGIE Lab)

GRHYD project: grid management by hydrogen injection for reducing carbonaceous energies

Background and Overview of GRHYD

- First Power-to-Gas-to-Grid project in France
- A new 100-home estate will be supplied with NG-H_2 blends up to 20 vol%
- natural gas vehicle fuelling station and dozens of urban buses will be adapted to a new fuel: Hythane® (20 vol% hydrogen)

Development of software for optimizing and monitoring the H_2 production-storage station vs. downstream gas consumption and renewable electricity sources upstream.

Demonstration: injection of natural gas/ hydrogen blends

- Technical feasibility: finalised with design optimisation
- Safety (regulations): approval for injection up to 20 vol% gained
- Social acceptance survey finalised without drawbacks; positive perception
- Technical studies about all the parts of the gas chain discovered no difficulties
- Start of the demonstration operation is planned in November 2017, for 1,5 years
- Ongoing: assessment of performance and economic + environmental results including life cycle analysis (LCA)

Demonstration: Hythane® fuel for bus fleet

- Hythane® advantages
  - ⇒ higher engine efficiency (+7% vs CNG)
  - ⇒ lower emissions of local pollutants (-10% vs CNG)
  - ⇒ lower consumption of primary energy (fossil energy replaced by renewable H_2 energy)
  - ⇒ synergy with other clean fuels like H2I
- Hythane® fuel station start is planned for 2018
- Sociological studies: no objection noticed
- Ongoing: risk management & permitting procedure, technical & economic analysis, developing sustainable economic model including life cycle analysis (LCA)

More information: website link (www.GRHYD.fr: only in French) or DRI-GRHYD@engie.com/ Isabelle.Alliat@engie.com

Impressions of the 4th HIPS-NET Workshop

Selection of appointments 2017/18

Nov., 02-03	3rd HYPOS Forum (Leipzig, Germany)
Nov., 06-17	COP 23 (Bonn, Germany)
Nov., 15-16	STORENERGY Congress (Offenburg, Germany)
Nov., 20	FCH JU Stakeholder Platform Plenary Session (Brussels, Belgium)
Dec., 4-5	19th Int. Conference on Hydrogen Energy and Fuel Cells Technology (Amsterdam, Netherlands)
Dec., 12-15	EFC17 - European Fuel Cell 2017 (Naples, Italy)
Jan., 24-25	Hydrogen & Fuel Cells Energy Summit (Brussels, Belgium)
Feb., 11-16	Latsis Symposium: 12th Int. Symposium Hydrogen & Energy (Lausanne, Switzerland)
March, 14-16	EHEC 2018 - European Hydrogen Energy Conference (Malaga, Spain)

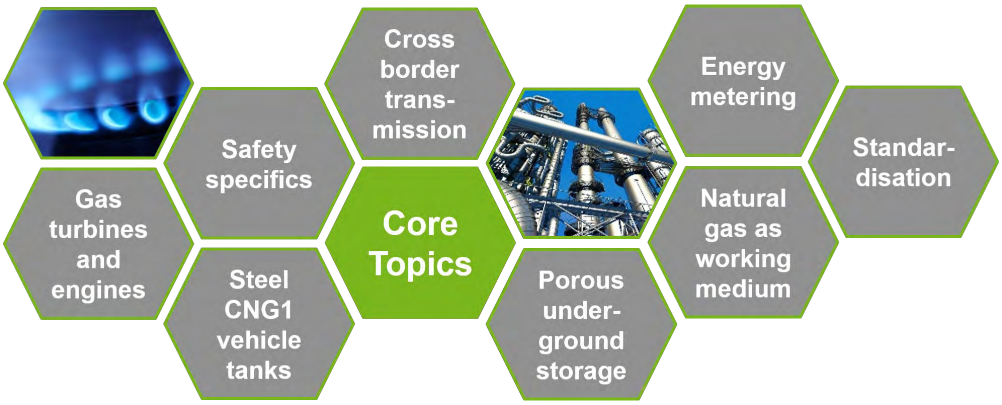
Current Partners

Alliander AG ++ Areva H_2Gen ++ DEA Deutsche Erdoel AG ++ DGC ++ DNV GL ++ Enagás ++ Enbridge ++ Energinet.dk ++ ENGIE ++ EWE AG ++ Gas Natural Fenosa ++ Gasum OY ++ Gasunie ++ GRTgaz ++ grzi e.V. (figawa) ++ Infraserv GmbH & Co. Höchst KG ++ INERIS ++ innogy SE ++ ITM Power ++ EC Joint Research Centre (JRC) ++ KOGAS ++ NAFTA ++ ONTRAS ++ Open Grid Europe GmbH ++ ÖVGW ++ RAG Rohöl-Aufsuchungs AG ++ Shell ++ Solar Turbines Europe ++ Storengy ++ SVGW ++ Synergrid ++ TIGF ++ Uniper Energy Storage GmbH ++ Uniper Technologies Limited ++ Verband der Chemischen Industrie (VCI) ++ Volkswagen AG ++

HIPS-NET Core Topics

We gather and disseminate the latest available knowledge to improve the understanding of hydrogen/natural gas blends in pipeline systems with emphasis on the core topics:

We additionally keep a minor focus on the general development of power-to-gas, hydrogen networks, and further topics around the utilisation of (renewable) hydrogen.



HIPS-NET Contact

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Certified DIN EN ISO 9001:2008

GERG
groupe européen de recherches gazières
the european gas research group

DBI GUT
Gas- und Umwelttechnik GmbH

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the european gas research group

HIPS-NET

"Establishing a pan-European Understanding of Admissible Hydrogen Concentration in the Natural Gas Grid"

Newsletter #16 | **March, 2018**

Content Newsletter #16

16th HIPS-NET Newsletter

Dear Colleagues,

Welcome to the 16th edition of the HIPS-NET newsletter.

We selected for this edition investment in multiple megawatt electrolysis in France and Germany and on the other side – one European and one global – roadmap supporting the integration of power-to-gas. Even though the power-to-gas plants are supported by grants for capital expenses, the research suggests that there are viable business cases in certain constellations coming up. (The operators are naturally reluctant with further information on their calculations for investment decisions.) Questions of technical integration are still open, as we can see with the HYBURN project on turbines and some answers are given for the effect of rising hydrogen admixture for permeation of gas pipelines, just to mention some of the developments.

We hope you find the newsletter interesting to read!

Your HIPS-NET Team

Gert, Anja, Sylvana & Stefan

PS: Our team is changing temporarily - our colleague Josephine who was supporting the DBI HIPS-NET team is at home for family reasons. We are confident to have her back on board next year in the team. Sylvana, a colleague with in-depth skills for gas network calculation is taking over in the meantime.

Please save the date!

HIPS-NET Workshop

2018

14th June

THE ROADMAP: HYDROGEN SCALING UP | WORLDWIDE

In November 2017, the hydrogen council released the position paper „hydrogen-scaling up", which succeeds the publication „How hydrogen empowers the energy transition" in January 2017. Both papers emphasise the importance of the energy transition and acknowledge that the countries' plans formulated in the Paris Climate Agreement are insufficient to limit global warming to 2°C. This results in the need for a vast energy transition from the use of fossil fuels to renewable, carbon-free energy sources. Hydrogen can play seven major roles in this transformation:

- Enabling large-scale renewable energy integration and power generation
- Distributing energy across sectors and regions
- Acting as a buffer to increase energy system resilience
- Decarbonizing transportation
- Decarbonizing industrial energy use
- Helping to decarbonize building heat and power
- Providing clean feedstock for industry.

HYDROGEN VISION 2050
"HYDROGEN WOULD AVOID 6 GT OF CO_2 EMISSIONS, CREATE A $2.5 TRILLION MARKET FOR HYDROGEN AND FUEL CELL EQUIPMENT, AND PROVIDE SUSTAINABLE EMPLOYMENT FOR MORE THAN 30 MILLION PEOPLE."
(SOURCE: HYDROGEN COUNCIL, "HYDROGEN SCALING UP", P.8, NOVEMBER 2017)

The Hydrogen Council formulates a plan to achieve specific goals in managing the mentioned challenges, with milestones set for 2030 and goals for 2050. The authors' intention is an ambitious but realistic picture based on viable technologies; it does not promote hydrogen as a winner-takes-all solution and considers other low-carbon technologies as well.

For example, in **building heating and power**, a milestone is the use of 3.5 million tons of hydrogen to heat the equivalent of 6.5 million households, either fed in to an existing natural gas pipeline system or with pure hydrogen. In 2050, 8% of global energy used for heat and power shall be provided by hydrogen. Together with waste heat recovery and electrification, these are the main three options to decarbonise building heating. In the vision proposed for the industry, hydrogen is used for medium- and high-heat processes, for which electrification is inefficient.

The hydrogen council focuses heavily on the decarbonisation of the **transport sector** because most carbon emissions can be abated (3.2Gt per year with 20 million barrels of oil replaced per day). The plan includes different low or zero emission technologies, like battery electric vehicles (BEV), fuel-cell electric vehicles (FCEV) and synthetic fuels. That way, the technologies can complement each other with BEVs for small vehicles, synthetic fuels for ships and planes and FCEVs for everything in between. Still, a strong case is made for the further implementation of FCEVs as the council states that by 2030 the efficiency of FCEVs may have gone up by 20-35%, which, combined with decreasing hydrogen costs, may lead to FCEVs having a cost advantage over diesel in all segments. That way by 2030, 10-15 million cars globally and 1 in 12 cars in Japan, California, Germany and South Korea, which are the leading states in the implementation of hydrogen, shall be hydrogen-powered.

Hydrogen is a **feedstock for industry**; with the goal of 30% of methanol and ethanol derivates being produced by hydrogen and CO_2 from carbon capture and utilization (CCU), which will be achievable due to the costs of CCU decreasing from 100 to 40$ per ton of captured CO_2.

In the field of **electricity production**, transportation and storage, hydrogen is an energy carrier. For example, due to the different cost of solar power in Japan and Australia, even with energy losses of 20-30% during the process, imported hydrogen can still be cheaper for Japan than importing electricity by cable. The vessels needed for the transport of hydrogen are estimated to be around 400, which is small compared to ten times as many oil and chemical tankers today.

CO_2 abatement costs will decrease. For example, replacing natural gas with hydrogen in an industrial process would cost 100 to 150$ per ton CO_2 and might drop to around 50$ per ton by 2030. Moreover, higher taxation of CO_2 is necessary to make hydrogen technologies economically viable. Now, less than 5% of global carbon emissions are priced more than 10$ per ton CO_2.

Low percentages of hydrogen - up 5 to 20 vol% - can be safely **blended into existing gas networks** without major adaptations to infrastructure or appliances. Blending hydrogen is actually an old, safe, and proven technology: hydrogen blends are still common in Hawaii, Singapore, and some other areas with limited natural gas resources.

The Hydrogen Council is a global CEO-level initiative of leading energy, transport and industry companies (e.g. Daimler, Honda, BMW, Shell, Total) with a united vision and long-term ambition for hydrogen to foster the energy transition. 13 members founded the Hydrogen Council in January 2017 and grew up to 18 steering members and 10 supporting members.

Contact: **Harriet Barham** at secretariat@hydrogencouncil.com
Source: "How hydrogen empower the energy transition" January 2017
"Hydrogen scaling up" November 2017

EASE / EERA ENERGY STORAGE RECOMMENDATIONS | EUROPE

EASE-EERA presented the Energy Storage Technology Development Roadmap 2017 to the European Commission (Directorate General for R&I and Directorate for Energy) in October 2017 to underpin R&D needs and regulatory changes in the coming decades for energy storage technologies.

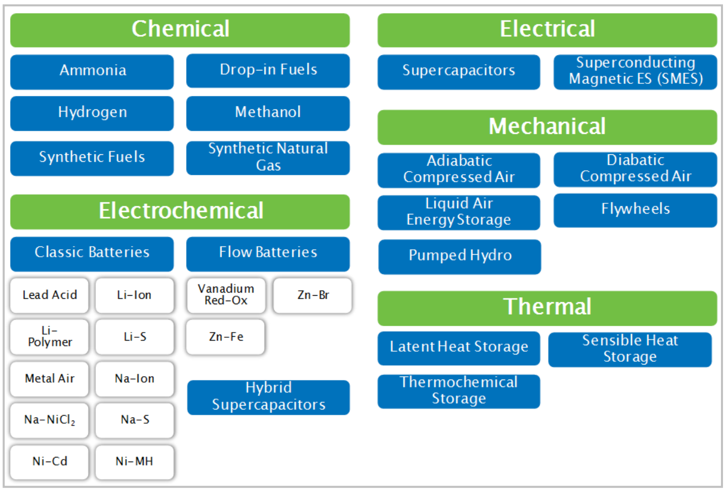
The roadmap aims to inform – with about 120 pages – policymakers for research, innovation, and demonstration in the energy storage sector to strengthen Europe's research and industrial competitiveness in the energy storage industry. It summarises contributions of 80 experts from both leading industry players and researchers.

In one of the core chapters, the roadmap describes different types of storage technology, their technical maturity, applications, R&D targets, identifies gaps, derives research priorities, and recommends research funding, infrastructure development, and incentives.

Hydrogen plays a central role in chemical energy storage. The authors argue, hydrogen is the only realistic chemical storage option (except perhaps ammonia) to avoid CO_2 emissions for all end users. The five given **research priorities** for hydrogen storage technologies mention as fifth point: knowledge build up for health and safety, environmental compatibility (emissions, emission control), reduction of risk of pipeline leakage and corrosion due to hydrogen admixture, existing legal boundary conditions.

The general recommendations include topics, one might know from the own national background, such as:

- establish energy storage as a separate asset class
- establish rules under which energy storage can access markets (e.g. clarify ownership of storage by regulated entities)
- ensure the procurement of all energy and ancillary services is market-based, subject to a Cost-Benefit Analysis (CBA)
- eliminate unwarranted/double charging
- remove regulatory barriers to innovative demonstration and pilot projects
- establish a definition of energy storage in the EU regulatory framework



TECHNOLOGY MATRIX | ENERGY STORAGE TECHNOLOGIES (SOURCE: EASE)

In terms of the 'energy storage' definition, EASE broadly supports a definition similar to the draft EU Electricity Directive:

> "energy storage' means, in the electricity system, deferring an amount of the electricity that was produced [*instead of generated*] to the moment of use, either as final energy or converted into another energy carrier."

This definition has a wide scope as it includes the use of hydrogen beyond the electricity sector for heat, mobility and non-energy applications (industry feedstock), and thus, addressing cross sectoral needs.

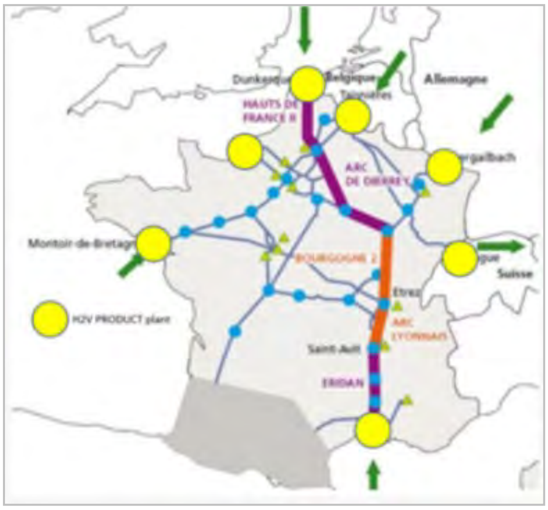
The roadmap proposes for the short term, within the next two years, supporting research for low cost materials also for hydrogen storage; further recommendations specifically for hydrogen are not included. The recommendations nevertheless focus also on the use of the gas infrastructure and its integration with the heat, electricity and refuelling infrastructure (two to five-year horizon). Large-scale demonstration is seen – independent of the type of technology – in the horizon of the next five to ten years.

The European Association for Storage of Energy (EASE) is the voice of the energy storage community, actively promoting the use of energy storage in Europe and worldwide. EASE is structured in three committees, few working groups with various task forces. Some task forces address power-to-gas directly as one option for energy storage. 38 members are supporting EASE.

The European Energy Research Alliance (EERA ERA), is an alliance of leading organisations in the field of energy research.

Contact: **Brittney Becker** at b.becker@ease-storage.eu
Myriam Elisa Gil Bardají at elisa.gil@kit.edu
Source: "EERA Storage Technology Development Roadmap" 2017

Deal for World's Largest Power-to-Gas Project | France



Planned locations of the 7 hydrogen plants
(Source: H2V Product)

H2V PRODUCT – a French company focussing on applications for the massive use of carbon-free hydrogen – has entered into a framework agreement with NEL ASA – a Norwegian hydrogen company, delivering solutions to produce, store and distribute hydrogen from renewable energy. Content of the contract is the design, construction and maintenance of **five hydrogen plants of 100 MW each**, which are planned to build from 2018 until 2025. In total 200 electrolysers would produce about 70,000 tons hydrogen per year. The contract value is around NOK2,450 million (ca. €255 million). Therefore, this proposal will be – so far – the world's largest power-to-gas project. The whole project is financed by SAMFI-INVEST, a private holding company associated with a French industrial partner.

The main utilisation path is the injection of hydrogen as a substitute to natural gas into the natural gas network. One quarter of the production will be marketed, in particular with the refiners. Further planned opportunities are the connection to underground storage facilities in the country and in networks dedicated to supplying mobility infrastructures. The production of hydrogen by electrolysis is not yet economically viable in France, the project partners envisage the implementation of taxes to improve competitiveness.

The first installations - a **100 MW turnkey renewable hydrogen production plant, including 40 electrolysers** – will be build in the North of France and inject hydrogen in the transmission pipeline that supplies a large part of France with gas from Norway.

The parties are expected to reach a final agreement on the delivery schedule in spring 2018.

Number of electrolysers	200
Electrical power rating	610 MW
Annual hydrogen production	72 690 tonnes (814 118 000 Nm³)
Load Factor	92% (8040 h/year)
Total electrolyser flow rate	93 600 Nm³/h

Technical facts about the project (Source: H2V Product)

Contact: **Sandra Moschetti** at moschetti@sam-energy.net
Source: H2V Product, Chemical Parks in Europe

PORTAL GREEN - Simplify Permission Procedures for PtG | Germany

The power to gas technology has been successfully tested and is ready for market introduction. Yet, viable business cases are rare; most plants were built for demonstration purposes. Operation and production of power to gas plants requires first a planning phase including basic and detailed engineering as well as gaining the necessary technical and legal permissions. Since the technology is still perceived as something new, all involved stakeholders on the construction side, the technical approval authorities and the competent legal authority 'pave a new way'. The experience so far reaches from normal to difficult permission processes. Difficulties can occur due to a high level of insecurity for technical and/or legal authorities/ administration, which can result e.g. in a high number of required documents for submission. The preparation of such documents costs time, effort and money and is difficult to predict in its extend. A higher degree of uniformity and clarity develops usually over the time with increasing experience of all stakeholders (learning process).

Portal Green is aiming to foster the technical and legal permission process in Germany with detailed guidelines for construction and operation rules of power to gas plants and thus will speed-up the actual learning process. The guidelines explain the applicable technical standards and legal provisions as well as the required permission processes. This will enhance the (legal and technical) certainty for constructors, operators, technical approval authority and administration. The project started in 2018 and is running for three years. The research is guarded by two public workshops per year; to include expertise as early as possible and regular feedback for the developers.

Save the date!

PORTALGREEN
for efficient permission procedures
1st workshop
in Bonn, Germany

15th May 2018

Supported by:
Federal Ministry for Economic Affairs and Energy
on the basis of a decision by the German Bundestag

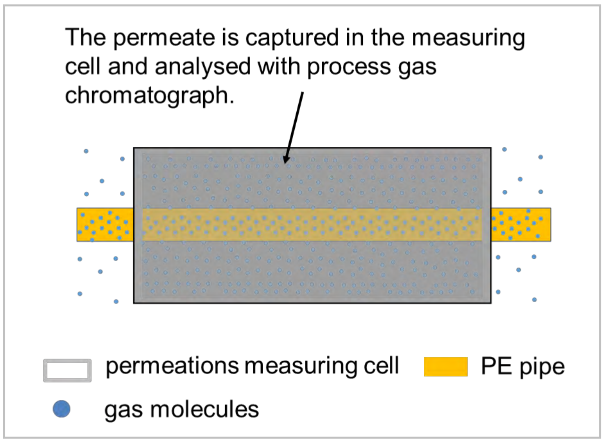
Partners: GRS (coordinator), BUW , DBI GUT, DVGW, Uniper Energy Storage
Project budget: € 1.5 million with co-funding by the BMWi € 1.3 million

Contact: **Dr. Manuela Jopen** at manuela.jopen@grs.de
Anja Wehling at anja.wehling@dbi-gruppe.de

PERMEATION OF HYDROGEN/NATURAL GAS BLENDS | GERMANY

The currently used permeation coefficients for the examination of permeation from gases through plastic pipes are usually valid for a temperature of 20°C. The monthly mean temperature of the soil is often lower. Due to the fact, that the quantity of plastic pipes and the future feed-in of hydrogen are increasing in the German distribution grid the permeation and its reliable examination are of high importance for grid operators. Experts studied the permeation of different plastic pipes in laboratory experiments with methane, hydrogen and gas mixtures. The findings suggest, that especially the temperature and to a lesser degree the pipe material and gas composition influence the permeation coefficient. The developed permeation measuring cells can be installed in field experiments and laboratory (see scheme).

The project analysed four different modern pipe materials (polymer pipe, multi-layer composite pipe and two polymer pipes with aluminium barrier layer). The samples were filled with three different gas compositions (see table).



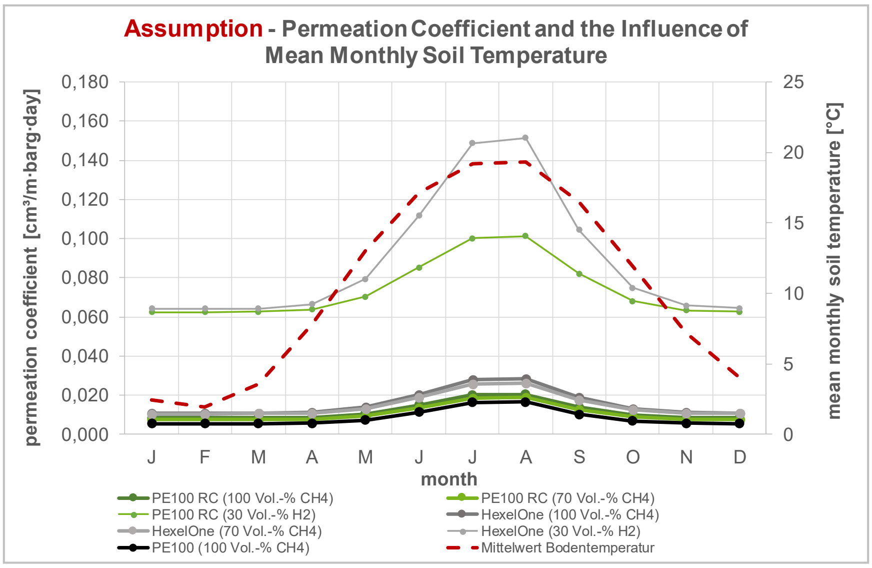
SCHEME OF MEASURING CELL FOR PERMEATION EXPERIMENTS (SOURCE: DBI)

Technical facts about the project	
pipe materials	PE100 RC HexelOne® HexelOne® + barrier layer of aluminium SLA Barrier® Pipe
pipe dimension	DN110 and SDR11
test gas composi-tion	100% CH_4, 70% CH_4 and 30% H_2 100% H_2
test temperatures	20°C and 8°C
duration	1 year
pressure	10 barg and 16 barg

The experts took gas samples from the measuring cell outside the pipe and analysed the gas quality using a process gas chromatograph. You can see the results calculated as permeation coefficient in the diagram.

Applying an educated estimation – with a supporting measurement point at 14°C – the project assumes the dependence between temperature and permeation coefficient to follow an exponential function as shown in the diagram. The monthly mean temperature of the soil varies between 2 and 20° C (one meter below the soil surface for a period of 120 years).

Pipes with barrier layer (for example with aluminuim) are available at the market and prevent to a large extend permeation.



PROJECT RESULT - CALCULATED PERMEATION COEFFICIENTS (SOURCE: DBI)

Contact: **Werner Wessing** at werner.wessing@eon.com and **Stefan Schütz** at stefan.schuetz@dbi-gruppe.de

2.4 MW Power-to-Gas Plant in Hybrid Storage Project | Germany

The multi-megawatt hybrid storage project is embedded in the wider project "NEW 4.0" (short for **N**orthern Germany **E**nergie**w**ende). Industry, administration and science are aiming to develop a viable vision how to supply Northern Germany – 4.5 million inhabitants – with 100 percent regenerative electricity until 2035. The hybrid storage project combines an existing 15 MW wind park with a 2.4 MW power-to-gas plant and a lithium-ion battery. Excess wind electricity will be used for hydrogen production. Wind investors are looking for innovative long-term solutions because feed-in premiums for wind electricity that cannot be fed into the grid will be phased out in the coming years.

The plant produces up to 450 Nm³/h hydrogen. Potential markets are heat, material use (industry) and mobility; negotiations are currently running. The hydrogen can be mixed with natural gas, because the high-pressure pipeline ensures year-round capacity even though the concentration is limited to 2 vol% hydrogen. Furthermore, the nearby ChemCoast industrial complex can be directly supplied with regenerative hydrogen via a potential connection to an existing hydrogen network. Future plans include an additional hydrogen fuelling station. The construction of the hydrogen production will commence in spring 2018.

Overview: Power-to-Gas location Brunsbüttel
(Source: Wind to Gas Energy)

Depending on changes in the legal framework, the project partners hope to scale the size of hybrid storage and reproduce the design in further locations after demonstration and gaining experience in Brunsbüttel.

The hybrid storage project budget is €6 million, including €4 million for the hydrogen plant. It is co-funded under SINTEG programme of the Federal Ministry of Economy (BMWi) with €2 million.

Partners: Wind power plant operators, Enercon and VR Bank eG Niebüll

Funding period: 4 years, December 2016 until November 2020

Supported by: Federal Ministry for Economic Affairs and Energy — on the basis of a decision by the German Bundestag

Contact: **Sonja Engfer** (engfer@w2g-energy.de)
Source: press release Hydrogenics - March 22, 2017 (English)
press release w2g-energy - 28.06.2017 (German)

"Green Refineries" 5 MW & 10 MW PEM Electrolysers | Germany

H&R Ölwerke Schindler inaugurated the world's largest dynamic hydrogen electrolysis plant in November 2017. The Siemens-built 5 MW PEM (nominal capacity) PEM electrolyser is able to produce several hundred tonnes of hydrogen per year. The hydrogen will not be used to produce energy as usual, but instead as a resource in the refinery process (material use) in Hamburg, Germany. H&R shifted hydrogen procurement from external delivery to self-supply. The whole investment totalled at more than €10 Mio, including €2.5 Mio funds procured by ERDF (European Regional Development Fund).

A similar project is planned by Shell Rheinland Refineries in Wesseling, Germany with inauguration in early 2020. The ITM Power PEM electrolyser has a nominal capacity of 10 MW and will produce at maximum 1.300 tonnes hydrogen per year. The entire hydrogen will also be used for the refinery process. The refinery needs more than 180.000 tonnes hydrogen per year, so that the electrolyser adds (only) 0,7 % to conventional produced hydrogen. Shell also wants to create new business models by testing this technology in large scale. The total investment amounts to €20 Mio, including €10 Mio funds by the EU (FCH 2 JU programme).

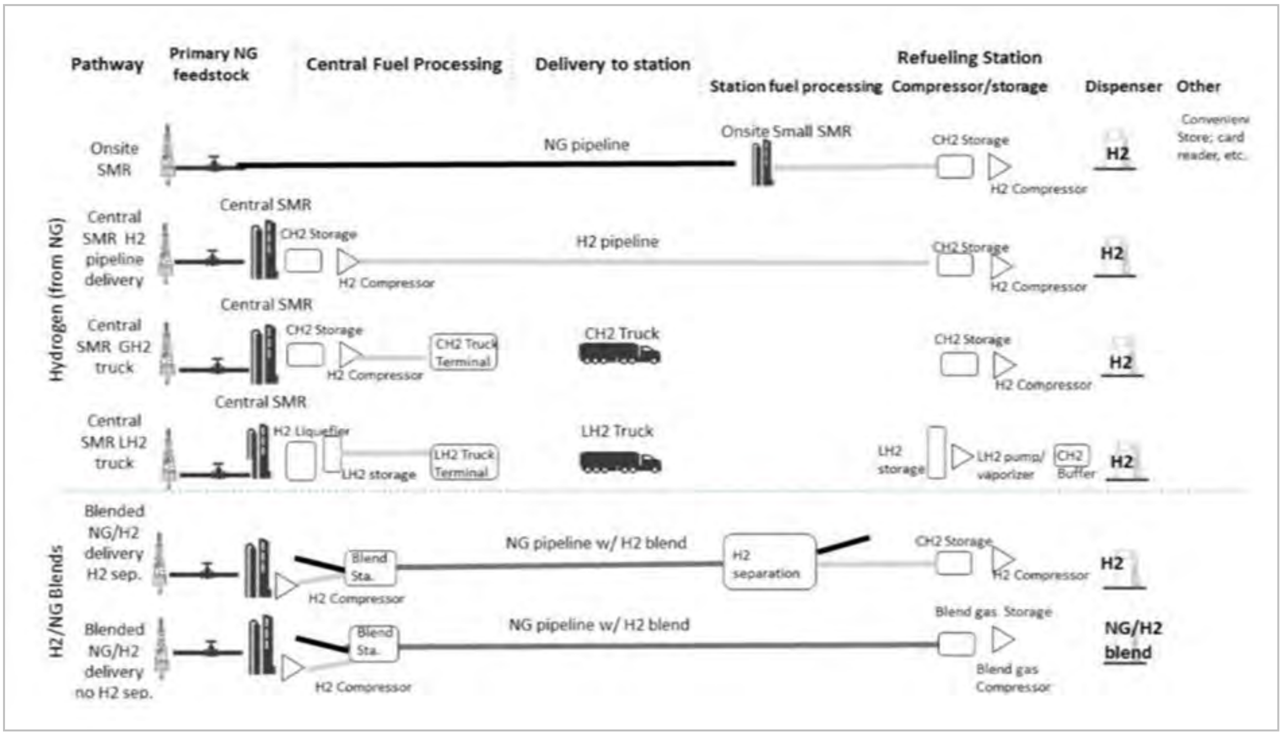
Both projects are aiming to gain experience with the concept of a "green refinery" by production of carbon free hydrogen.

Contact: **Ties Kaiser** at ties.kaiser@hur.com
Jan Zeese at Jan.Zeese@shell.com
Source: press release H&R - 11/24/2017, ITM Power

Hydrogen Blending as Path for Transportation | California U.S

"The Potential to Build Current Natural Gas Infrastructure to Accommodate the Future Conversion to Near-Zero Transportation Technology"

California is looking for future strategies to lower the carbon footprint in the transport sector. The authors examine the natural gas infrastructure that is economically and technologically synergistic for both natural gas and renewable natural gas in the near-term, and alternative fuels like renewable natural gas (RNG) and hydrogen in the long term. Other than in European countries, hydrogen blending is not yet done in California. The supply of hydrogen fuelling stations – though mostly by truck delivery – is in two cases covered by small-scale steam methane reforming. The study addresses blending of hydrogen into a natural gas pipeline and separation at a station as one path in the study. The greenhouse gas reduction potential by admixture is limited for fuel cell vehicles and overbuilding natural gas filling station equipment for future pure hydrogen service is not attractive.



Overview of Case Studies (Source: UC Davis, Report p. 26)

The authors nevertheless suggest the following policies related to hydrogen-blending with natural gas and power to gas (e-gas).

- Conduct a rigorous, **scientifically-based assessment to establish acceptable** limits for hydrogen blend concentrations in California's natural gas system. Develop protocols for introducing hydrogen into the natural gas grid. This assessment will be based on site-specific analyses of hydrogen compatibility, including natural gas end-use, transmission, storage and distribution equipment in California's natural gas system. Timely to do this.
- **Establish a process to certify** different parts of the natural gas system including end□use devices such as end-use appliances, storage, compressors, transmission and distribution pipelines for use with hydrogen blends.
- Establish a **strict regulatory and permitting process for hydrogen blending** with natural gas should be established that includes independent verification of extensive testing that pipes and polymer liners are made of sufficiently strong materials consistent with hydrogen transport and are free from cracks and weaknesses that might be worsened by hydrogen's more corrosive properties.

The report suggests as "rule of thumb", that blending relative low concentrations of hydrogen with natural gas (<5%–15% H_2 by volume) would not significantly increase risks for potential damage to end-use devices (such as household appliances) or adversely affect the durability and integrity of the existing NG pipeline network or public safety.

Authors: Amy Myers Jaffe et al., UC Davis 2017
Source: Research Report – UCD-ITS-RR-17-04 - March 2017

HYBURN PROJECT – Hydrogen Tolerance of Turbines | Germany

Gas turbine power plants are now well optimized for very specific fuels, like natural gas. Despite the maturity of gas turbine power plant technology, most gas turbine combustors will not accept natural gas fuel with high admixture of hydrogen. H_2-enrichment alters the combustion dynamics of natural gas, affecting its burning velocity, auto-ignition limits, flame shape, temperature and susceptibility to extinction. It affects the stability characteristics of the combustor and can lead to stronger combustion pulsation and increased susceptibility to flashback. H_2-enrichment can be beneficial too. In addition to a reduction of CO_2 emissions, it has been observed to extend the operability limits of combustors to leaner conditions, resulting in lower peak temperatures in the combustor and significantly reduced nitric oxide emissions. While frequently observed, these effects are extremely difficult to predict and quantify a priori.

Why is it so difficult to give reliable information about acceptable limits for hydrogen admixture for installed turbines?

The gas turbine engines used in large-scale power generation plants typically operate at pressures of 15 to 20 atmospheres. At these pressures, turbulence in the flows through the combustor becomes so strong that it dramatically affects the structure and dynamics of a flame. The mutual influence between turbulence and chemical reactions changes with the operating condition of the gas turbine and particularly with the amount of H_2-enrichment. There are very few measurements of the structure and dynamics of turbulent flames at gas turbine operating conditions currently available. This leaves engine designers with little choice but to predict combustor dynamics based on trends extrapolated from measurements taken at significantly different flame conditions. The consequences of this can be severe. Despite the mentioned difficulties, as of today the scientists are confident, a multi-fuel capability of gas turbine combustors is technically achievable after research and development work.

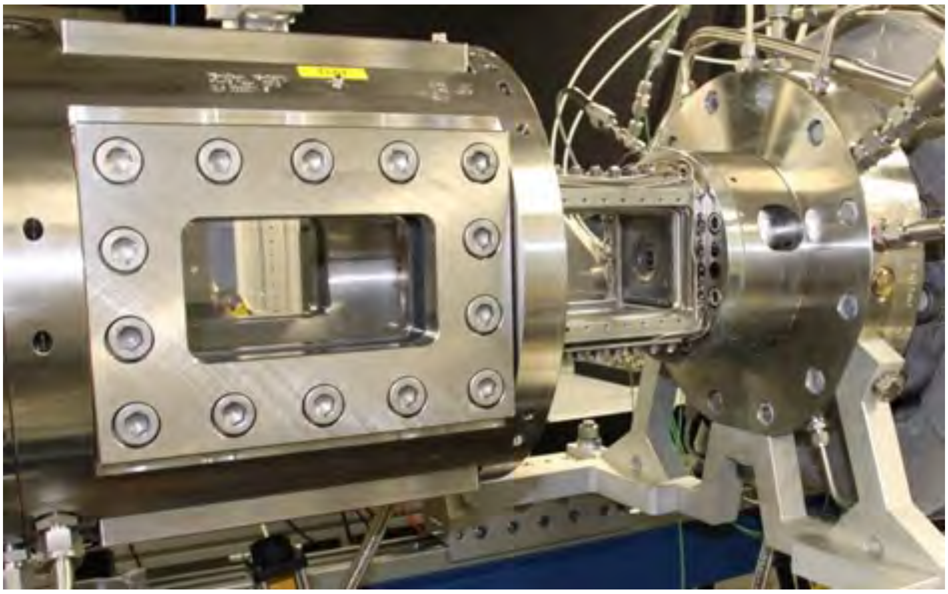
What is the goal of the HYBURN project?

The HYBURN project expands our understanding of how hydrogen enrichment affects flames in gas turbine combustors for power generation and provides guidance for new combustion concepts. The test-rigs of the DLR Institute of Combustion Technology enable the operation of combustors at high pressure and high turbulence conditions found in modern gas turbines. A special feature of the test-rigs is their large optical access provided by quartz glass windows, which enable the application of laser measurement techniques. One of the main goals of the project is to analyse the fast processes of the interplay between the turbulent flow field and the flame by applying by applying advanced laser technology. The scientist anticipate to examine admixture up to 30 vol% of hydrogen in the test rig. Based on this knowledge, engine designers will be able to understand and better predict the dynamics of gas turbine combustors with varying levels of H_2-enrichment.

A further key advantage of the HYBURN project is that it will provide an open-source data set that can be used by European turbine manufacturers to develop their own solutions to the challenges of H_2-enriched combustion. By avoiding OEM-specific, proprietary combustor designs, the HYBURN project will generate a unique resource to benefit all European gas turbine manufacturers.

Project duration: 5 years, June 2016 until May 2021

Funding: €2 million by European Research Council



High-pressure test-rig with optical access for the study of gas turbine combustion (source: DLR)

Contact: **Dr. Isaac Boxx** at isaac.boxx@dlr.de
Source: press release DLR - 02.03.2016 (German)

SELECTION OF APPOINTMENTS 2018

April 17-19	**Global Energy Village 2018** (Barcelona, Spain)
April 25-28	**EnerSTOCK 2018 – 14th International conference on energy storage** (Adana, Turkey)
April, 23-27	**Hanover Messe – Hydrogen, fuel cells and battery exhibition** (Hanover, Germany)
May, 17	**WHEC – 22nd World Hydrogen Energy Conference** (Rio de Janeiro, Brazil)
June, 6-7	**8th German Hydrogen Congress** (Berlin, Deutschland)
June, 13-14	**HIPS-NET Workshop 2018** (Brussels, Belgium)
June, 25-29	**27th World Gas Conference** (Washington DC, USA)

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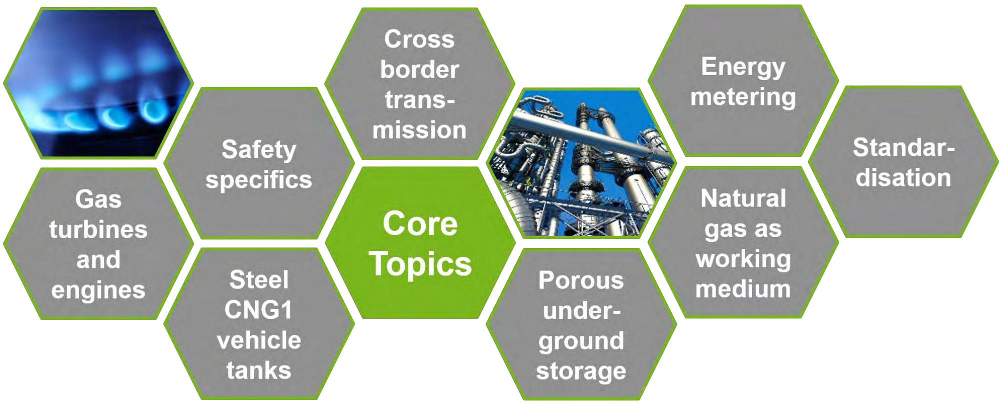
HIPS-NET CORE TOPICS

We gather and disseminate the latest available knowledge to improve the understanding of hydrogen/natural gas blends in pipeline systems with emphasis on the core topics:

We additionally keep a minor focus on the general development of power-to-gas, hydrogen networks, and further topics around the utilisation of (renewable) hydrogen.



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HIPS-NET

"ESTABLISHING A PAN-EUROPEAN UNDERSTANDING OF ADMISSIBLE HYDROGEN CONCENTRATION IN THE NATURAL GAS GRID"

NEWSLETTER #17	June, 2018

CONTENT NEWSLETTER #17

"A network leads to cooperation, cooperation leads to creativity and innovation - this changes the world." Marissa Mayer (CEO Yahoo)

17TH HIPS-NET NEWSLETTER

Dear Colleagues,

We welcome you to the latest version of our HIPS-NET newsletter. Once again, we are happy to provide you with new insights into our core topics, and general developments in the fields of power-to-gas and hydrogen. We hope you find the articles interesting and informative. Please feel free to let us know if you are interested in a specific topic, or have heard of any further advances in the state of the art.

We cover in the present edition developments of gas turbines and the ability to handle fluctuation hydrogen concentrations in the gas stream. Further, feature articles include two reports underpinning the importance of the gas infrastructure in future in Germany. The conclusions may be transferred to other European countries. France is taking decisive steps forward in proposing a vision for a 100 % renewable gas mix. The Netherlands are taking this vision forward with a hydrogen roadmap for a Dutch ministry. The newsletter also introduces an update of the HYREADY project which is in its final phase. Just to mention some of the topics, you will find further subjects covered.

Our next HIPS-NET workshop is just around the corner on 13th/14th June. After the success of previous workshops, we look forward to seeing many of you at the GERG premises in Brussels. We expect meeting 25 colleagues this week and having another chance to exchange ideas and information.

Your HIPS-NET Team

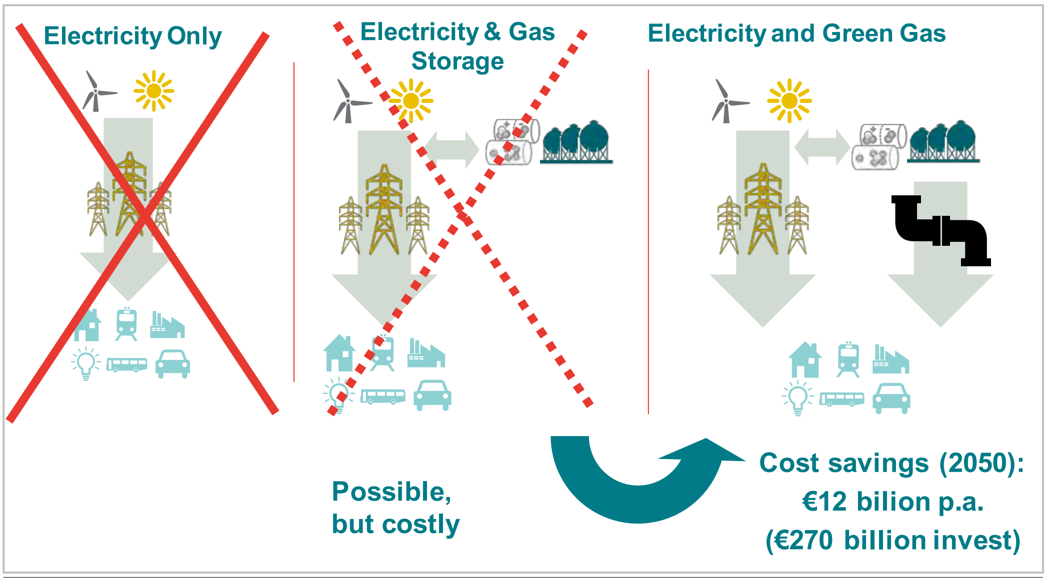
Gert, Anja, Sylvana & Stefan

The Importance of the Gas Infrastructure in 2050 | Germany (1/2)

The Paris Climate Agreement aims to achieve a rapid reduction of climate-damaging emissions worldwide to limit global warming to two degrees. Severe weather events, as the heat wave in summer 2003, has already given us an impression of what the future might look like even if we succeed to reach the Paris' goals. The German gas transmission operators issued a study looking at possible future infrastructure scenarios until 2050 to reduce greenhouse gas emissions in Germany up to 95 % as compared to 1990.

Greenhouse gas reduction can be achieved using renewable electricity in transport, heat, and industrial sectors. However, the question how energy is transported to the end-consumer and how it should be stored, is still unsolved. The study "The importance of the gas infrastructure for Germany's energy transition" proposes using a mix of electricity and gas infrastructure – as opposed to an all-electric infrastructure that politicians seemed to focus on earlier – after comparing three different scenarios:

- "Electricity only"-scenario
- "Electricity and gas storage"-scenario
- "Electricity and green gas"-scenario



Schematic overview of the three scenarios including results
(Source: Frontier Economics)

"Electricity only" – unfeasible option

In the "Electricity only"-scenario the supply of energy is only made by electricity storage and networks without using any gas. The analysis shows that this is impractical and prohibitively expensive, due to the seasonality of heat demand, which requires an immense effort to provide sufficient capacity, and due to missing technological options for long-term electricity storage.

"Electricity and gas storage" – limited use of the gas infrastructure

In the "Electricity and gas storage"-scenario the final energy use is based on electricity. Gas technologies (e.g. power-to-gas) are only used for long-term storage. Thus, gas distribution and transportation networks are no longer required.

"Electricity and green gas" – safe energy supply and cost-effectively

In the "Electricity and green gas"-scenario, end consumers can also use green gas applications – in addition to electric applications. The electricity network gains of importance but the gas infrastructure is still required for transport and distribution. Power-to-gas as the production technology of "green gas" with renewable electricity is widespread.

The German gas (mainly transmission) network features parallel (redundant) pipelines (including loop lines) in many areas. These could be decoupled in future and used for a separate hydrogen network to supply industrial customers and power plants. The supply of household customers will also in the future rely on mainly methane and avoid costly technical conversions. The study assumes that 50 % (energy content) of the green gas is methanised and particularly served for the transmission and distribution of heat, while the other half is directly transported and used as hydrogen.

The "Electricity and green gas"-scenario offers significant advantages for end consumers by directly using green gas. As the diagram on the next page shows, the system costs will save 12 billion Euro per year by 2050 using gas networks. An important element of these savings are savings of 10 billion Euro per year for replacing end-user applications, while 6.3 billion Euro would be saved through lower expansion requirements of the electricity network. All in all, these savings outweigh the additional costs of 4 billion Euro per year caused by using gas to deliver energy.

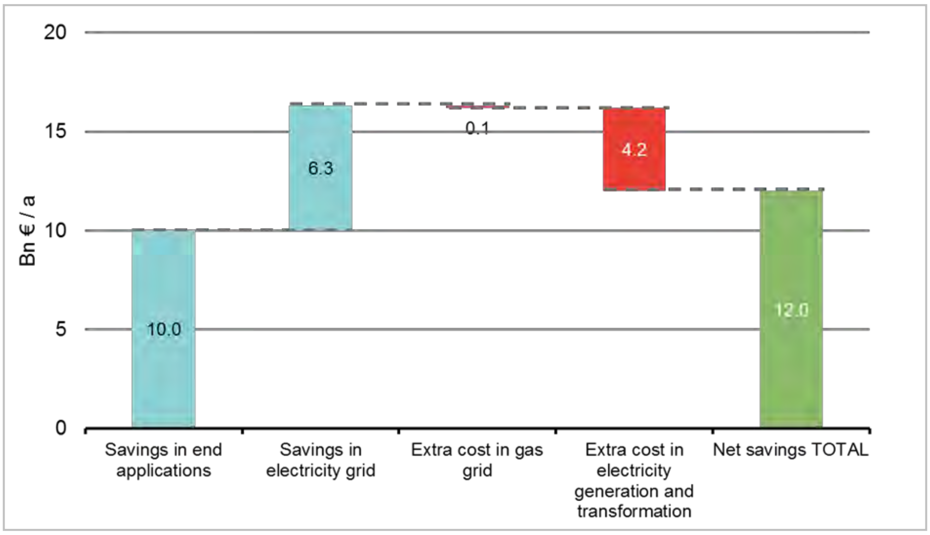
Compared to the "Electricity and green gas storage"-scenario, the expansion of the electricity distribution network can be reduced by 60 % and the electricity transmission network by 40 % by using the gas infrastructure. Thus, utilising the existing gas infrastructure will increase the public acceptance of the energy transition. Furthermore, security of energy supply is raised because of extensive storage options by retaining the gas network.

The Importance of the Gas Infrastructure in 2050 | Germany (2/2)

(continued)

To summarise, retaining gas networks offers substantial benefits, i.e. significant cost savings as well as an increase in public acceptance and supply security.

Partners: Frontier Economics, IAEW Aachen, 4 Management, EMCEL
Contact: **Dr. David Bothe** at david.bothe@frontier-economics.com
Source: "The importance of the gas infrastructure for Germany's energy transition" January 2018



Annual system net cost savings by 2050 (Source: Frontier Economics)

100% RENEWABLE GAS MIX IN 2050 | France

Carbon neutrality by 2050 is one of the ambitious objectives of the French Climate Plan, initiated in July 2017 by France's Minister of the Ecological and Inclusive Transition. ADEME, in an effective collaboration with GRDF and GRTgaz, has explored the technical and economic feasibility of 100% renewable gas in 2050, reaping the full potential of electricity/gas sector coupling. The study explores the conditions of feasibility and obstacles of such an ambition and recognises gas as second most consumed grid energy. The total demand in 2050 for gas is forecasted around 300 TWh_{HCV}, compared with today's figure, 460 TWh_{HCV}. The authors favoured scenario: demand will be covered by anerobic digestion (30 %), pyrogasification (40 %) and electrolysis/ methanation (30 %).

Renewable gas mix in four scenarios in 2050
(Source: "A 100% renewable gas mix in 2050?" January 2018, page 6)

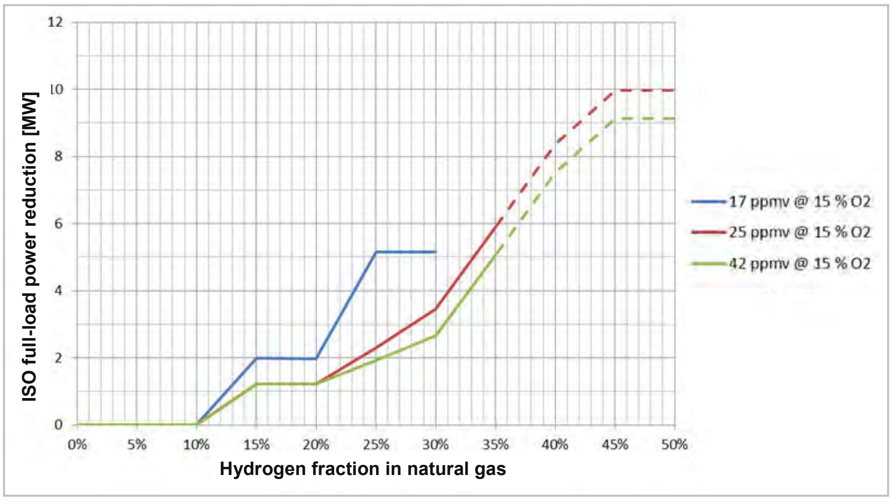
This study follows a cautious approach to ensure grid compatibility and sets the current technical knowledge about hydrogen tolerance as limit for the future scenarios. The French gas infrastructure can currently handle admixtures up to 6 vol%. The renewable gas injected in the grids will therefore consist of synthetic methane mainly, but hydrogen could account for 6 vol% of the gas mix, originating from power-to-hydrogen. The gas demand will be covered with up to 140 TWh_{HCV} of gases from power-to-gas. The total cost of gas consumed per MWh, i.e. the sum of production costs and network and storage costs, varies from €105 to €153 per MWh_{HCV}. These costs are in the same magnitude the €120-130 per MWh_{HCV} calculated for electricity in the study "A 100% renewable electricity mix? Analyses and optimisations" (2015). Network and storage costs only represent a small proportion: 15-20% of total cost (€20-23/MWh_{HCV}). In particular, the sole cost of connection, including limited distribution network reinforcement needs and reverse flow stations, represent approximately €3/MWh_{HCV}.

Contact: **ADEME - French Environment & Energy Management Agency**
Source: "A 100% renewable gas mix in 2050?" January 2018 (english summary)
"Un mix de gaz 100% renouvelable en 2050" January 2018 (full report in French)

TOLERANCE OF TURBINES FOR VARYING HYDROGEN CONCENTRATIONS

What is the hydrogen tolerance of gas turbines? Most of us know, either due to previous articles or from other sources that the unknown hydrogen tolerance of gas turbines is one of the constraints to raise hydrogen concentration in the gas network.

Turbine OEMs are addressing the technical challenges of hydrogen rich gases. Kawasaki for example developed based on a conventional Dry-Low-NO_x (DLN) combustor with hydrogen injection over a supplemental burner up to 60 vol% hydrogen tolerance. With this combustor, it can be switched from natural gas to hydrogen or natural gas and hydrogen mixing gas. The NO_x emission can be kept below 25 ppm guaranteed level.



IMPACT OF HYDROGEN ADMIXTURE ON POWER REDUCTION OF A 50 MW SIEMENS TURBINE (SOURCE: SIEMENS)

Similarly, also Siemens successfully tested DLN turbines at full load with hydrogen admixture up to 50 vol% and reports from continuous operation since September 2014 with 10 vol% hydrogen. The results prove the burners comply with NO_x emission limit of 17 ppm while burning quantities of up to 30 vol% hydrogen and 25 ppm with up to 50 - 60 vol% H_2. Moreover, it is possible to vary the co-firing in the gas turbines in any range from 0 vol% to the highest possible hydrogen ratio, according to information from Siemens experts. Extending the fuel flexibility of the SGT-800 turbine – a well proven design with more than 330 units sold worldwide – with higher (i.e. >15 vol% H_2) levels of hydrogen is now commercially available. The downside: Mixing hydrogen into the gas stream showed a clear effect on emissions. The chosen approach accepts power reductions to stay within the emission limits as the diagram shows. Development is ongoing for SGT-800 to be emissions compliant with H_2 co-firing also at full load.

By the way, the tested turbine model is mostly installed for combined cycle for electricity production. Last but not least, we were asking whether it is possible to improve the hydrogen compatibility of existing gas turbines. Siemens experts acknowledged the importance of this question but also see the difficulties: "Since there are very many existing gas turbines on the market it is interesting to understand to what extent they can be retrofitted. This work is ongoing. For our SGT-800 turbine (Dry-Low-NO_x) work is ongoing and we think 100% H_2 is definitely possible, but the burner design might need changes to the extent that it is far from existing standard ones. This will in the end be a matter of cost."

Contact: **Prof. Jenny Larfeldt** (Siemens Industrial Turbomachinery AB, Finspång, Sweden)
Source: Nurettin Tekin et al., "Enhancement of fuel flexibility of industrial gas turbines", VB PowerTech, November 2017
"Hydrogen addition to flames at gas-turbines-relevant conditions" May 2017

HYDROGEN ROADMAP | NETHERLANDS (1/2)

"The introduction of hydrogen must be launched *here and now*." – one central messages of the action plan of the Hydrogen Roadmap, commissioned by the Dutch Ministry of Economic Affairs and Climate Policy.

The Netherlands currently have over 100 hydrogen initiatives in various stages of development, and this number is growing. In the transition pathways of the Dutch Energy Agenda, hydrogen is emerging as one of the pillars of the energy transition, in addition to all kinds of other sustainable and climate-neutral options.

The Roadmap illustrates the renewed and large interest in the role hydrogen can play in the Energy Transition in the Netherlands. Currently, it is high on the political agenda and intensively discussed in light of the Climate and Energy Agreement 2.0 that will outline the way forward to achieve 2030 climate goal (minus 49% compared to 1990 CO_2 levels) as an intermediate step towards 2050. The study – as one of many recently – underlines that Paris climate goals needs the reduction of net greenhouse gas emissions related to the use of fossil energy to 'zero' in 2050.

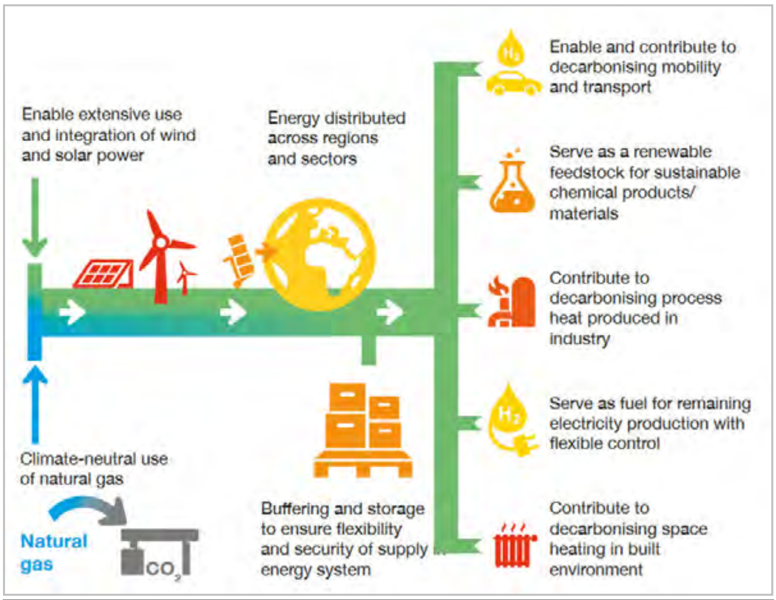
Hydrogen Roadmap | Netherlands (2/2)

(continued)

The findings are a result of active participation (via workshops, discussions etc) and address three topics:

1. Outlining the potential of sustainable hydrogen in the energy supply in 2050
2. Mapping out the various actions and actors in the Netherlands regarding sustainable hydrogen
3. Defining the initial steps and actions to realise the potential of sustainable hydrogen and the role the central government and other parties are expected to play in this process

The importance of electricity is rising and accounts for about 50 % of the final energy consumption. This leaves a great need for fuels, namely gaseous and liquid ('molecules'). The authors concentrate hydrogen usage mainly for applications with limited possibilities for electrification as the picture shows.



Roles and Functions of Hydrogen
(Source: "Outlines of a Hydrogen Roadmap" May 2018, page 18)

With the vision of direct hydrogen use in the future, it is suggested to utilise the high-pressure natural gas infrastructure, as it can cope with high percentages of hydrogen (up to 100 %) after necessary modifications. The study covers further topics, we decided to concentrate on only selected topics. If you are curious, please take a look at the study of Topsector Energie.

Contact: **Jörg Gigler** at jorg@gigler.nl (director TKI New Gas)
Source: "Outlines of a Hydrogen Roadmap" May 2018

Power-to-gas and the North Sea Wind Power Hub

Two main reasons are driving the project idea of the North Sea Wind power hub: First, the energy sector must be fully decarbonised well before 2050 to fulfil the Paris Agreement & second, offshore wind is essential to realise 100 % decarbonisation of the electricity supply. The project North Sea Wind Power Hub joined forces to develop a large scale European electricity system for offshore wind in the North Sea.

With mass-scale wind power roll out, conversion and storage solutions such as power-to-gas could help balance and stabilise power transmission to onshore markets, limiting investments in interconnectors. Furthermore, a strong development of power-to-gas may have a significantly positive effect on the business case for the wind farms offshore. Instead of curtailing or delivering electricity in hours with low or zero-prices, selling hydrogen to the mainland can generate additional revenues.

Left picture: individual network connection for offshore wind farms
Right picture: centralised connection via North Sea Power Hub
(Source: image film NSWPH)

Project Partners: Gasunie, TenneT, Port of Rotterdam, Energinet
Contact: info@northseapowerhub.eu
Source: "Gasunie to join North Sea Wind Power; Hub consortium", September 2017
Studies: https://northseawindpowerhub.eu/studies/
Image film: https://northseawindpowerhub.eu/project/

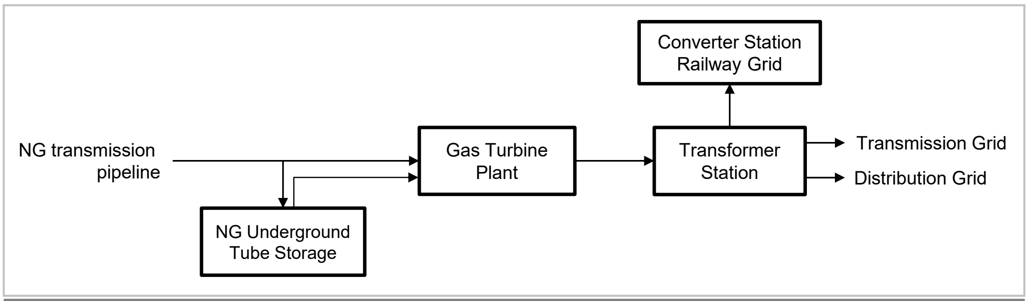
The volumes of offshore wind energy required for the energy transition are so large that gas-based transmission and storage solutions may be considered as a vital element in addition to electricity connections in order to ensure a cost-efficient transition. The costs of energy transmission and long-term storage in gas form are considerably lower per unit of energy than if the energy is transmitted and stored in the form of electricity. In addition, combining the strengths of the electricity and gas supply system can provide a key boost to the use of hydrogen as a sustainable solution in numerous applications in industry, transportation, and the built environment.

RES & STORAGE FEASIBILITY STUDY SPERENBERG | GERMANY (1/2)

CONCEPTS FOR AN INNOVATIVE POWER PLANT COMBINING RENEWABLES AND ENERGY STORAGE TECHNOLOGIES

On behalf of the Ministry for Economic Affairs and Energy of State Brandenburg (Germany), innovative power plant concepts were developed and investigated for a specific location in Brandenburg in a feasibility study. The concepts were supposed to combine renewable energy sources (RES) with energy storage technologies. One main aspect was to integrate an existing natural gas infrastructure by the means of renewable gases and hydrogen in specific.

The foremost aim of the study was to develop an innovative energy concept for re-utilizing a conversion area in Sperenberg, a place approximately 60 km in the south of Berlin. The 3,500 hectare area was formerly used for various military purposes throughout the years of the German empire in the 1870ies until the Soviets left around 1990.



SCHEMATIC DEPICTION OF EXISTING ENERGY INFRASTRUCTURE IN THYROW
(SOURCE: DBI GUT GMBH, GERMAN STUDY: "MACHBARKEITSSTUDIE SPERENBERG" JANUARY 2018)

In Thyrow, with round about 12 km not far from the location, one can find a unique energy infrastructure interfacing different networks of electricity and gas as schematically depicted in the figure.

On the gas side there is a six-unit gas turbine plant with a total rated power of 187 MW, built 1989 and supplied with natural gas from a transmission pipeline. Since 2010 it also has an underground tube storage attached, holding a volume of up to 480.000 m³ natural gas which can run the plant for approximately 8 hours.

On the electricity side there is the power plant's grid connection at the transformer station Thyrow on transmission level (280/220 kV) and distribution level (110 kV) interface. Beyond that, a converter station is directly attached and interconnects the independent electricity grid of the German railway and the public electricity grid.

Due to the location in a nature reserve area and a pile of legal restrictions, the first step was mapping the legal situation for renewable energies, especially wind and solar, at the very location in Sperenberg. After that, the unique infrastructural characteristics, i.e. the vast conversion area and the existing energy infrastructure, were the starting point of the concept development process. Within these, certain objectives were specified and prioritised with the customer. These were especially: legal and technical feasibility, innovative strength in the field of system integration of renewable energies, integration of the existing energy infrastructure and little required funding.

Based on these objectives, four concepts with estimated time schedules were developed and modelled techno-economically all differing in system configuration, innovative strength and (future) business case.

- **Gas Grid Injection**
  The idea of this concept was to produce hydrogen from renewable electricity and inject it into the transmission pipeline for direct marketing to private and commercial customers.
- **Power-to-Gas-to-Power Balancing Power**
  The idea of this concept was to provide negative balancing power in an electrolyser and positive balancing power by reconversion of the hydrogen into electricity in the gas turbines for the electricity grid and offer it on the balance power market.
- **RES Traction Power Plant**
  The idea of this concept was to imitate the flexible electrical properties of a conventional power plant by combining wind and solar power with a short-term (battery) and long-term storage (electrolyser, tube storage, gas grid, gas turbine). This was done in order to be able to supply the variable load curve of the converter station of the German railway.
- **Flexible RES Power Plant**
  The idea of this concept was to dimension a power plant option which could supply 70,000 inhabitants in the surrounding and follow their load curve with renewable electricity at all time. It was based on an identical system configuration as for the concept RES Traction Power Plant.

The results of the techno-economic modelling showed that for all concepts apart from concept Power-to-Gas-to-Power Balancing Power a technically sensible system configuration could be dimensioned. The economic outcomes, however, varied strongly between the single concepts and showed an estimated required funding of between 50 (Gas Grid Injection) and 780 million € (Flexible RES power plant) for the power plant concept over a 20 years lifetime.

The consortium's final recommendation for the customer regarding the concepts was to pursue the concepts Gas Grid Injection for a straight-forward option with little funding and RES Traction Power Plant for an ambitious option with high international innovative strength and moderate funding.

RES & STORAGE FEASIBILITY STUDY SPERENBERG | GERMANY (2/2)

(CONTINUED)

Most of the developed concepts utilise the existing natural gas infrastructure in one or another way. This comprises simply injecting hydrogen into the transmission pipeline, requalifying the underground tube storage for pure hydrogen or even running the gas turbines fuelled by a NG-H2 mixture which is calculatory carbon-neutral.

Despite the promising techno-economic outcomes and a broad willingness within the operators of the existing infrastructure at the same time, the results of the planning regulation analysis especially for wind but also for solar power at the conversion area in Sperenberg showed to be rather challenging. So, another main recommendation of the authors was to – in a first step – proactively start the process of establishing the planning prerequisites for wind and solar power at the areas identified within the location in the study.

	Objectives			
	Techn. Dimension	Innovative Strength	Integration Infrastructure	€ Estimated Required Funding (over 20 Years)
Gas Grid Injection	38,4 MW WEA 2,6 MW PV 31,2 MW ELY	💡💡	🔗🔗	50 million €
Power to Gas to Power Balancing Power	2,16 MW ELY	💡💡	🔗🔗🔗	36 million €
RES Traction Power Plant	52,8 MW WEA 14,7 MW PV 22,2 MW ELY 53,5 MW BAT	💡💡💡💡	🔗🔗🔗🔗	220 million €
Flexible RES Power Plant	115,2 MW WEA 101,8 MW PV 48,9 MW ELY 164,1 MW BAT	💡💡💡	🔗🔗🔗	782 million €

RESULTS OF RENEWABLE ENERGY GENERATION CONCEPTS
(SOURCE: DBI GUT GMBH, GERMAN STUDY: "MACHBARKEITSSTUDIE SPERENBERG" JANUARY 2018)

Partners: DBI GUT, Müller-Wrede & Partner, Reiner Lemoine Institut
Contact: **Steffen Schlegl** at steffen.schlegl@mwe.brandenburg.de
Marek Poltrum at marek.poltrum@dbi-gruppe.de

INTEGRATED ENERGY TRANSITION | GERMANY

The "dena-Leitstudie Integrierte Energiewende" was published in June 2018. The pilot study translates as "integrated energy transition" and was initiated by the German Energy Agency. It is expected to play an important role for future policy decisions of parliament and government as guiding instrument. 18 months of intensive work with about 250 participants in the study and the accompanying dialog process resulted in exciting findings and recommendations.

What are the best possible transformation paths to decarbonise Germany and reach the Paris' climate goal? The authors recommend:

1. 80 % or 95 % greenhouse gas reduction in 2050 – the goal needs clarification. It does make a big difference and influences the decision-making process today already.
2. Allow a wide range of technologies and energy carriers instead of focussing on selected. This saves up to 600 billion € in comparison to focus mainly on electric technologies.
3. 8.5 gigawatt each year for new renewable electricity generation capacity is needed in Germany. The current market design and system integration needs further development.
4. **Synthetic gaseous and liquid energy carriers are crucial.** Combine imported and national production. They cover in 2050 between 150 and 900 TWh per year and are named "Green PowerFuels".

One of the main pillars – and this is a rather new development in Germany after many years awareness work – are synthetic gaseous and liquid energy carriers. To take this development serious, market launch of power to gas capacity needs to start today, in the running parliament season. The learning curve follows an exponential function and needs time to develop its effects. International trade for a global market needs to grow and support by the German governments on high political level.

Beyond production and use of synthetic gaseous and liquid energy carriers, the pilot study underlines the importance of infrastructure development also for gas network. Raising the hydrogen tolerance of the gas network is explicitly recommended. Joint duties are placed with the government and the gas network operators for future transport and distribution of rising hydrogen shares. The study acknowledges and relies on the importance of the electricity network but it includes the need for further networks such as gas, heat, and for power-to-liquid in addition.

The pilot study contains a promising outlook for near future market uptake of power-to-gas production. It is worth reading for the role of the gas infrastructure as well as further discussion (i.e. electric overhead infrastructure for heavy goods traffic).

Source: german study, "dena-Leitstudie Integrierte Energiewende" June 2018

UPDATE ON HYREADY | EUROPE

In order to support the decarbonisation of the energy system and to put focus on more and more sustainable energy supply, stakeholders are considering the accommodation of hydrogen (e.g. from power-to-gas) in the natural gas grid. With HYREADY Guidelines, transmission and distribution system operators (TSOs and DSOs) can prepare their natural gas networks and operations for the injection of hydrogen with acceptable consequences. The guidelines will be based on existing knowledge and particularly address practical questions, including a sound balance between mitigation measures and remaining consequences.

Challenge

The chemical and physical properties of hydrogen differ from those of natural gas. As natural gas does not usually contain any hydrogen, the design of the gas infrastructure is focused on natural gas. Examples of possible impacts of hydrogen added to natural gas in the natural gas system are:

- Material degradation
- Safety (e.g. zoning, suitability of safety devices)
- Performance and integrity of end user equipment, such as burners, engines and turbines
- Performance of measurement equipment, including gas chromatographs
- Gas losses due to permeation through pipe walls
- Efficiency reduction of compressors
- Reduction of transmission capacity in MJ/h

Currently there are no guidelines for the gas infrastructure supporting TSOs and DSOs preparing their assets for the injection of hydrogen with acceptable consequences.

HYREADY Objective

To prepare guidelines for TSOs and DSOs to support the preparation of natural gas networks and operations for the injection of hydrogen with acceptable consequences. They should lay down sound engineering practice and guidance on mitigation measures to ensure that the considered hydrogen injection in the natural gas system can be done with acceptable consequences.

Approach

HYREADY will distinguish the impact of hydrogen on the natural gas system and feasible countermeasures on:

- Component level: To which extent are the components' performance and characteristics – including lifetime, leakage, permeability, efficiency, accuracy– affected by hydrogen?
- System level: To which extent is the functionality of the system affected by hydrogen addition? Think of e.g. network capacity (MJ/hr) and caloric determination system for billing purposes
- Location level: To which extent are the installation requirements, including safety zoning, affected by hydrogen addition?
- Operational level: To which extent are repair procedures, maintenance tools, personal safety equipment, etc. affected by hydrogen addition?

Deliverables

Practical guidelines to support gas TSOs and DSOs in preparing their networks and end users for hydrogen addition to natural gas with acceptable consequences. They will describe an unbiased methodology where practical "how-to" questions will be addressed.

The HYREADY Guidelines will be based on existing knowledge and will be treated as confidential among project partners. The HYREADY Guidelines are to be converted into DNV GL Recommended Practices. These documents will be public documents, but will contain less detail than the HYREADY Guidelines.

Project Status

The first project phase, comprising gas transmission and gas distribution networks will be finalised by the mid of 2018. The project has been supported by an increasing number of partners (see above) and was conducted by DNV GL and DBI. A follow up activity focusing on further assets in the gas chain is currently discussed and expected to start in the second half of 2018. The project is open to further interested party.

Contact: **Albert van den Noort** at albert.vandennoort@dnvgl.com

Selection of appointments 2018

June, 25-29	**27th World Gas Conference** (Washington DC, USA)
June, 27	**3rd HYPOS Dialogue - Hydrogen Safety** (Halle, Germany)
July, 5	**6th Hydrogen Day Lampoldshausen** (Lampoldshausen, Germany)
July, 24 - 27	**Hypothesis XIII - HYdrogen POwer THeoretical & Engineering Solution International Symposium** (Singapore, Republic of Singapore)
July, 26-28	**China International Hydrogen and Fuel Cell Exhibition (CHFCE)** (Beijing, China)
August, 23-24	**Renewables Confo 2018** (Singapore, Republic of Singapore)
September, 13	**Annual Meeting of the Network Fuel Cells and Hydrogen, Electric Mobility** (Wuppertal, Germany)
September, 18-19	**F-Cell 2018** (Stuttgart. Germany)
September, 24-27	**Hydrogen + Fuel Cells North America** (Anaheim, California, USA)

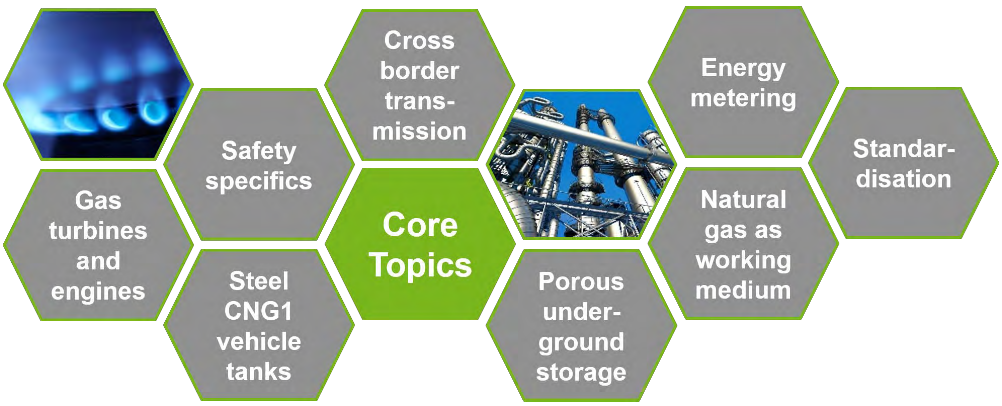
Current Partners

Alliander AG ++ Areva H_2Gen ++ DEA Deutsche Erdoel AG ++ DGC ++ DNV GL ++ Enagás ++ Enbridge ++ Energinet.dk ++ ENGIE ++ EWE Netz ++ Gas Natural Fenosa ++ Gasum OY ++ Gasunie ++ GRTgaz ++ grzi e.V. (figawa) ++ Infraserv GmbH & Co. Höchst KG ++ INERIS ++ innogy SE ++ ITM Power ++ EC Joint Research Centre (JRC) ++ KOGAS ++ NAFTA ++ ONTRAS ++ Open Grid Europe GmbH ++ ÖVGW ++ RAG Rohöl-Aufsuchungs AG ++ Shell ++ Solar Turbines Europe ++ Storengy ++ SVGW ++ Synergrid ++ TIGF ++ Uniper Technologies Limited ++ Verband der Chemischen Industrie (VCI) ++ Volkswagen AG ++

HIPS-NET Core Topics

We gather and disseminate the latest available knowledge to improve the understanding of hydrogen/natural gas blends in pipeline systems with emphasis on the core topics:

We additionally keep a minor focus on the general development of power-to-gas, hydrogen networks, and further topics around the utilisation of (renewable) hydrogen.



HIPS-NET Contact

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DBI Gas- und Umwelttechnik GmbH
Karl-Heine-Straße 109/111
04229 Leipzig
GERMANY

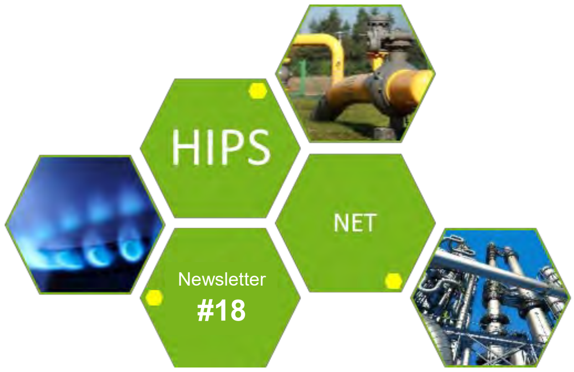
www.dbi-gruppe.de

CEO: Prof. Dr. Hartmut Krause, Olaf Walther

Certified DIN EN ISO 9001:2008

GERG groupe européen de recherches gazières the european gas research group

DBI GUT Gas- und Umwelttechnik GmbH



HIPS-NET

“ESTABLISHING A PAN-EUROPEAN UNDERSTANDING OF ADMISSIBLE HYDROGEN CONCENTRATION IN THE NATURAL GAS GRID”

NEWSLETTER #18 | **October, 2018**

CONTENT NEWSLETTER #18

“A network leads to cooperation, cooperation leads to creativity and innovation - this changes the world.“ - Marissa Mayer (CEO Yahoo)

18TH HIPS-NET NEWSLETTER

Dear HIPS-NET Partners,
Dear HIPS-NET Colleagues,

In this issue of our HIPS-NET Newsletter we would like to draw your attention to a study ordered and paid by EU DG Ener about the value of hydrogen for sectoral integration. Rapid greenhouse gas emission reductions up to 95 % shortly after 2050 are needed and they can be reached by sector coupling via hydrogen.

Furthermore we address with two articles the topic of storing hydrogen/ natural gas blends as well as pure hydrogen covered in upcoming projects one in France and one in Germany.

As in the last years we recall in this newsletter the contents of the HIPS-NET workshop in June, our 5th anniversary, with a short summary. If you are interested in more details you can access the presentations in the members’ area on our HIPS-NET website.

Your HIPS-NET Team

Gert, Anja, Sylvana, Charlotte & Stefan

SECTORAL INTEGRATION WITH HYDROGEN AS A DRIVER OF ENERGY TRANSITION | EUROPE (1/2)

Within the Paris Agreement, the European Union (EU) has committed to limit greenhouse gas (GHG) emissions to stay well below a 2 °C rise in average global temperature compared to preindustrial levels. Within a world effort-sharing allocation, it is likely that OECD countries will need to **limit energy-related emissions at a level close to zero shortly after 2050**. The EU scenario quantifications (using the PRIMES energy systems model) show that there are significant remaining emissions primarily in mobility, but also in the domestic (residential, services and agriculture) and industrial sectors in 2050, which are difficult to abate completely. It might be necessary to enhance sectoral integration by considering inclusion of hydrogen in various roles.

The study analyses the importance of **sectoral integration** to decarbonise the energy system in the EU. It explores three stylised strategies and a balanced pathway for sectoral integration based on hydrogen (the latter modelled with PRIMES model):

Strategy A - **Hydrogen** as a carbon-free energy carrier **in every consumption sector**, and secondarily as a provider of electricity storage. Requires the development of end-use technologies using hydrogen directly, including fuel cells in stationary and mobile energy uses, and equipment combusting hydrogen directly. Because of the widespread use of hydrogen in Strategy A, the development of **a fully-fledged hydrogen distribution system is necessary**. Blending up to 15 vol% hydrogen in the gas network are foreseen for a transition period. In the long-term, the grid should be adapted to hydrogen.

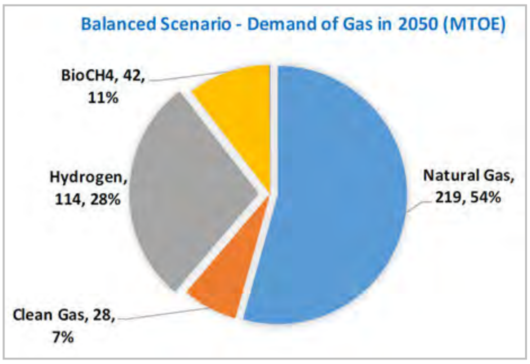
Strategy B - **Hydrogen** as a feedstock to produce carbon-neutral gas **and liquid hydrocarbons**, and as a provider of electricity storage. Requires the development of power-to-gas and power-to-liquid technologies to substitute the remaining fossil fuels in the long-term. This strategy has the disadvantage of a huge electricity demand, higher than in Strategy A. **The end-use sectors do not require changes of equipment or in infrastructure.**

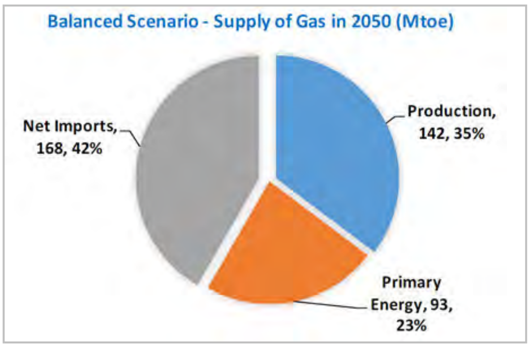
Strategy C - Hydrogen serving mainly as versatile **power storage to support electricity**; gives priority to **maximum electrification in all sectors**. It seems initially less complex, but this strategy would require the full electrification of all end-use sectors to achieve near-zero emissions. While this can work for the domestic sector, **for industry and transport it is barely possible**. In industry, complete electrification is assumedly impossible without considerable changes in production processes. In transport, extreme solutions such as electric aviation and shipping would need to succeed, or alternatively massive production of biofuels that are able to fully substitute petroleum fuels will be necessary for aviation and ships.

Balanced Pathway

- The study quantifies a balanced sectoral integration scenario that **combines elements of all three strategies**. The balanced scenario includes the development of **hydrogen as an end-use fuel, as a feedstock and as a power storage option.** It leads to **hydrogen-based sectoral integration,** combining roles of hydrogen in the by current knowledge most promising market segments. Selected key elements are:

- Mix of **hydrogen up to 15 vol%** in the gas distribution grids. The mix of hydrogen, bio-methane and clean methane in the gas distribution system allows 50 vol% of the gas to be carbon-free by 2050 (see diagram). The merit is to continue using the gas infrastructure and maintain the use of gas in the domestic and industrial sectors
- Use of electrolysis-produced hydrogen to feed fuel-cell powertrains in large vehicles (trucks, buses, etc.) and long-distance travelling cars (including taxis)
- Direct use of hydrogen in high-temperature furnaces in various industrial sectors, including in the iron and steel industry and the chemical industry
- 96% reduction in CO_2 emissions from the energy sector (including industrial processes) in 2050 (relative to 1990)
- The part of the power sector producing hydrogen and clean fuel reaches 29% of total power generation by 2050. Despite the significant increase in power generation, average EU electricity prices do not increase.

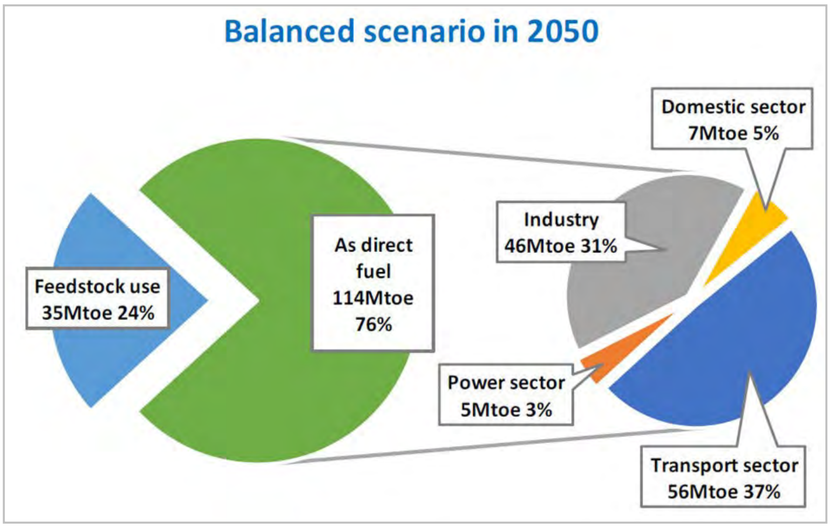




STRUCTURE OF GAS SUPPLY IN BALANCED SCENARIO IN 2050
(SOURCE: ASSET CONSORTIUM)

SECTORAL INTEGRATION WITH HYDROGEN AS A DRIVER OF ENERGY TRANSITION | EUROPE (2/2)

(CONTINUED)



USES OF HYDROGEN IN THE BALANCED SCENARIO
(SOURCE: ASSET CONSORTIUM)

The study finds, that the production of hydrogen from natural gas steam methane reforming is not compatible with the decarbonisation aims unless combined with CCS technologies for the permanent storage of CO2 emissions. The value chain of steam reforming with CCS is likely to be significantly less competitive than an electrolysis-based value chain benefitting from large economies of scale.

Two possible business models exist for hydrogen: decentralised hydrogen production close to end-users or centralised hydrogen production. For the transition period and in view of using hydrogen as an energy carrier, decentralised hydrogen production is a valid option for private investment. It is currently uncertain whether electrolysis at the scale of refuelling stations or in industrial areas is more economic than the distribution of hydrogen to the refuelling stations **using tanks or tubes**. However, **the centralised option would probably be the preferred option** to produce hydrogen in the long-term because the industry expects large economies of scale for large-scale electrolysis.

If hydrogen-related technologies (on both the demand and supply sides) reduce significantly in costs compared to today, they can become a key technology to help reduce emissions beyond the levels achieved in the basic decarbonisation scenario and at affordable costs.

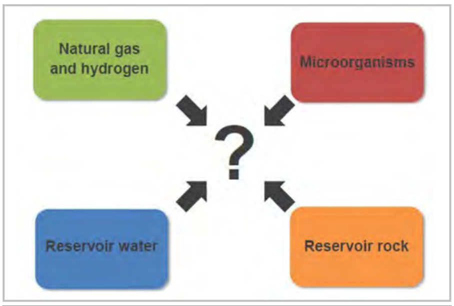
Partners: E3Modelling, Ecofys, Tractebel
Financing: Ordered and paid by the European Commission, Directorate-General for Energy Source
Source: "Sectoral integration - long-term perspective in the EU Energy System" February 2018 (study - draft version)
"Sectoral integration - long-term perspective in the EU Energy System" March 2018 (presentation)

RINGS: A PROJECT TO ASSESS HYDROGEN REACTIVITY IN RESERVOIRS | FRANCE (1/2)

AUTHOR: DAVID DEQUIDT (STORENGY) AND GUILHEM CAUMETTE (TERÉGA)

RINGS stands for Research on the Injection of New Gases in Storages. The objective of this programme is pre-normative research to assess H_2 reactivity in underground gas storage (UGS) reservoirs to define standard conditions for H2NG (hydrogen natural gas mixture). Possible biogeochemical processes between reservoir rock, aquifer water and stored gas need to be understood and quantified.

The standardisation process for hydrogen in natural gas has started at European level (standardisation group CEN/TC 234).



DEFINE STANDARD CONDITIONS H2NG
(SOURCE: STORENGY AND TERÉGA)

First Phase: RINGS1 Programme

The objective is to design and test an experimental reactor, and then to make laboratory static experiments. These experiments will be made under **reservoir conditions** with sampled rocks, **sampled micro-organisms**, reservoir water and synthetic gas. The goal is to rebuild in-situ conditions of **existing natural gas aquifer storages of Storengy and Teréga** and identify the impacts of the injection of new gases (hydrogen, biomethane) on the equilibrium of the storage. Composition evolution of gas and water phases (including microorganisms' population) will be followed.

Duration: The project started in 2018 and will end in 2021. Preliminary results will be available during 2019.
Partners: Storengy and Teréga are equally financing the first phase and are working together with five research laboratories of University of Pau and Pays de l'Adour.

RINGS: A PROJECT TO ASSESS HYDROGEN REACTIVITY IN RESERVOIRS | FRANCE (2/2)

(CONTINUED)

Second Phase: RINGS-H2 Programme

Storengy and Teréga are willing to build a new project with European industrial partners, based on the existing project RINGS1. This new project could be a great opportunity to gain access to European funding programmes, to share knowledge on a common topic, and to reach a common position. Storage operators could provide samples or data to contribute to (one of) the following work packages and they would benefit from the results corresponding to their assets. Technology providers could bring improvement in the programme or new approaches.

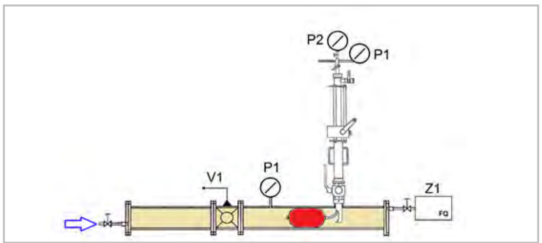
This second phase consists of two work packages:

- Work Package 1: Laboratory static experiments will be made using the same experimental set-up as in the first phase RINGS1. As the underground of every UGS is different (rock mineralogy, water chemistry and microbiology), H_2 reactivity is expected to be site-specific. The goal is to rebuild different in-situ conditions of UGS (owned by further partners) in aquifers and depleted reservoirs.
- Work Package 2: Reinterpretation of existing UGS data for hydrogen storage. For instance, town gas (containing up to 50 vol% hydrogen) has been a first experiment to store H_2 before the 1970s. Reinterpretation of operating data of town gas underground storage will be full of lessons. This could be done with a 3D-compositional and reactive reservoir model.

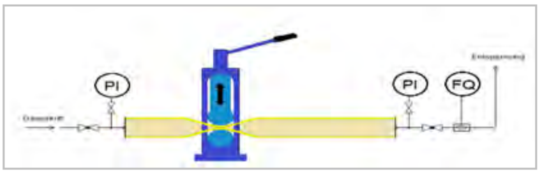
Duration: 4 years for work package 1,
1 year for work package 2
Financing: 50 kEUR/year per partner in case of five partners for work package 1, including experimental and laboratory costs; cost of work package 2 depends on data shared by the different partners
Partners: Storengy, Teréga; further partners wanted.

Contact:
Guilhem Caumette at guilhem.caumette@terega.fr and +33(0)559133397
David Dequidt at david.dequidt@storengy and +33(0)146523331

H2STOP - INFLUENCE OF HYDROGEN ADMIXTURE ON PIPELINE BLOCKING TECHNOLOGIES I GERMANY



GAS STOP-OFF BAG IN A PIPELINE
(SOURCE: DBI GUT GMBH)



SQUEEZING-OFF OF A PLASTIC PIPELINE
(SOURCE: DBI GUT GMBH)

Squeezing-off of plastic pipelines and gas stop-off bags (for plastic and steel pipelines) are typical pipeline blocking procedures for maintenance measures, network connection of new customers, reconstructions and in emergency cases. The technologies are used for operating pressures up to 10 bar.

For a blocked pipeline, the admissible amount of leaking gas in the working space is up to 30 dm³/h according to the technical guidelines of the Employers' Liability Insurance Association BG ETEM (BG500).

The project H2Stop evaluates how hydrogen admixture influences the above-mentioned pipeline blocking technologies. The goal is to find out if the admissible amount of leaking gas is exceeded when natural gas contains certain amounts of hydrogen and if occupational safety can still be guaranteed.

Hydrogen concentrations of 10, 20, 50 and 100 vol% will be tested in the operating pressure range of 1-5 bar on PE100 and steel pipelines with diameters of DN110 and DN200.

Duration: June 2018 until June 2019 (12 months)

Partners: DVGW German association for gas and water
DBI Gas- und Umwelttechnik GmbH
German providers of stopping technologies: Hütz + Baumgarten GmbH, Städtler + Beck GmbH
Employers' Liability Insurance Association BG ETEM
Contact: **Andreas Bilsing** at andreas.bilsing@dbi-gruppe.de

H2-UGS - Preparation of Salt Caverns for hydrogen blends | Germany

Salt caverns are currently used for natural gas storage. The conversion to H_2 storage is subject to several technical and operational preconditions and uncertainties. The project H2-UGS aims to establish scientific and technical basis for storing H_2 in salt caverns on industrial scale. It will recommend standardised and comprehensive processes to convert existing caverns. The project will further suggest a suitability test process for new locations for underground gas storage (UGS) of H_2.

The processes include detection and monitoring tools for the technical equipment and installation technologies for surface and subsurface facilities of a UGS.

The working packages include a variety of geological, technical, micro-biological, and security-related tasks:

- Definition of thermo-dynamic and fluid-dynamic basis of H_2/CH_4 blends, if cushion and working gas are changed, dew point under high pressure, and H_2-solubility in the brine
- Analysis of infiltration of H_2 in the cavern walls and the influence on geomechanical characteristics of the salt formation
- Microbiological assessment of H_2 and H_2/CH_4 blends for digestion processes, trace substances and precipitation
- Development of operation concept for realistic storage operation
- Development of a guideline for the entire storage facility including compressor station and H_2 cavern
- Design of specimen to estimate expected lifetime of different materials and welding technologies for parts of the subsurface facility (i.e. tubes, packer, safety valve) in H_2/CH_4 environment. Testing of resistance against gas blends and salty water.
- Assessment of quickly changing storage operation between injection and withdrawal of gas on the reservoir rock and the connection of casing, cement and formation.

Based on the research results, the project consortium will develop guidelines for the permission process for authorities and potential investors. They will include legal and technical aspects for the integrity of H_2 caverns.

Duration: 3 years, September 2018 until September 2021
Budget: 4,5 Mio EUR (including funding grant of 3,3 Mio EUR)

Partners: DBI, VNG Gasspeicher, ESK, Fraunhofer IWM, ifG, Isodetect, MicroPro, TU Bergakademie Freiberg, Helmholtz-Zentrum für Umweltforschung, Untergrundspeicher- und Geotechnologie-Systeme
Contact: **Cindy Kleinickel** at cindy.kleinickel@dbi-gruppe.de

HYPOS - Hydrogen Power Storage & Solutions East Germany "The revolution of the hydrogen economy initiated in East Germany"

The HYPOS consortium aims to further research and develop hydrogen production from renewable sources in East Germany (see presentation in newsletter #3 page 4). The HYPOS consortium was founded in 2013 and currently has 103 members. The German Federal Ministry for Education and (BMBF) proposes to subsidise the consortium until the year 2020 with up to 45 million € within the programme "Twenty20 – Partnership for Innovation".

zwanzig20 PARTNERSCHAFT FÜR INNOVATION

GEFÖRDERT VOM Bundesministerium für Bildung und Forschung

Summary of the 5th HIPS-NET Workshop (1/4)

The subsequent pages provide an overview about the HIPS-NET Workshop with summaries of the given presentations. The organisational aspects of our network with the outlook for the coming year follow thereafter.

In total seven presentations were held covering a wide range of topics. Robert Judd, GERG Secretary General, and Gert Müller-Syring (DBI) opened the event. Rene´ Schoof (Uniper) shared findings on the evolution of P2G-facilities over the last years and informed on the integration of a methanation at the P2G plant in Falkenhagen. EU policy was, once again, a major focus of the workshop. Nicolas Jensen (EUROGAS) informed on current negotiation results for the 2030 energy policy goals and the role that hydrogen technologies will play in this. John Newton (ITM) and Huw Sullivan (Cadent) informed us on the UK perspective, strategy and projects regarding hydrogen. RAG has started a new project to further invest the opportunities of storing methane/hydrogen mixtures in underground gas storages. Stephan Bauer (RAG) shared details on this project "sun conversion". Gert Müller-Syring presented strategies how to transform the gas infrastructure aiming to support reaching the 2050 climate goals with green gas. Gert also informed on the latest developments in the HIPS-NET group including the the work plan for 6th project year, which has been approved by the group.

SUMMARY OF THE 5TH HIPS-NET WORKSHOP (2/4)

(CONTINUED)

5th HIPS-NET Workshop, Brussels, 14th June 2018 - Agenda and Impressions

Presentation	**Welcome**
	Introduction and Short Introduction of Participants
	Robert Judd (GERG), Gert Müller-Syring (DBI)
I	**„Power to Gas – Storing renewable Energy in the gas infrastructure“**
	René Schoof (Uniper Energy Storage)
	Part 2
II	**“Hydrogen in the energy system - latest developments and ITM key projects”**
	Dr John Newton (ITM)
III	**“Recent developments in EU legislation – green gas and the 2020 package”**
	Nicolas Jensen (Eurogas)
IV	**“Hydrogen Projects in the UK – A Network perspective”**
	Huw Sullivan (Cadent Gas)
	Part 3
V	**„Underground Sun Conversion – aims, benefits and state of the affairs”**
	Stephan Bauer (RAG Austria)
VI	**“Transformation path towards a GHG neutral energy system – cost optimised transition paths for gas grids and underground gas storages”**
	Gert Müller-Syring (DBI)
	Part 4
VII	**Organisational Aspects HIPS-NET**
	Gert Müller-Syring (DBI)
	Conclusions
	Robert Judd (GERG), Gert Müller-Syring (DBI)
	Closure of the Meeting



SUMMARY OF THE 5TH HIPS-NET WORKSHOP (3/4)

I RENÉ SCHOOF (UNIPER)

Uniper‘s experiences and vision

Experience from **Falkenhagen** with alkaline electrolysis

- 3 years of operational experience; efficiency better than expected
- Over 10,000 operating hours, over 8,000 starts and stops without detectable degradation
- Further development in the frame of the Store&Go project by installing a methanation facility to gain technical experience and assess economic aspects incl. market-uptake potential of the technology

Experience from Hamburg with PEM electrolysis

- Successful upscaling of PEM-technology to MW range
- The new PEM-Technology is very compact and efficient
- The maximum power uptake of the PEM-stack (1,5 MW_{el}) is 50 % higher than initially planned

Scenario for a hydrogen economy until 2050 – main reason: emission reduction

- First market are refineries, followed by industry and mobility and subsequently green gas supply via gas network

II DR JOHN NEWTON (ITM)

Latest developments and ITM key projects

Hydeploy - to reduce the carbon impact of heat

- First practical UK demonstration of hydrogen in a representative, but closed private network
- Goal: lifting threshold (0.1 vol%) for hydrogen admixture in the UK gas network

REFHYNE – 10 MW electrolyser for refinery applications

- World‘s Largest PEM Electrolyser with 10 MW in refinery
- Goal: Assessing the economic, technical & environmental impact

III NICOLAS JENSEN (EUROGAS)

The European energy legislation and hydrogen

Clean Energy Package:
“Current” legislative framework and targets for 2030 with latest news about adapted goals from negotiations

- Explains the role of hydrogen in the legislation (intermediate result of negotiations, therefore here not explicitly recalled)
- Electricity-only world couldn’t deliver sustainable, secure and affordable energy: the EU needs dual or at least hybrid system
- Digitalisation will hit both energy sectors

SUMMARY OF THE 5TH HIPS-NET WORKSHOP (4/4)

IV HUW SULLIVAN (CADENT)

Hydrogen projects in the UK

UK strategy is reducing carbon intensity of the gas network by blending hydrogen with bio-methane, bio-SNG or supplying pure hydrogen. Selected projects around hydrogen are H21 Leeds City Gate (results presented at HIPS-NET workshop 2017), HyNET, Hy4Heat, and H100

- HyNET North West – hydrogen production and direct supply of industrial gas users with additional blending to the distribution gas network; all planned with carbon capture and storage of CO_2 by using existing infrastructure
- CO_2 abatement costs via CCS at the moment less expensive - [HyNET project] CO_2 abatement costs are estimated at 150-200 £/t CO_2; [H21 Leeds project] 300 £/t CO_2 and via [electrolysis] 500 £/t CO_2
- Hy4Heat – feasibility of 100 % hydrogen downstream of the meter (using hydrogen in homes)
- H100 – demonstration of safe delivery of 100 % hydrogen in a new network

V STEPHAN BAUER (RAG)

Underground Sun Conversion Project

- Laboratory tests and “in-situ” experiments suggest a natural conversion of hydrogen and CO_2 to methane (= main component of natural gas) in suitable underground gas reservoirs.
- Sun Conversion Project aims to prove the results and produces renewable natural gas in the reservoir (underground gas storage) with a natural microbial process.

VI & VII GERT MÜLLER-SYRING (DBI)

Transformation pathways for gas networks and storage

- Scenarios developed for future gas consumption in Germany as basis
- Modelling of cost-effective transformation scenarios until 2050 by considering the opportunities of hydrogen injection and technical modification of the gas infrastructure or to methanise the hydrogen with additional costs but without the need to modify the existing gas infrastructure
- Preliminary results were shown, indicating that for the gas infrastructure itself (without considering the production of green hydrogen and the consumer) the transformation is cost efficient by introducing high hydrogen concentrations

HIPS-NET Organisational Aspects

Overview of partners:

- TIGF (France) joined in 2017 and Cadent joined in August 2018
- Steadily growing number of partners; 37 at the moment.

Working plan for year 5:

- newsletters, workshop, addressing R&D subjects and communication, short status report, maintaining website are either running or completed

Working plan for year 6 (2018/19):

- newsletters, workshop, addressing R&D subjects and communication, short status report and as optional additional scope updating power-to-gas map, cooperation with SFEM WG Hydrogen/TC6

Selection of appointments 2018/19

Nov., 22 — [Erdgasbeschaffenheitsschwankungen Prozessindustrie]
(Düsseldorf, Germany)

Dec., 09-11 — [7th Int. Hydrogen and Fuel Cell Conference]
(Jodhpur, India)

Jan., 20-25 — [13th Int. Symposium Hydrogen and Energy]
(Incheon, South Korea)

Jan./Feb., 30-01 — [H2FC SUPERGEN 2019 Conference: A vision for hydrogen and fuel cells in the UK]
(Warwick, UK)

Feb. 12 -14 — [8th International Conference on "Fundamentals & Development of Fuel Cells" FDFC 2019]
(Nantes, France)

March, 27 - 29 — [Hydrogen Days 2019 - 10th International Conference on Hydrogen Technologies]
(Prague, Czech Republic)

Feb./March, 27 - 01 — [World Smart Energy Week 2019]
(Tokyo, Japan)

March, 28 -31 — [4th Int. Conference on Renewable Energy and Smart Grid (ICRESG 2019)]
(Hangzhou, China)

Current Partners

Alliander AG ++ Areva H_2Gen ++ Cadent ++ DEA Deutsche Erdoel AG ++ DGC ++ DNV GL ++ Enagás ++ Enbridge ++ Energinet.dk ++ ENGIE ++ EWE Netz ++ Gas Natural Fenosa ++ Gasum OY ++ Gasunie ++ GRTgaz ++ grzi e.V. (figawa) ++ Infraserv GmbH & Co. Höchst KG ++ INERIS ++ innogy SE ++ ITM Power ++ EC Joint Research Centre (JRC) ++ KOGAS ++ NAFTA ++ ONTRAS ++ Open Grid Europe GmbH ++ ÖVGW ++ RAG Rohöl-Aufsuchungs AG ++ Shell ++ Solar Turbines Europe ++ Storengy ++ SVGW ++ Synergrid ++ TIGF ++ Uniper Technologies Limited ++ Verband der Chemischen Industrie (VCI) ++ Volkswagen AG ++

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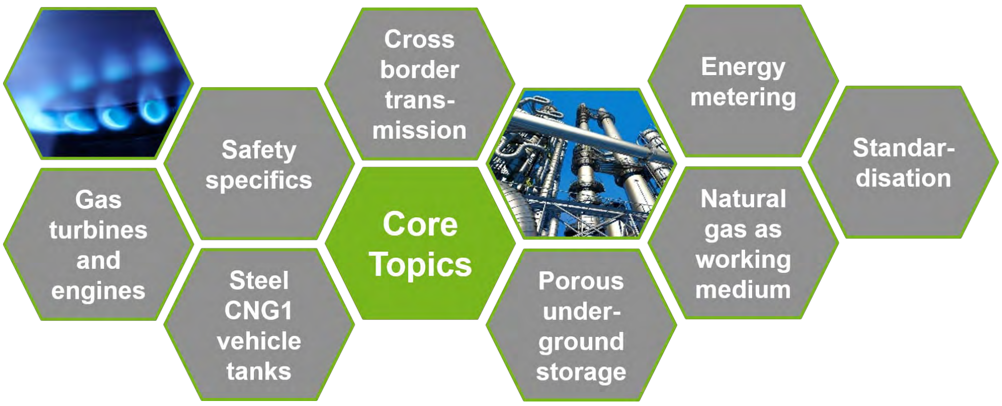

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HIPS-NET

"Establishing a pan-European understanding of admissible hydrogen concentration in the natural gas grid"

Newsletter #19	December, 2018

Content Newsletter #19

19th HIPS-NET Newsletter

Dear HIPS-NET Partners,

Christmas is coming and the 19th HIPS-NET newsletter arrives just before the end of the year with eight short articles about upcoming and completed projects around hydrogen.

During our last workshop, preliminary findings of the project "Transformation pathways for gas networks and storages" were already presented. Now, this newsletter delivers more detailed results. Two completed projects on the use of hydrogen in households and the effect on gas installations are presented. A new project in Germany is announced, investigating the hydrogen tolerance of gas pressure regulating and meter stations. Another German project has the aim to produce condensed fact sheets issuing the hydrogen compatibility of the distribution network. A similar goal has a new MARCOGAZ task force on hydrogen injection. Moreover, the project Centurion is announced, which covers a feasibility study for a 100 MW PtG energy storage in the UK. And last but not least, this newsletter shares findings on options to improve the regulatory framework in Germany aiming to stimulate the market integration of renewable gas technologies.

We wish you relaxing holidays and a happy new year!

Your HIPS-NET Team

Gert, Anja, Charlotte, Josi, Stefan & Sylvana

> **FIND A DATE!**
>
> **HIPS-NET Workshop in Brussels**
>
> **2019**
>
> ***5th/6th or 26th/27th June***
>
> **Please remember to vote until 07-01-19 in the survey received via e-mail.**

PS: Please remember the running survey for our 6th HIPS-NET workshop in June 2019 in Brussels. There are two possible dates and we want to find the most suitable. You received an e-mail from Charlotte Große on the 6th December 2018, inviting you to participate in an online survey. Don´t forget to vote!

POSSIBLE INFLUENCE OF HYDROGEN ON COMPONENTS FOR GAS INSTALLATIONS | GERMANY (1/2)

A 20 vol-% hydrogen blend in natural gas would provide no particular safety hurdles for components of current gas installations. This is the result of a study recently released by the German Association of Gas and Water (DVGW), which examined the effect of hydrogen-natural gas blends on domestic gas installations. The research considered necessary changes to safety concepts required by the blending of hydrogen. Material tolerance, permeability testing, explosion protection, piping construction and gas flow monitoring were included in the study for the following components:

- Polymers and elastomers for gas piping
- Gas meters (diaphragm, thermal and ultrasonic)
- Connecting components for gas piping and gas units
- Gas flow monitors

The study shows that in almost all areas analysed the 20 vol-% hydrogen blend would be compliant with the conditions laid out in the DVGW standard G 600 "Technical Rules for Gas Installations (TRGI)" with regard to safety, permeability, construction and layout of the components. According to the research, higher hydrogen concentrations in the future is also foreseeable. The only major issue reported is related to certain gas meters (thermal and ultrasound meters) which would lose their calibration validity at higher hydrogen concentration levels.

Polymers and Elastomers for Gas Piping

In the field of gas piping, the analysis was based on materials for use in distribution networks. The applied low-pressure conditions were comparable to those at domestic appliances. A selection of elastomers and polymers represented the majority of piping materials commonly used for low-pressure throughput. Both theoretical calculations and a six-month physical analysis were conducted to determine the material tolerance of the chosen materials in an atmosphere with increased hydrogen content. It concluded that, the higher permeability of hydrogen compared to air or natural gas provided no additional safety concerns in the piping and can be regarded as uncritical according to the requirements of G 600. Even in rooms with poor geometry or air-exchange conditions, the concentration of combustible gas was significantly below the lower explosion limit.

Electrical and Electronic Components in the Gas System

Electrical and electronic components are a particular source of ignition, due to either spark creation or high-temperature surfaces. This is particularly important during commissioning and decommissioning of units. The study considered a range of criteria related to the explosion protection standards of hydrogen-natural gas blends including upper and lower explosion limits, maximum explosion pressure, ignition temperature and many others. Testing of ignition levels for electrical and electronic components using a 30 vol-% hydrogen-propane blend showed no notable difference from standard ignition tests using pure propane. These results were well within the parameters set out by the German standard DIN EN 1127-1.

Hydrogen Tolerance of Gas Meters

Within the project, the hydrogen tolerance of three different types of gas meter technology was analysed: diaphragm, thermal and ultrasound metering. The meters were exposed to varying concentrations of hydrogen (up to 100 vol-%) for a period of four weeks. Diaphragm gas meters were able to provide acceptable gas measurements with up to 100 vol-% H_2. Ultrasound meters, in turn, no longer exhibited any measurement values beyond 60 vol-% H_2. Exact parameters for acceptable measurement of hydrogen blends using this technology could not be clearly defined. Thermal meters continued to display active measurements beyond 60 vol-% H_2, however, the standard valid calibration parameters were exceeded by approximately 5 %.

Connecting Components for Gas Piping and Gas Facilities

A selection of DVGW or DIN-standardised connecting components were tested for permeability with hydrogen concentrations of up to 100 vol-% H_2. The component selection included thread connections, gas sockets, hose assemblies, smooth pipe connections, press connections and sliding sleeve fittings with and without O-rings. The results showed no change in the permeability of components even when subjected to pure hydrogen. A safety analysis at connection points was also conducted, simulating a possible leak and analysing the released medium. As a result, hydrogen concentrations of up to 30 vol-% H_2 (for thread connections, smooth pipe connections, and press connections even 100 vol-% H_2) would be uncritical according to the requirements of the TRGI.

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Gas Flow Monitors

The study evaluated the effects of hydrogen on the reactions of gas flow monitoring technologies. Devices were tested for changes in behaviour with hydrogen-natural gas blends of 10 vol-% H_2 and 30 vol-% H_2. In both cases, even at the highest flow levels, closure mechanisms were not triggered.

Thermal Resistance and Explosion Limits

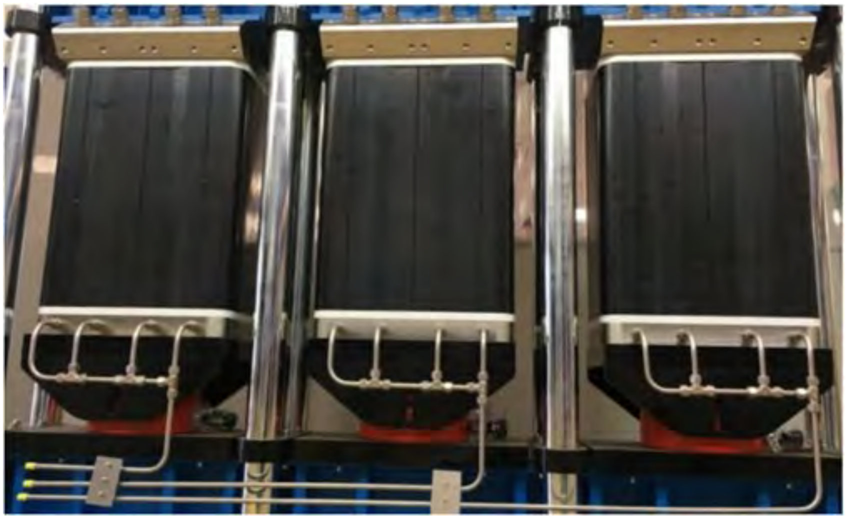
Testing on different components did not display an increased potential endangerment with higher concentrations of hydrogen in natural gas. This is because the viscosity of hydrogen increases with temperature. As a result, hydrogen-natural gas blends have lower total medium leakage amounts than natural gas.

The lower explosion limit of hydrogen-natural gas blends is comparable to the lower explosion limit for natural gas (4.4 vol-%). Even when using 100 vol-% H_2, the lower explosion limit falls only slightly to 4.0 vol-%.

Partners: DBI Gas- und Umwelttechnik GmbH (DBI GUT), Gas- und Wärme-Institut Essen (GWI), DVGW-Forschungsstelle am Engler-Bunte-Institut (EBI) des Karlsruher Instituts für Technologie (KIT)
Contact: **Philipp Pietsch** at philipp.pietsch@dbi-gruppe.de
Florian Scholten at f.scholten@gwi-essen.de
Peter Limbach at limbach@dvgw.de
Source: "Mögliche Beeinflussung von Bauteilen der Gasinstallation durch Wasserstoffanteile im Erdgas unter Berücksichtigung der TRGI" February 2018 (full report project nr. G201615 in German)

CENTURION - FEASIBILITY STUDY FOR A 100MW POWER-TO-GAS (P2G) ENERGY STORAGE | UNITED KINGDOM

In September 2018, ITM Power announced the funding for Project Centurion, a feasibility study to explore the system design and costs of a 100 MW Power-to-Gas (P2G) energy storage at Runcorn, Cheshire, UK.



100 MW P2G ENERGY STORAGE FEASIBILITY STUDY
(SOURCE: ITM POWER)

The project is an opportunity to examine water electrolysis, pipeline transmission, salt cavern storage and gas grid injection of green hydrogen at an industrial scale. The work builds on experiences of HyDeploy (reported in Newsletter #12 – Jan.17) which will demonstrate the blending of 20 % hydrogen in the gas network at Keele University in the British Midlands.

Centurion will analyse the design and siting of a 100 MW Proton Exchange Membrane (PEM) electrolyser at the INOVYN Runcorn Site, which already produces hydrogen as a by-product of the chlorine alkali process. A supergrid connection of 420 MW, and planning consent for industrial scale hydrogen production are available onsite.

Additionally, the hydrogen transportation by pipes to salt caverns near Lostock and the injection into the local gas distribution network will be explored. Other potential demands and uses for hydrogen will be assessed, including industrial and transport use which will support existing studies in the area, particularly Cadent's HyNet NW (reported in NL #18 - Oct.18).

Partners: ITM Power, INOVYN, Storengy, Cadent and Element Energy
Project Duration: 18 months
Contact: **Dr John Newton** at jn@itm-power.com
Source: press release ITM Power - 09/28/2018

Marcogaz Task Force on Hydrogen Injection | Europe

MARCOGAZ, the technical association of the European natural gas industry, initiated a task force on hydrogen injection in the natural gas infrastructure. The task force's aim is to publish an overview of relevant technical studies (existing and on-going) and knowledge concerning the injection of hydrogen in the natural gas infrastructure including underground storages and end use devices. Deliverable is an infographic showing the hydrogen tolerance of the covered natural gas chain elements.

Partners: experts of European gas grid operators and research institutes, chairman: Gert Müller-Syring (DBI)
Contact: **Gert Müller-Syring** at gert.mueller-syring@dbi-gruppe.de)

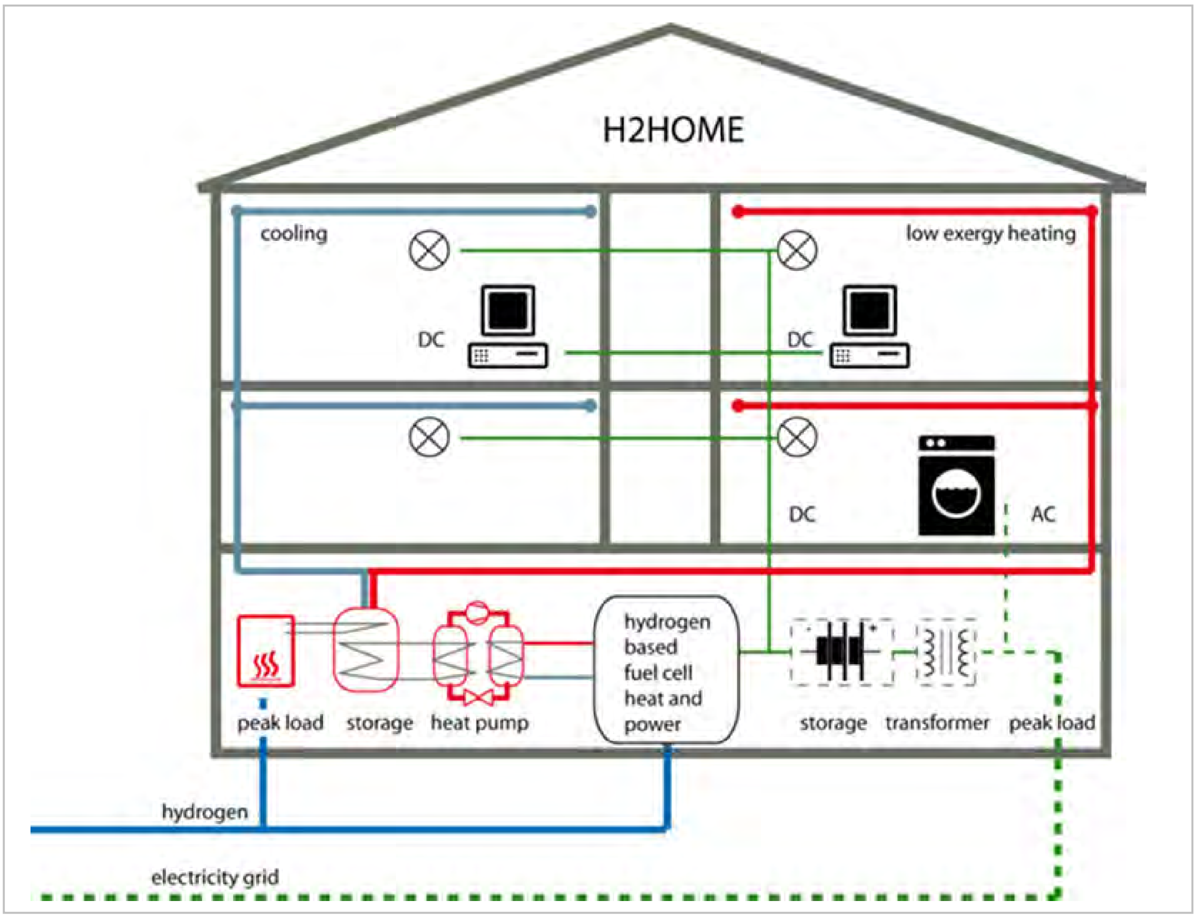
The kick-off-meeting was held in September 2018 and work is expected to be finished within 8 months.

H2home - Development of an H_2-Heat Module and Investigations on the Deodorization of H_2 for PEM Fuel Cells | Germany (1/2)

Within the R&D project "H2home" a hydrogen powered, fuel cell based combined heat and power (CHP) plant with integrated peak load boiler was developed. The ideal fields of application of the CHP system were investigated by analysing electrical and thermal load profiles of different building types.

The main objective of the project was to develop a modular H_2 CHP system (based on PEMFC technology) in the range of 5 kW electrical power and concepts for the optimized building integration for a high efficient use of hydrogen in residential applications.

A hydrogen peak load burner with a thermal power of 10 kW has been developed and integrated into the H_2 CHP to provide the required heat for the building and electrical energy, which is fed into the grid. The direct current of the fuel cell system is used, for instance, for heat pumps and PCs in order to reduce conversion losses.



Scheme of the Energy Supply of a Building with a H_2 CHP
(Source: inhouse engineering GmbH)

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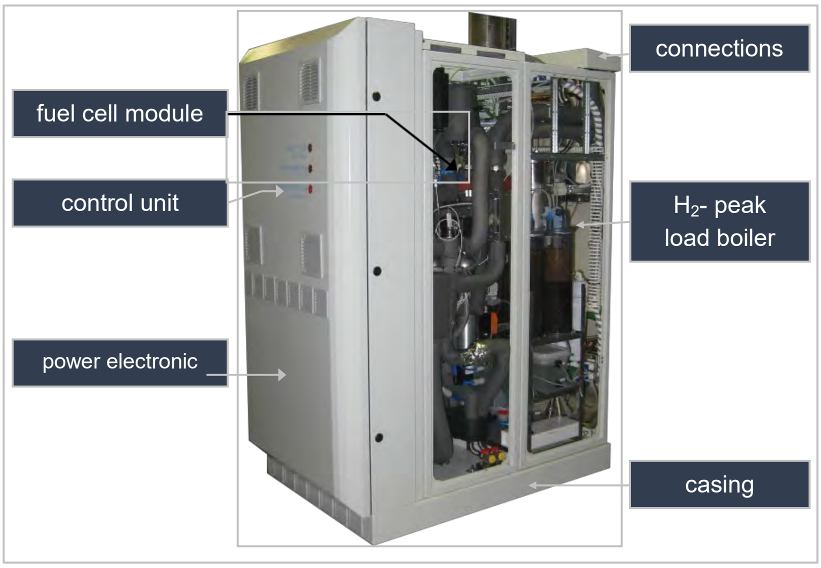


H_2-CHP with H_2-peak Load Boiler
(Source: inhouse engineering GmbH)

A future hydrogen supply will most likely be pipeline-bound, so that odorization and deodorization of hydrogen in such a CHP system will become important. Various desulphurization materials for different odorants were investigated and their capacity determined. Based on the results, a compact deodorization unit was designed.

After successful testing of all individual components (deodorization, PEM stack, power electronics, peak load boiler) the entire system was set up and put into operation. In a long-term test, the thermal and electrical efficiencies were determined at various operating conditions and different load profiles, leading to an overall efficiency of 103 %. After completion of the test phase, a two-year continuous operation of the plant in the "HYPOS Energy Pavilion" in Bitterfeld, Germany is planned for the mid of 2019.

HYPOS - Hydrogen Power Storage & Solutions East Germany "The revolution of the hydrogen economy initiated in East Germany"

The HYPOS consortium aims to further research and develop hydrogen production from renewable sources in East Germany (see presentation in newsletter #3 page 4). The HYPOS consortium was founded in 2013 and currently has 103 members. The German Federal Ministry for Education and (BMBF) proposes to subsidise the consortium until the year 2020 with up to 45 million € within the programme "Twenty20 – Partnership for Innovation".

zwanzig20 PARTNERSCHAFT FÜR INNOVATION — GEFÖRDERT VOM Bundesministerium für Bildung und Forschung

Partners: inhouse engineering GmbH, ENASYS GmbH, DBI Gas- und Umwelttechnik GmbH, TU Bergakademie Freiberg, Fraunhofer Institute IMWS
Funding: German Federal Ministry for Education and (BMBF) within the HYPOS initiative
Contact: **Steffen Giesel** at steffen.giesel@dbi-gruppe.de

Hydrogen Compatibility of a Gas Pressure Regulating and Meter Station (PRMS) | Germany

In the laboratory of DBI GUT Leipzig, a standardized gas pressure regulating and meter station (PRMS) will be built up and tested for performance and material compatibility during operation with hydrogen natural gas mixtures. Different concentration levels will be evaluated, retrofitting measures at increased hydrogen concentrations will be recommended, if necessary.

Project Objectives:

1) To obtain real data on the effects of varying hydrogen concentrations on PRMS
2) Gain operational experience for a plant using natural gas with admixtures of 5, 10, 20, 30 and 100 vol-% on the basis of load curves defined in advance.
3) Determination of the critical hydrogen concentration for single components of the plant (e.g. regulator, filter, meter, sealings, fittings (incl. block ball valve), safety shut-off valve, safety blow-off valve).
4) Development of recommendations for the necessary retrofitting work of standardized PRMS stations for the investigated hydrogen concentrations.

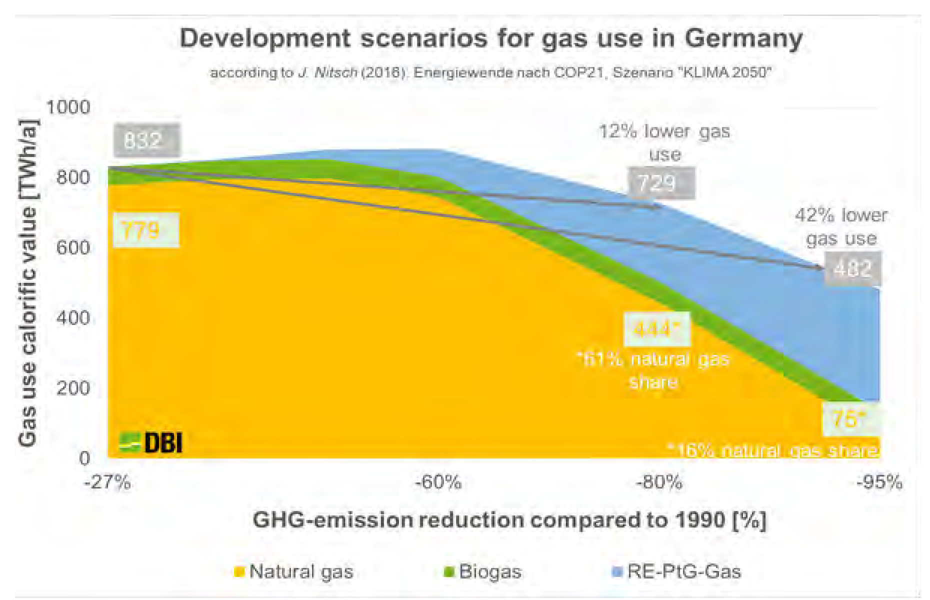
Partners: Westnetz (Client), DBI Gas- und Umwelttechnik GmbH (Project Execution)
Project Duration: 01/01/2019 to 03/01/2020
Contact: **Stefan Schütz** at stefan.schuetz@dbi-gruppe.de

Transformation Pathways to Greenhouse Gas Neutrality of Gas Networks and Gas Storages after COP 21 | Germany (1/2)

On behalf of the DVGW (German Gas and Water Association), DBI Gas- und Umwelttechnik conducted a study alongside with Bergische Universität Wuppertal and the DVGW-Forschungsstelle at the Engler-Bunte-Institut. The aim was to find cost-optimum transformation pathways for the greenhouse gas neutrality of the gas networks and gas storage facilities by the technology paths “green/GHG-neutral” hydrogen and “green/GHG-neutral” methane for integration. Focus was on the gas infrastructure, gas users of all sectors were not considered yet.

Starting Point – Development of Gas Demand

In a first step, a scenario for the development of the gas demand in Germany, which is in line with the 2 °C climate goal of the Paris agreement, was determined by a literature research. The scenario selected (see figure below) expects a reduction from 832 TWh in 2015 to 482 TWh in 2050 with an intermediate peak (882 TWh) around 2030 and distinguishes between conventional natural gas, biogas and renewable gases from Power-to-Gas (RE-PtG-Gases).



Development of the Gas Demand in Germany
(Source: DBI Gas– und Umwelttechnik GmbH)

Two aspects were important to keep in mind for the subsequent work packages:

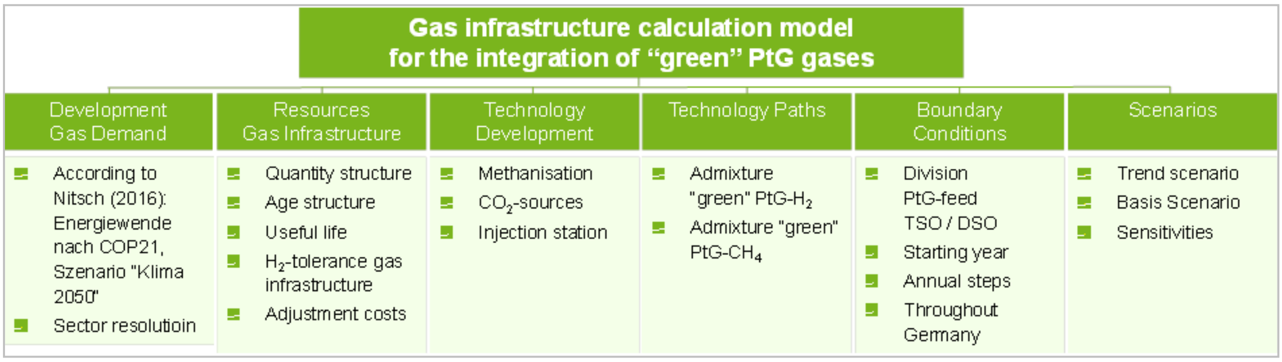
To reach greenhouse gas (GHG) neutrality for gas networks and gas storages, the gas infrastructure must be able to accommodate the gas demand drafted in the figure beside at all time.

The scenario chosen does not give information on whether RE-PtG-Gas is expected to be hydrogen (RE-PtG-H_2) or methane (RE-PtG-CH_4).

Research Question and Model

In a second step, a comprehensive calculation model was developed to find cost-optimal transformation paths for a transformation of gas grids and gas storages to GHG neutrality within the technology pathways admixture of RE-PtG-H_2 and RE-PtG-CH_4. A basis scenario with sensitivities was used alongside with a trend scenario ignoring the climate goals. For both scenarios additional costs for the integration of the RE-PtG-Gases until 2050 were calculated.

Beyond the projected gas demand, the model was supplied with comprehensive techno-economic data on PtG technologies and a quantity-cost-structure of the gas infrastructure which was compiled dedicatedly for the study (see below).



Scope of the Model Developed for the Project
(Source: DBI Gas– und Umwelttechnik GmbH)

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Main Findings and Conclusions

- In order to meet the 2 °C aim of the Paris climate agreement (-95% GHG compared with 1990), the gas industry should develop a strategy for the supply of GHG neutral gases in a timely and proactive manner.
- Within the technology paths “green” PtG-H_2 and “green” PtG-CH_4, a sufficient integration of GHG neutral gases in the sense of the climate targets can be achieved, which is strongly supported by underground gas storages (UGS). Keeping UGS in the gas infrastructure is important for the energy transition for reliability of supply.
- For gas networks and storages (excluding gas use and generation of “green” PtG-H_2), the transformation of costs is optimally achieved mainly via the admixture of “green” PtG-H_2.
- The additional costs for the transformation amount to at least 45 billion EUR (2020-2050); a five-year delay in the transformation leads to an increase of costs of about 25 %.
- The trend scenario does not achieve the greenhouse gas neutrality by 2050.

Further Information

For the further findings as well as the authors´ recommendations for action, please see the final report which is available for members on the DVGW website in German language only.

Partners: DBI Gas- und Umwelttechnik GmbH, Bergische Universität Wuppertal, DVGW-Forschungsstelle am Engler-Bunte-Institut (EBI)
Contact: **Marek Poltrum** at marek.poltrum@dbi-gruppe.de

SMARAGD - Technical-economic Modelling of a Sector-coupled Overall Energy System from Gas and Electricity under Updating of the Regulatory Framework | Germany

Germany's current legal framework lacks effective instruments for the necessary reduction of emissions and inhibits the evolution of promising low-emission technologies. However, targeted regulatory measures can make their use viable and encourage deployment.

These are the results of the SMARAGD research project that comprehensively examines the German energy law for obstacles to the use of renewable gases. The study also offers suggestions how to improve market opportunities for green gases, to stimulate their distribution via the gas network and to promote sector coupling via Power-to-X. Analyses cover the sectors electricity, heat, transport and non-energetic use as well as the entire value chain from production to the use of renewable gases.

Various instruments are proposed with the most promising options being

- **Option 1:** a minimum quota for renewable gases, and
- **Option 2:** a temporary exemption from all taxes and levies ("complete exemption").

Option 1 should obligate wholesalers to ensure a minimum quota of renewable gases fed into the public gas network. Under the assumptions and conditions made, the quota has the highest positive effect on the expansion and use of renewable gases. The quota obligation in the sectors heat, transport and non-energetic use provides a boost for Power-to-X technologies such as Power -to-Gas, Power-to-Liquid and Power-to-Chemicals. Moreover, it ensures the use of biomethane potentials.

Option 2 also leads to a significant increase in renewable gases, however, not in the same level as the quota. In addition, there are differences in the mechanisms of action and the effort required for implementation.

Assuming a 95%-reduction in greenhouse gas emissions by 2050 – according to the climate plan of the German government, renewable gas technologies would become establish even without the suggested instruments in later years. This is due to learning effects and series production, which will lead to lower costs. However, the market launch needs to be stimulated at an early stage. Thus, the suggested two options could be of temporary nature and gradually reduced, if the legal framework in Germany established as obligatory the reduction goal of 95 % by 2050.

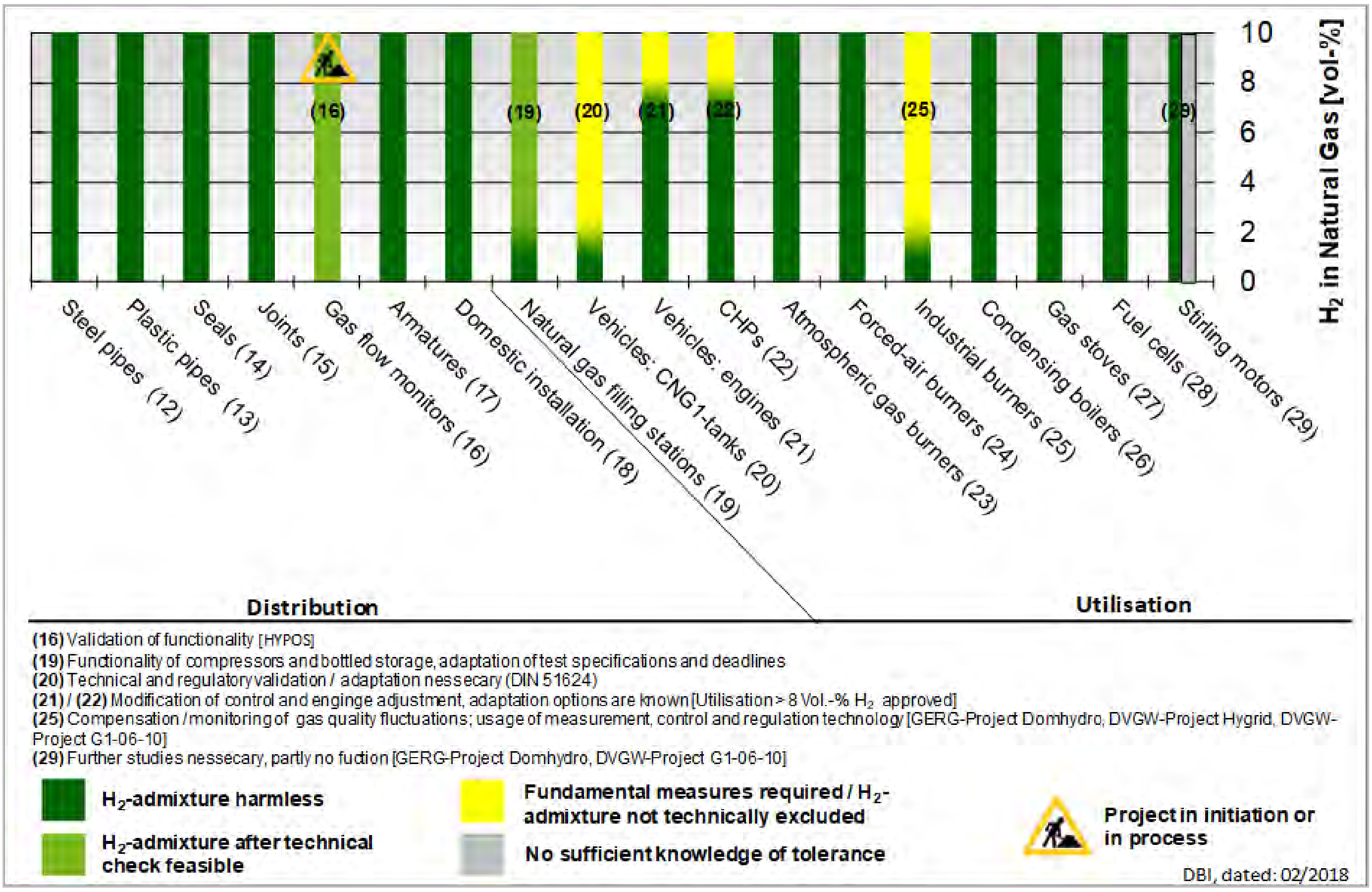
Partners: DBI Gas- und Umwelttechnik GmbH (project coordination), Gas- und Wärme-Institut Essen (GWI), DVGW-Forschungsstelle am Engler-Bunte-Institut (EBI) des Karlsruher Instituts für Technologie (KIT), Becker Büttner Held (BBH), Forschungsstelle für Energienetze und Energiespeicher (FENES) der OTH Regensburg
Contact: **Jens Hüttenrauch** at jens.huettenrauch@dbi-gruppe.de,
Hans Rasmusson at rasmusson@dvgw.de

COMPENDIUM OF HYDROGEN ADMIXTURE IN GAS DISTRIBUTION NETWORKS - ANALYSIS OF THE COMPATIBILITY OF HYDROGEN ADMIXTURE IN THE GAS DISTRIBUTION NETWORKS UP TO 100 VOL-% | GERMANY

On behalf of a consortium of German distribution system operators (DSOs) DBI Gas- und Umwelttechnik GmbH creates a “Compendium of Hydrogen Admixture in Gas Distributions Networks”. The compendium is designed as a reference work of the state-of-the-art knowledge on hydrogen compatibility of the distribution network. In this function, it shall facilitate the next step towards a more extensive utilization of the gas infrastructure with hydrogen. This includes hydrogen admixtures to natural gas, as well as pure hydrogen.

At its core, the compendium will consist of condensed fact sheets issuing the hydrogen compatibility of the distribution network by its components (pressure regulating and metering stations, pipelines, house service connections, in-house installations and gas appliances) and system level aspects (material compatibility of steels and metals, sealing materials, safety).

Beyond the fact sheets, an updated and extended version of the well-known overview chart of the hydrogen tolerance of the gas infrastructure will be created. The extension will cover the whole range of NG-hydrogen mixtures up to pure hydrogen.



HYDROGEN ADMIXTURE IN DISTRIBUTION AND UTILISATION
(SOURCE: DBI GAS– UND UMWELTTECHNIK GMBH)

The project is divided into two parts: Part A comprises compiling, sighting, evaluating and processing existing information mainly from research projects, pilot plants, industry experience and codes and standards. In Part B the component-specific fact sheets will be supplemented by information from component manufacturers.

Partners: DBI Gas- und Umwelttechnik GmbH and several distribution system operators (e.g. Avacon Netz GmbH, Thüga AG)
Contact: **Marek Poltrum** at marek.poltrum@dbi-gruppe.de

SELECTION OF APPOINTMENTS 2019

Jan., 20-25	**13th Int. Symposium Hydrogen and Energy** (Incheon, South Korea)
Jan., 24-25	**Hydrogen & Fuel Cells Energy Summit** (Brussels, Belgium)
Jan./ Feb., 30-01	**H2FC SUPERGEN 2019 Conference: A vision for hydrogen and fuel cells in the UK** (Warwick, UK)
Feb., 12-14	**8th International Conference on „Fundamentals & Development of Fuel Cells“ FDFC2019** (Nantes, France)
March, 27-29	**Hydrogen Days 2019 - 10th International Conference on Hydrogen Technologies** (Prague, Czech Republic)
Feb./March, 27 - 01	**World Smart Energy Week 2019** (Tokyo, Japan)
March, 28 -31	**4th International Conference on Renewable Energy and Smart Grid (ICRESG 2019)** (Hangzhou, China)
April, 01 -05	**Hydrogen + Fuel Cells EUROPE** (Hannover, Germany)
April, 24-26	**14 th HYdrogen POwer THeoretical and Engineering Solutions International Symposium** (Foz do Iguaçu, Brasil)

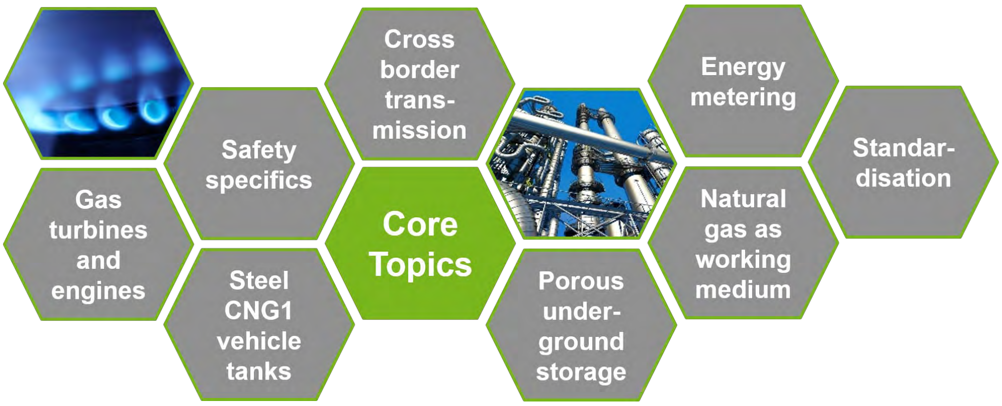
CURRENT PARTNERS

Alliander AG ++ Areva H_2Gen ++ Cadent ++ DEA Deutsche Erdoel AG ++ DGC ++ DNV GL ++ Enagás ++ Enbridge ++ Energinet.dk ++ ENGIE ++ EWE Netz ++ Gas Natural Fenosa ++ Gasum OY ++ Gasunie ++ GRTgaz ++ grzi e.V. (figawa) ++ Infraserv GmbH & Co. Höchst KG ++ INERIS ++ innogy SE ++ ITM Power ++ EC Joint Research Centre (JRC) ++ KOGAS ++ NAFTA ++ ONTRAS ++ Open Grid Europe GmbH ++ ÖVGW ++ RAG Rohöl-Aufsuchungs AG ++ Shell ++ Solar Turbines Europe ++ Storengy ++ SVGW ++ Synergrid ++ TIGF ++ Uniper Technologies Limited ++ Verband der Chemischen Industrie (VCI) ++ Volkswagen AG ++

HIPS-NET CORE TOPICS

We gather and disseminate the latest available knowledge to improve the understanding of hydrogen/natural gas blends in pipeline systems with emphasis on the core topics:

We additionally keep a minor focus on the general development of power-to-gas, hydrogen networks, and further topics around the utilisation of (renewable) hydrogen.



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GERG groupe européen de recherches gazières the european gas research group

DBI GUT Gas- und Umwelttechnik GmbH

HIPS-NET

"Establishing a pan-European understanding of admissible hydrogen concentration in the natural gas grid"

Newsletter #20 | **March, 2019**

Content Newsletter #20

20th HIPS-NET Newsletter

Dear HIPS-NET Partners,

The first newsletter of the year 2019 addresses a lot of European activities around hydrogen: The project HyLaw was finalised in December 2018 and provides us a European database of legal and administrative requirements and procedures for fuel cell and hydrogen applications. The HYREADY team could initiate the next work package and is now developing European guidelines for the hydrogen tolerance of end user's natural gas infrastructure and appliances. We report latest news from Brussels about thoughts on a European Gas Package as well as an update on the activities in European standardization from the Sector Forum Energy Management/ Working Group Hydrogen.

Positive signals on the implementation of hydrogen applications are coming from the United Kingdom, where the regulator OFGEM just granted the funding of £14.9 million for trials on the public gas network to heat homes with hydrogen. The German steel manufacturer Salzgitter prepares itself for a hydrogen future by implementation of electrolysis into the existing steelworks and the polymer expert REHAU talks about his experiences with a calculation tool that enables techno-economic assessments of power-to-gas-to-power systems for use in an industrial environment. Last but not least, results of the project WESpe are presented, giving a full value-chain analysis of hydrogen for long-term renewable energy storage.

There is also organisational news for HIPS-NET: First, we have a new partner in our network: Gasnetz Hamburg from Germany joined recently. Welcome on board! Second, the date for our workshop is fixed and we are currently searching for presenters so that we can share an agenda with you soon. If you would like to give a presentation, please let us know! The official invitation (also for the dinner on the evening before) will follow.

Your HIPS-NET Team

Gert, Anja, Sylvana, Josephine, Charlotte & Stefan

Please save the date!

HIPS-NET Workshop in Brussels

2019

26th/27th June

HyLAW - A Database and Analysis of the Current Legislation Applicable to FCH Technologies | Europe

On the 1st of January 2017 the project HyLAW (Hydrogen Law – announced in HIPS-NET newsletter 12, January 2017) started with the aim to boost the market uptake of hydrogen and fuel cell technologies by providing market developers with a clear view of the applicable regulations whilst calling the attention of policy makers on legal barriers to be removed. The project consortium of 23 partners has identified the relevant legal and administrative requirements and procedures for various fuel cell and hydrogen applications in 18 countries across Europe. The findings have been collected in an online and publicly available database (HyLAW Database) and will be maintained for a minimum of three years after the end of the project. Furthermore, the HyLAW partners published a set of national policy papers describing the most important legal barriers related to fuel cells and hydrogen technologies with country specific benchmarks and recommendations on how to remove these barriers. In addition, a pan-European policy paper which targets European decision makers was prepared.

The project was coordinated by the association Hydrogen Europe. It ended in December 2018 and received financial support of € 1.14 million from Fuel Cell and Hydrogen Joint Undertaking (FCH JU).

The project studied about 64 legal and administrative procedures for 25 hydrogen and fuel cell applications across the 18 countries. The procedures were structured along eight categories (production of hydrogen, gas grid issues, vehicles, stationary storage, etc.). The evaluation was made based on the following criteria:

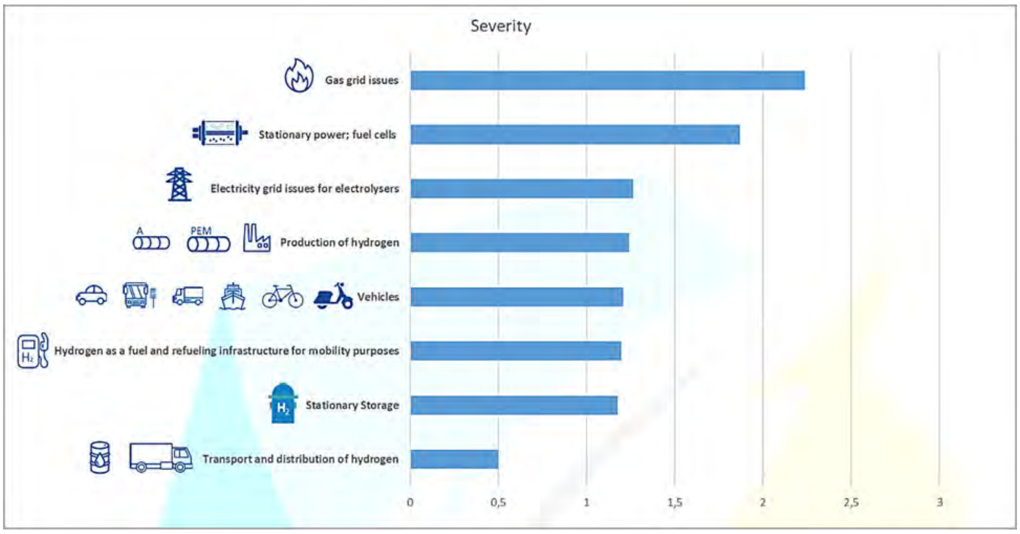
i. whether the process represents a barrier or not

ii. which type of barrier can be observed (structural, operational, economic or regulatory gap)

iii. the severity of the barrier (0 = no barrier; 1 = low; 2 = medium; 3 = high)

The analysis of the current legislation applicable to FCH technologies shows a medium to high severity of legal and administrative barriers regarding the injection of hydrogen into the gas grid. The reasons, in particular, are permitting requirements, injection limits, payment of remuneration mechanisms, gas quality requirements as well as safety and end-user equipment requirements.

Stationary power in residential and commercial buildings has the second highest severity of barriers. This type of barrier is mostly economic (e.g. lack of financial incentives).



Average Severity of Barriers Within Different Categories of Hydrogen Applications (Source: HyLAW)

The HyLAW project has concluded that the main barriers in electricity grid issues for electrolysers are the absence of recognition of balancing services to the power grid. The production of hydrogen is hampered in small-scale production because of long and costly permitting processes. For road vehicles moderate barriers were identified, e.g. the lack of incentive policies and infrastructure investments. Major regulatory barriers can be found in maritime applications due to non-hydrogen specific requirements, preventing commercial-scale deployment of hydrogen vessels.

Project Duration:	January 2017 - December 2018
Partners:	WaterstofNet vzw, FHYPAC, CEA, SINTEF, Brintbranchen Hydrogen Denmark and others (see here)
Sources:	https://www.hylaw.eu/
Contact:	Dennitsa Nozharova at hylaw@dwv-info.de

UPDATE ON HYREADY - START OF WORK PACKAGE 3: GUIDELINES FOR THE END USER'S NATURAL GAS INFRASTRUCTURE AND APPLIANCES | EUROPE

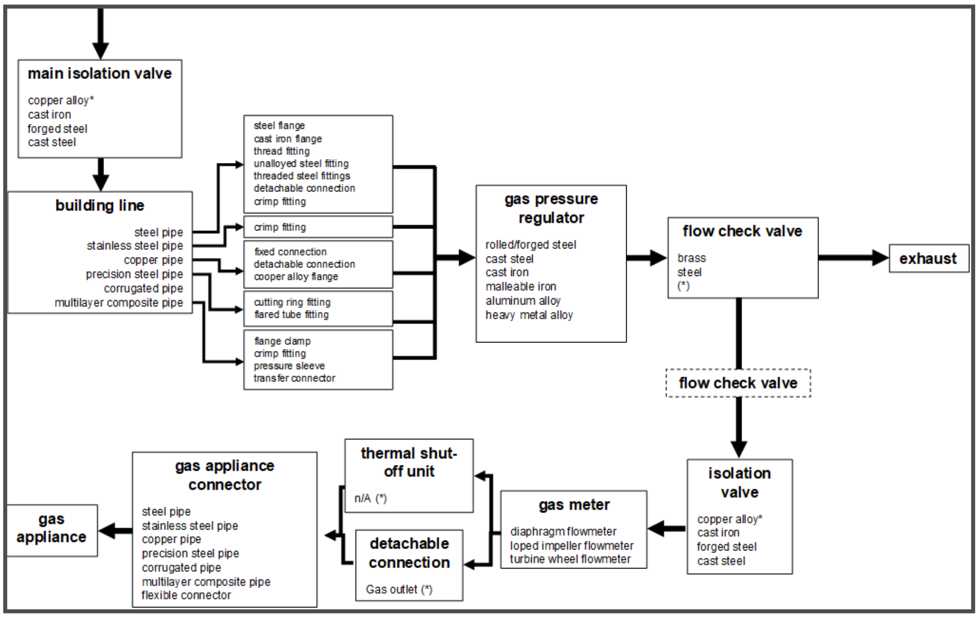
Developing guidelines to determine hydrogen concentrations that can be accommodated by the existing gas infrastructure with acceptable consequences, is the aim of the project HYREADY (announced in newsletter 17, June 2018). The HYREADY project consists of multiple work packages. The first two work packages focussing on gas transmission and distribution networks (ended in 2018), while the third work package focusses on the admixing of hydrogen to natural gas for end-use appliances.

The work package 3 is focussing on the installed fleet of end-use equipment and indoor gas infrastructure/ gas piping. An inventory of the maximum hydrogen fraction will be made for an installed base of end-use equipment and selected range of gas compositions, including: combustion performance, the performance and physical integrity of the infrastructure from the meter to the appliance, and the performance and physical integrity of the internal components of the appliance itself. Furthermore, recommendations for mitigating measures for increasing the hydrogen addition up to 30 % will be made. As in the first two work packages DNV GL and DBI combine their strengths to cover the topics.

The effect of hydrogen addition on the performance of:

- Domestic and small commercial appliances
- Industrial burners
- (Micro-) gas turbines and
- Gas engines

will be investigated by gas interchangeability methods in which DNV GL has broad experience and supplemented with a market inventory and a literature review regarding the impact of hydrogen addition on the performance of end use equipment. Aiming to cover the different gas compositions used by the HYREADY-partners, gases with high, medium and low Wobbe index will be considered in the investigations.



FLOW CHART OF TYPICAL PARTS OF THE INDOOR INSTALLATION
(SOURCE: DBI GAS– UND UMWELTTECHNIK GMBH)

Regarding the inhouse infrastructure, DBI will focus on the physical integrity of the structure from the end of the gas service line to the appliance. The assessment is based on experiences from other projects and in-house testing of the indoor installation´s most common parts. Due to various rules and standards in the home countries of the participating gas distributors, the work will focus on around 15 different commonly used configurations and materials.

All identified typical parts of the in-house gas installation and end-use equipment will be screened and assessed on their maximum hydrogen tolerances by experts of DBI and DNV GL. Based on the results, a guideline for the safe use of indoor gas installations with hydrogen/ natural gas blends up to 30 vol.-% will be made.

The flow chart in the figure above shows typical parts of the indoor gas installation which are applied in similar configurations in most European and North American countries.

HYREADY work package 3 has been started in December 2018 and the final report will be delivered in mid-2019. The HYREADY consortium still welcomes new members.

Project Duration:	WP3 started in December 2018, the final report will be delivered in mid-2019
Partners:	DNV GL Netherlands B.V., DBI Gas- und Umwelttechnik GmbH and a consortium of international gas transmission and distribution companies
Contact:	Albert van den Noort at albert.vandennoort@dnvgl.com and Gert Müller-Syring at gert.mueller-syring@dbi-gruppe.de

Thoughts on a Future European Gas Package | Europe

With the final approval of the Clean Energy Package in January, the European Commission began its preparations for the Gas Package. In recent years, it has become clear that the Commission does not see full electrification as a realistic option to achieve climate goals. Instead, it wishes to encourage the decarbonisation of the gas sector and the long-term utilisation of the existing infrastructure. Hydrogen is a major topic in this respect and has received extra encouragement in the industrial sector, where several major players have showed great interest in the use of hydrogen for the decarbonisation of industrial processes such as the production of steel and fertiliser.

The kick-off for Gas Package activities occurred at the Madrid Forum in October 2018 where, for the first time, one and a half days were dedicated solely to the topic of renewable and decarbonised gas. As part of its preparations, the EC has commissioned seven studies on key topics for the Gas Package. These studies will be published throughout 2019 and form a basis for the coming legislation.

1. Sector Coupling – Identification of regulatory barriers
2. Tailor-made Regulation – Analysis of measures to solve remaining issues in individual markets
3. Capacity and Commodity Release Programs – Analysis of measures to increase liquidity and address the role of long-term capacity contracts
4. Harmonisation of TSO-revenues
5. LNG – Analysis of the existing regulatory framework
6. The role of trans-European gas infrastructure in the light of the 2050 decarbonisation targets

Parallel to these studies, CEER has commissioned its own analysis of the "Future Role of Gas". An initial report was published in 2018 and a consultation and further recommendations are expected in 2019.

However, the analysis goes deeper than this. In Madrid concrete topics were delegated to different organisations for further research. These included CCS, gas quality, gas storage with hydrogen, cross-sectoral flexibility markets, methane emissions, guarantees of origin and definitions. An online available interview with Professor Borchardt, Deputy General Secretary of the EC Directorate General for Energy from December 2018 provides a good overview of these activities (https://www.youtube.com/watch?v=qHCAc_5Yrh4)

The Gas Package is expected to be considerably smaller than the Clean Energy Package as many topics relevant to gas have already been addressed in the Renewable Energy Directive 2, the Energy Efficiency Directive or in the ACER Regulation. The Commission plans to prepare the initial draft of the Gas Package documents by the end of this year - after the new commissioner is elected and present it to the newly-elected Parliament and Council in 2020.

The parallel discussion of the long-term strategy 2050 has a great impact on the gas package. The gas sector is working hard to deliver a credible path towards decarbonisation. That can also be seen in the development of the new Ten Years Network Development Plan (TYNDP) 2020. For the first time, the process includes combined gas- and electricity scenario simulations until 2040/50, taking into account the CO_2-savings requirements mandated by the COP 24 agreement. The scenarios clearly outline the importance of renewable and decarbonised gases for the long-term sustainability of the gas sector.

To underline the seriousness of the gas industry and to test various use cases, hydrogen projects are well underway in several European countries. At the forefront of these activities is the UK with the H21 project, which intends to convert 3.5 million gas customers in the North of England to hydrogen from 2027 onwards. Additionally, there are large-scale projects currently underway in the Netherlands, Germany, France, Denmark and Austria for blending hydrogen into natural gas grids or production of hydrogen. Of particular importance are the efforts of the Austrian European Council Presidency in September 2018 (Linz Hydrogen Initiative) which includes 24 countries and over 80 companies and organisations. The goal of the initiative is to encourage the massive potential of hydrogen technologies in the decarbonisation of the energy system. The initiative recognises the role of hydrogen as a solution for energy storage and as a carbon-neutral energy carrier in a diverse range of sectors. A particular focus shall be placed on the market development of hydrogen for direct industrial use, in transport or for injection into the gas grid. Although the initiative is non-binding, it sends a clear political message regarding the importance of hydrogen in the energy transition.

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Update on the SFEM/WG H2 Activities | Europe

Author: Eveline Weidner | European Commission, DG JRC

The Sector Forum Energy Management/ Working Group Hydrogen (SFEM/WG H2 - last reported in newsletter 15, October 2017) has updated an action plan for pre-normative research, standardization and other relevant topics in the area of power-to-hydrogen and hydrogen in natural gas. Since 2015 and the publication of the first SFEM/WG Hydrogen Report, major improvements have been made in this field and new projects and relevant initiatives launched. The priority challenges identified in the 2015 report have been updated for the various technical areas within the scope of work. Recommendations are made on proposed actions and means of implementation. The near term key challenges, which are the outcome of a prioritisation exercise, have been visualised in a roadmap.

For electricity grid connection and electrolyser technology topics, the activities related to the provision of grid services by electrolysers are considered as having high priority. Partial load, intermittent operation and fast response will be some of the performance requirements for electrolysers when coupled to renewable energy sources or for provision of ancillary services to the electricity grid. The ongoing pre-normative research (PNR) activities on test procedures should feed into the appropriate standardisation work. Control strategies for integrating electrolysers with intermittent renewable energies need to be developed. There are ongoing activities, but further work is likely to be required. Future development of electrolysers should focus on up-scaling the systems to the required multi-MW level.

Moreover, there is still no understanding of an acceptable hydrogen concentration in the natural gas system at European level to date. This point had been seen as a key, overarching priority in 2015. It is clear that there are still a number of technical challenges, depending on the hydrogen concentration, as different components of the gas system or end-user appliances and processes will be affected. Since 2015, several projects, often at national level, have addressed these challenges, but there are some remaining gaps. For hydrogen admixture levels above 2 vol%, the hydrogen concentration limit for steel tanks for CNG vehicles remains a barrier. In addition, further investigations are needed for the operation of gas turbines, in particular with variable natural gas/ hydrogen mixtures, and the effect of hydrogen on industrial processes. To increase the concentration of hydrogen above 5 vol%, there are still knowledge gaps to be filled concerning the compatibility of hydrogen with porous rock underground gas storage. Ensuring safety and performance of compressor stations has not yet been sufficiently tackled. Gas sensors are a key enabling technology for the safe distribution and use of natural gas, therefore their performance in the presence of hydrogen should be ascertained. Although much knowledge already exists on this topic, the effect of hydrogen on the large variety of materials in the gas grid and at end-use level warrants further attention. The performance of gas engines with variable hydrogen concentration has been identified as another potential area where more research is needed.

For pure hydrogen technologies, the priority actions for PNR and standardization are targeted to facilitate the uptake of hydrogen in the transport market. Although many of the gaps identified in 2015 have been filled, or are receiving a sufficient level of attention, some issues related to Hydrogen Refuelling Stations (HRS) remain. One of these topics is the research needed to develop refuelling protocols for medium/ heavy duty vehicles. For the hydrogen refuelling stations it is still necessary to develop risk assessment methodologies for failure modes of hydrogen refuelling stations in order to understand the consequences for the on-board hydrogen storage system. For fuel cell development, the medium and heavy-duty transport applications will need further PNR and standardisation work. For the use of hydrogen and fuel cells for rail and maritime applications, both PNR and standards are needed.

The update report identifies cross-cutting items such as safety, in particular related to H2NG. Sustainability aspects were highlighted, as further work is still needed on life cycle assessment of power-to-gas technologies. Furthermore, the recycling of critical raw materials, such that they can be fully integrated into a circular economy approach, is regarded as an important aspect. A critical issue is the development of the appropriate guarantees of origin for green hydrogen. There are already ongoing activities at PNR and standardisation level with the target of EU-wide deployment of the scheme.

Background:

In the context of the European strategy related to energy transition, the SFEM forum offers a unique platform for sharing needs and for bringing together all stakeholders and players of the hydrogen energy chain. This platform gathers all the necessary expertise to meet RDI challenges and to provide input to improve the EU policy framework. The main objective is to identify standardization needs and then propose standardization development to CEN and CENELEC. This platform of experts is a real strength within the European Union to face our challenges regarding energy, environment and competitiveness, as well as to meet our common Energy Union targets. The SFEM/WG Hydrogen has created momentum for power-to-gas, hydrogen and H2NG, and has reached out to a variety of stakeholders. Most importantly it has created a forum in which experts from the natural gas industry, hydrogen industry and power sector can exchange knowledge and expertise and address common issues.

Sources: https://ec.europa.eu/jrc/en/publication/cen-cenelec-sector-forum-energy-managementworking-group-hydrogen-final-report (The updated report is expected to be published in the first half of 2019 and will also be available on the JRC website.)

Contact: Eveline Weidner at eveline.weidner@ec.europa.eu or Françoise de Jong at Francoise.dejong@nen.nl

HYDEPLOY2: FIRST TRIALS ON PUBLIC GAS NETWORK TO HEAT HOMES | UNITED KINGDOM

Plans to use hydrogen to help heat UK homes – and to significantly cut the country's carbon emissions from heat – took a big step forward in November 2018 with a £14.9 million funding boost announced by industry regulator Ofgem. The money will fund two yearlong field trials on public gas networks which will aim to demonstrate blending with up to 20 vol% hydrogen is both safe and practicable. HyDeploy2 is a follow-up of the HyDeploy project at Keele University, already announced in HIPS-NET newsletter 12, January 2017.

Over the course of the four-year programme, starting in early 2019, the team will monitor the performance and safety of injecting hydrogen into two public gas networks. The project will build further evidence and clear remaining barriers to enable a wider roll-out of hydrogen blends on the distribution network. If adopted across the UK, using a hydrogen blend in the gas network could save the equivalent amount of carbon dioxide as taking 2.5 million cars off the road. A major benefit of this blending approach is that it comes with no disruption to customers – they do not need to change their gas appliances or the pipes to their homes but they are still able to decarbonise.

Backed by two gas distribution networks – Cadent and Northern Gas Networks (NGN) – there will be one trial in each company's geographic footprint. This means one in Cadent's North West network and one in NGN's area in North East/ Yorkshire. Identifying suitable locations, and consulting customers and authorities in those areas, will be the next steps.

TIMELINE OF THE HYDEPLOY PROJECT
(SOURCE: HTTPS://HYDEPLOY.CO.UK/)

The trials will take place following the successful completion of the first trial on a closed gas network at Keele University. Earlier in November 2018, after extensive scientific analysis and safety checks, the Health and Safety Executive (HSE) gave the HyDeploy team permission to commence the trial. Injection of hydrogen will commence this summer.

Background

- Heating homes and industry accounts for nearly half of all energy use in the UK and one third of the country's carbon emissions. More than 80 % of homes in the UK are heated by gas.
- Hydrogen was a major component in 'town gas', gas created from coal and used widely throughout Britain before the discovery of North Sea gas in the 1960s. Up to 60 % of the gas (by volume) being used by consumers was hydrogen.
- Cadent is involved in a wider portfolio of projects – such as HyNet North-West, to use hydrogen to power industry and blended hydrogen to heat two million homes in North West England – which first depend on the success of the HyDeploy trials, in proving the concept.
- Building on the HyDeploy principles towards wider deployment of hydrogen, Northern Gas Networks is delivering a suite of hydrogen projects called H21, focused on converting the gas network to 100 vol% hydrogen.

Partners: Cadent, Northern Gas Networks, Keele University, ITM Power, Health and Safety Laboratory (HSL), and Progres sive Energy

Sources: www.hydeploy.co.uk https://cadentgas.com/media/press-releases/2018/green-light-for-leading-edge-hydrogen-_trial-(1)

Contact: Andy Lewis at Andy.Lewis@cadentgas.com

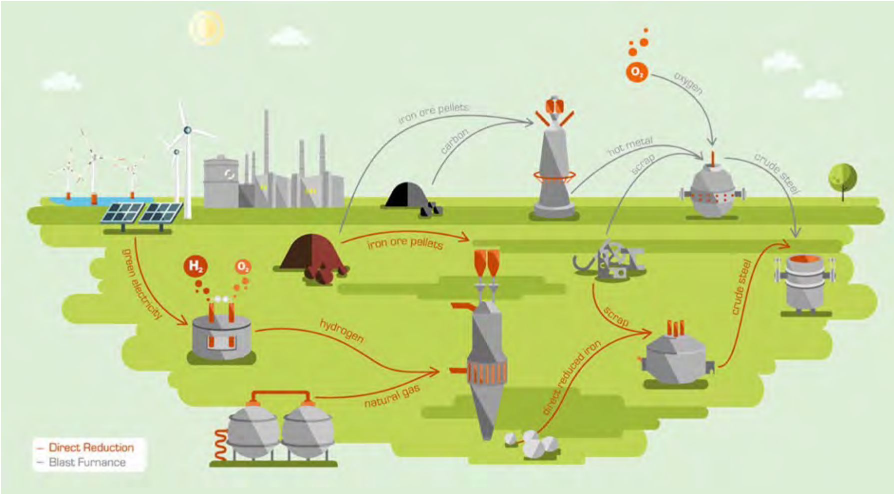
A HYDROGEN-BASED STEEL INDUSTRY - PROJECTS OF THE SALZGITTER AG | GERMANY (1/2)

Salzgitter´s CO_2-Emissions amount to eight million tons per year. New technologies should lead to a significant reduction.

The Vision: "SALCOS" - Salzgitter Low CO_2 Steelmaking

Salzgitter is producing steel using the blast furnace route where iron ore is reduced with carbon. Converting this process step by step by changing to the direct reduction route starting with natural gas and replacing it with ever higher proportions of renewable hydrogen can lead to a 90-95 % reduction of CO_2-Emissions by 2050. This is the aim of the project "SALCOS" - Salzgitter Low CO_2 Steelmaking.

Although the framework conditions prevailing today do not permit the commercial operation of a hydrogen-based direct reduction plant in the long term, Salzgitter started first innovating projects to explore new technologies and integrate them into the existing steelworks.



"DIRECT REDUCTION ROUTE" AND "BLAST FURNACE ROUTE" FOR STEELMAKING (SOURCE: HTTPS://SALCOS.SALZGITTER-AG.COM/)

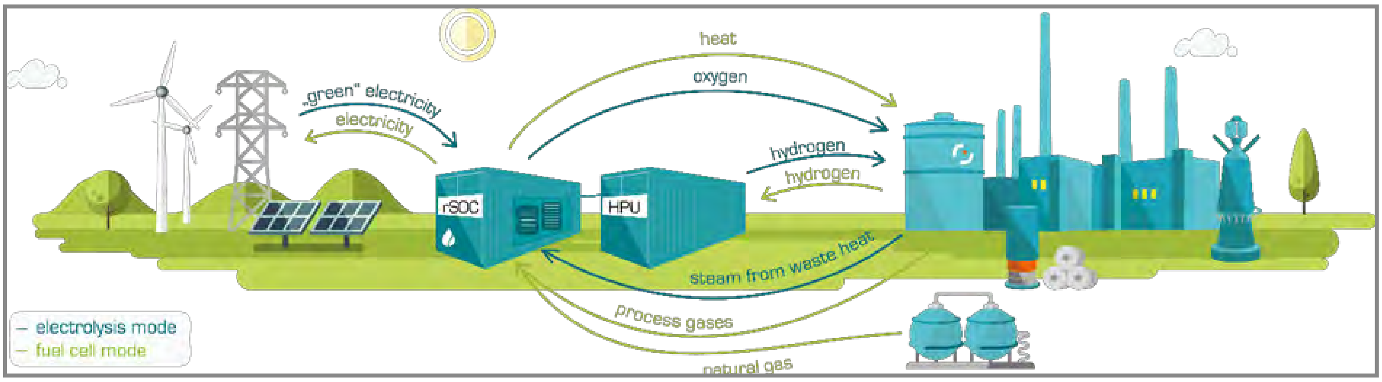
Towards a Hydrogen-based Steel Production - Project „Salzgitter Wind Hydrogen"

A first step towards the goal of "Salzgitter Low CO_2 Steelmaking" is the project "Salzgitter Wind Hydrogen", between Salzgitter Flachstahl GmbH, Linde AG and Avacon Natur GmbH. Via this cooperation, wind power and hydrogen through electrolysis should be generated. The partners aim to build up know-how in on-site production of hydrogen and its integration into the complex processes of steelmaking. Salzgitter AG plans the construction and operation of a PEM electrolysis plant while Avacon will be responsible for the installation and operating of seven wind turbines on the premises of the Salzgitter Group. Linde AG will provide a steady supply of hydrogen as backup in times of lacking wind energy.

For the entire project (installation of the wind turbines and, the hydrogen plant, as well as linking them to the existing distribution networks) costs of 50 million Euros are expected.

GrInHy - Reversible Electrolyser in Action

Another step to a hydrogen-based steel production is the Green Industrial Hydrogen project (GrInHy), which seeks the integration of Sunfire's reversible electrolysis technology into the production processes of Salzgitter. Electrolysis and fuel cell operation are achieved with one set of equipment, the system will be operated reversibly using natural gas and industrial process gases in order to improve the economics of the installation. GrInHy is in progress since March 2016 and is part of the EU funding program for Horizon 2020.



IMPLEMENTATION OF SUNFIRE´S REVERSIBLE ELECTROLYSER INTO THE PROCESSES OF SALZGITTER AG (SOURCE: HTTP://WWW.GREEN-INDUSTRIAL-HYDROGEN.COM/HOME/)

(CONTINUED)

The solid oxide electrolyser has an input power of 150 kilowatts and a hydrogen output of 40 Nm³/h. The solid oxide fuel cell produces 25 kW_{AC} at operation with natural gas or CH_4 and 30 kW_{AC} at operation with H_2. Results will be publicly available in spring 2019.

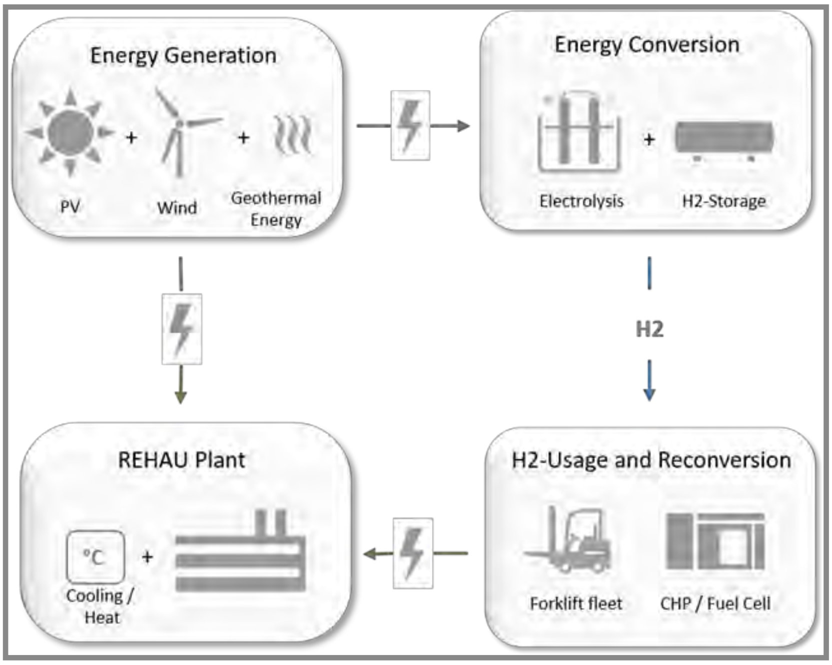
Sources: SALCOS: https://salcos.salzgitter-ag.com/
Salzgitter Wind Hydrogen: https://www.salzgitter-ag.com/en/press/press-releases/press-release-of-salzgitter-ag/2018-10-30-1/salzgitter-clean-hydrogen.html
GrInHy: http://www.green-industrial-hydrogen.com

Contact: Dr. Alexander Redenius at a.redenius@sz.szmf.de, Ralph Schaper at schaper.r@salzgitter-ag.de

TECHNO-ECONOMIC ASSESSMENT OF POWER-TO-GAS-TO-POWER SYSTEMS FOR USE IN AN INDUSTRIAL ENVIRONMENT | GERMANY

On behalf of the German polymer expert REHAU AG, DBI Gas- und Umwelttechnik GmbH conducted a study on the integration of renewable energy plants (RE plants) in combination with a Power-to-Gas-to-Power system (PtGtP system) into the plant supply at the beginning of 2016. The study results (Phase I) showed an amortisation time of less than twenty years at adequate design. Based on this assessment, a follow-up project (Phase II) was launched. The aim of Phase II was to develop a calculation tool, which models a comprehensive energy supply system based on various usage scenarios and variable input parameters. Thus, the existing infrastructure of the plant supply should be variable in order to be able to apply the process to further plant sites.

The economic and technical optimisation processes are based on different targets such as peak load coverage/ peak shaving, hydrogen production or supply of cooling energy. These targets (scenarios) were defined and characterised in cooperation between the customer and the contractor. The following illustration shows the structure of the overall system, modelled in the context of the project.



SCHEME OF THE MODELLED POWER SUPPLY SYSTEM
(SOURCE: REHAU AG, TRANSLATED)

The starting point for the considerations is the utilisation of RE plants already existing or being installed. The electrical energy generated in this way is used for the direct supply of the plant or converted into storable hydrogen in accordance with the selected target. Thus, the PtGtP system has two functions: provision of storage capacity for renewable electricity and production of green hydrogen for further applications, e.g. the forklift fleet.

In addition to the technical design of system parameters, the calculation tool can be used to perform an economic assessment of the required investments and operating costs and can compare them with the expected monetary return. The required database is accessible via an individual user interface as well as associated Excel tables and can be adapted to techno-economic developments in the future.

The customer has been using the calculation tool in the field of energetic optimisation of plant sites for almost one year. Markus Weiß, project engineer at REHAU AG, reports:

“We have already examined each of the 14 German REHAU plants for cost effectiveness and found out that it would be worthwhile for four plants to use a storage system to reduce network charges to such an extent that it pays to invest in renewable energy on a large scale. We are currently in the process of implementing the system in the most promising location.”

Duration: August 2016 - October 2017

Partners: Rehau AG und Co. (customer) and DBI GUT Leipzig (contractor)

Contact: Stefan Schütz at stefan.schuetz@dbi-gruppe.de

WESpe – Full Value-Chain Analysis of Hydrogen for Long-Term Renewable Energy Storage | Germany (1/2)

The final report on project WESpe has been published and provides a detailed analysis of the power-to-gas process including the technological, economic and societal impact of the power-to-gas value chain in Germany. The project, which was outlined previously in HIPS-NET newsletter 10 in June 2016, is a joint undertaking by Deutsche Umwelthilfe e.V. (DUH), Brandenburg Technical University (BTU), DBI Gastechnologisches Institut, German Aerospace Center (DLR) and the Fraunhofer Institute for Solar Energy Systems (ISE). The analysis took place over more than three years and considered the following topics:

Work Package	Subject
WP 1	Evaluation of core components incl. electrolyser technologies
WP 2	Identification of methods and designs for underground hydrogen storage
WP 3	Modelling and functional analysis of the entire hydrogen/electrolysis supply chain
WP 4	Studying the environmental impact of hydrogen/electrolysis
WP 5	Public acceptance and transparency
WP 6	System analysis and macro-economic analysis

Work Packages of the Project „WESpe“

A key feature of the WESpe study is its analysis of the entire hydrogen supply chain via electrolysis: From the source of renewable electricity, the conversion into hydrogen, the hydrogen storage, the injection into the gas grid, to the end use in different sectors.

Development of Electrolyser Technologies

The principle focus of the research on electrolyser technologies was to evaluate the electrolyser performance and the degradation of that performance over time in conjunction with dynamic and high-demand operation. The project researched optimisation and cost-reduction technologies, which might improve the long-term performance. In particular, the project recognised the value of corrosion-limiting coatings on bi-polar plates and improved designs for the gas diffusion layer, which significantly extended the lifetime of the electrolyser under high-demand operation.

In addition, the project also analysed the influence of different factors (pressure, temperature, electrical current density, alkaline levels) on the efficiency rate of an alkaline electrolyser under both static and dynamic operation. Among the notable conclusions drawn by the evaluation is that, while temperature has a considerable influence on the efficiency of the electrolyser, pressure is shown to have very limited influence.

Hydrogen Cavern Storage and Gas Grid Injection

The analysis of the technological optimisation for hydrogen storage and grid injection determined that salt caverns are currently geologically suitable for hydrogen storage. Porous storage facilities need to be analysed individually based on the geological conditions.

As part of the research, a full simulation model for the underground storage of hydrogen was developed. The model calculated the thermodynamic, fluid-dynamic and geomechanical processes for hydrogen storage. This model also considered subsystems related to hydrogen storage such as compressors, extraction facilities, injection systems and related transport lines. The model also takes the reliability and depreciation rates of the facility technologies.

Full-System Scenario Modelling

In order to illustrate the role of power-to-gas on a large scale, two full-system analyses were conducted based on different use-case scenarios for power-to-gas in the German domestic market. The goal of the analyses was to determine the economic and technological impact of scaling-up power-to-gas as part of a relevant decarbonisation scenario.

The first analysis simulated the large-scale use of electrolysis and hydrogen infrastructure for the sole purpose of re-electrification based on the demand for renewable electricity storage in Germany until 2050. Assuming the use of alkali electrolysers on a dynamic load profile, the simulation calculated a required electrolyser capacity for Germany in 2030 of 4 GW with 2,270 full load hours per year. The required capacity increased to 67 GW in 2050 with 2,150 full load hours. To ensure adequate storage capacity as part of this simulation, eight salt caverns with a capacity of 500,000 m^3 would be necessary in 2030, increasing to 170 caverns in 2050. In addition, 1 GW of gas turbine capacity would be necessary in 2030 with 2,520 full load hours in order to re-electrify the stored hydrogen. This would increase to 26 GW capacity in 2050 with 1,630 full load hours. Economically, the simulation calculated an H_2 cost in 2050 of 5.52 €/kg H_2. The cost of electricity generation using this value chain would be 42.9 Ct/kWh_{el}.

(CONTINUED)

The second full-system analysis was based on a present-day scenario in which green electricity was converted to hydrogen via electrolysis, stored in caverns and then transported via pipeline to end-users in the transport and industrial sectors. This scenario utilised PEM electrolysers with dynamic load profiles directly attached to onshore wind parks. Assuming 12,500 private hydrogen vehicle units and 340 hydrogen buses in Germany, the simulation calculated 590 MW of required electrolyser capacity at 7,700 operating hours annually (4,300 hours of which would be at full load) and a single storage cavern with 530,000 m^3 capacity. The full-system investment costs of 1.4 billion Euro led to a levelized cost of hydrogen at 4.0 €/kg H_2, which would decrease to 3.7 €/kg H_2 with increases in surplus renewable electricity generation.

Societal Acceptance

DUH analysed the societal acceptance of the large-scale development of power-to-gas projects. To do this, they created a communications concept based on the following questions:

- Which actors are involved?
- Which areas have the greatest conflict potential?
- Which safety concerns do citizens have regarding hydrogen?
- To what extent does green hydrogen in particular have a higher level of transparency?
- Which means of communication would most optimally be utilised?

This concept was then put into practice. As part of the Multi-Energy Power Station in Sperenberg, Germany – a hybrid power plant providing wind electricity and hydrogen from electrolysis for the 145,000 houses in the region – the DUH utilised its communications concept to engage with the local community and provide open and transparent information about the project from an early stage. The concept in particular addressed citizens' concerns regarding the environmental impact of the project at the time of the application for planning permission, in order to ensure a smoother and more transparent administrative process.

Project Duration:	December 2013 - December 2017
Partners:	Brandenburgische Technische Universität, DBI-Gastechnologisches Institut GmbH Freiberg, Deutsche Umwelthilfe e. V., Deutsches Zentrum für Luft- und Raumfahrt e. V.
Funding:	Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit (BMU)
Sources:	„Ergebnisse des Projekts WESpe“ in HZwei, Hydrogeit Verlag, 18. Jahrgang, Heft 2, April 2018 (in German)
Contact:	Steffen Schmitz at steffen.schmitz@dbi-gruppe.de

NEW HIPS-NET MEMBER: GASNETZ HAMBURG

The HIPS-NET is growing further. Our newest partner is Gasnetz Hamburg from Germany. The municipally owned gas grid operator is committed to pursuing a clear vision for urban climate protection in Hamburg. The company is preparing to use its natural gas grid as an "evolutionary infrastructure" for the transport of renewable gases. Within the next few years, smaller shares of hydrogen will make the existing infrastructure more climate-friendly. Simultaneously, new grid areas could operate with even higher H_2 shares. Hamburg's gas grid can thus steadily increase its contribution to protecting the climate: The city's households and industry obtain almost two third (21 billion kilowatt hours) of their grid-bound energy via the gas grid. Only around one third (12 billion kilowatt hours) of energy consumed is electricity.

Gasnetz Hamburg GmbH, a company of the Free and Hanseatic City of Hamburg, operates the natural gas grid with a length of approximately 7,900 kilometers. It connects approximately 160,000 buildings and serves almost 230,000 grid customers. The grid is comprised of high-, medium-, low-pressure and house connection lines as well as around 600 gas pressure-regulating stations. The network is operated and monitored from a central load control center.

"Sharing know-how and experience within the framework of HIPS-NET will help us to expand our own competence in hydrogen technology. At the same time, it will allow us to contribute our experience to the discussion of this future-oriented topic," says Udo Bottlaender, Technical Director of Gasnetz Hamburg GmbH. "This will enable us to develop solutions for Hamburg that optimally combine economy, safety, and sustainability. We are very much looking forward to cooperating with HIPS partners".

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Selection of appointments 2019

March, 11-15 **ISH**
(Frankfurt a. M., Germany)

March, 12-14 **IRES - Speicherung Erneuerbarer Energien**
(Düsseldorf, Germany)

March, 12-14 **Energy Storage Europe**
(Düsseldorf, Germany)

March, 19 **Hydrogen & Fuel Cells - Powering the Future**
(Birmingham, UK)

March, 26-27 **DBI-Fachforum Wasserstoff & Brennstoffzellen**
(Cologne, Germany)

March, 27-29 **Hydrogen Days 2019 - 10th International Conference on Hydrogen Technologies**
(Prague, Czech Republic)

March, 28-31 **4th International Conference on Renewable Energy and Smart Grid (ICRESG 2019)**
(Hangzhou, China)

April, 01-05 **Hydrogen + Fuel Cells EUROPE**
(Hannover, Germany)

April, 08-09 **Future Mobility**
(Berlin, Germany)

April, 24 **EAGE/DGMK Joint Workshop on Underground Storage of Hydrogen**
(Celle, Germany)

April, 24-26 **14th HYdrogen POwer THeoretical and Engineering Solutions International Symposium (Hypothesis XIV)**
(Foz do Iguaçu, Brasil)

May, 06-08 **China International Hydrogen & Fuel Cell Exhibition**
(Beijing, China)

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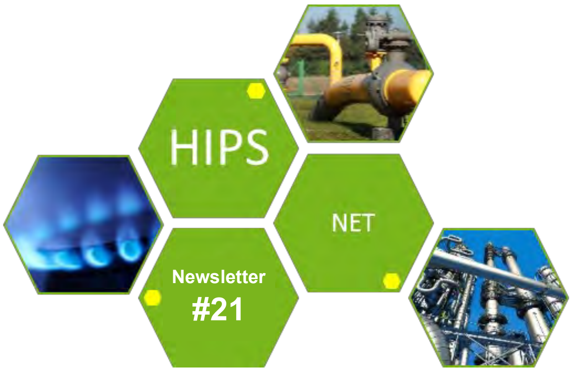


"ESTABLISHING A PAN-EUROPEAN UNDERSTANDING OF ADMISSIBLE HYDROGEN CONCENTRATION IN THE NATURAL GAS GRID"

NEWSLETTER #21 | **JUNE, 2019**

Dear HIPS-NET Partners,

At the energy summit of the Handelsblatt, the largest German daily newspaper for economic and financial issues, the German Minister for Economic Affairs Peter Altmaier said:

> *"We will build a modern energy system. This system won't work without sectoral integration. And this system - if we want to store renewable electricity - will never work simply by installing thousands of lithium-ion batteries. Because if we want to use electricity in winter, which is produced during the summer and used less, then it is best to use clean gas, hydrogen, which is produced by electrolysis and renewable electricity. And then we have to ask ourselves how many electricity lines we still need, how many pipelines we can fill with it, and above all after acceptance. Many citizens say: we do not want five, four, or three as many wind turbines as we have today. That is why the energy revolution is far from over; we have to discuss it."* *(Source: https://short1.link/3cSrPw; minute 17-18)*

Novel words (to us) is the recognition on the top level of the government how important hydrogen and the gas infrastructure are in the process of energy transition. The hard work of the recent years, we observed pays (slowly) out. The awareness for clean gases in the gas infrastructure rises for political decision-makers.

Are there similar developments in your country? If so, please let us know.

Your HIPS-NET Team

Gert, Anja, Josephine & Charlotte

HIPS-NET Workshop in Brussels

2019

26th/27th June

Please register here!

CONTENT

CONTENT NEWSLETTER #21

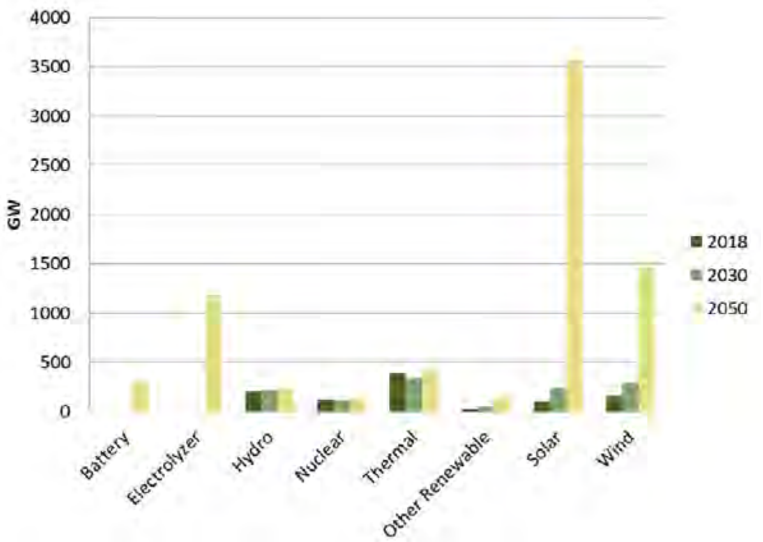
JRC - Potential Role of Hydrogen Production | Europe (1/2)

JRC Technical Report | The Potential Role of Hydrogen Production in a Decarbonised System Powered by Renewables in 2050

The European Commission's science and knowledge service JRC (Joint Research Centre) released a report in 2019 that explores the potential role of electrolysers in a future largely decarbonised energy system and uncovers the reasons why this technology may be an important building block towards the transition to a stable, sustainable and fully renewable power system.

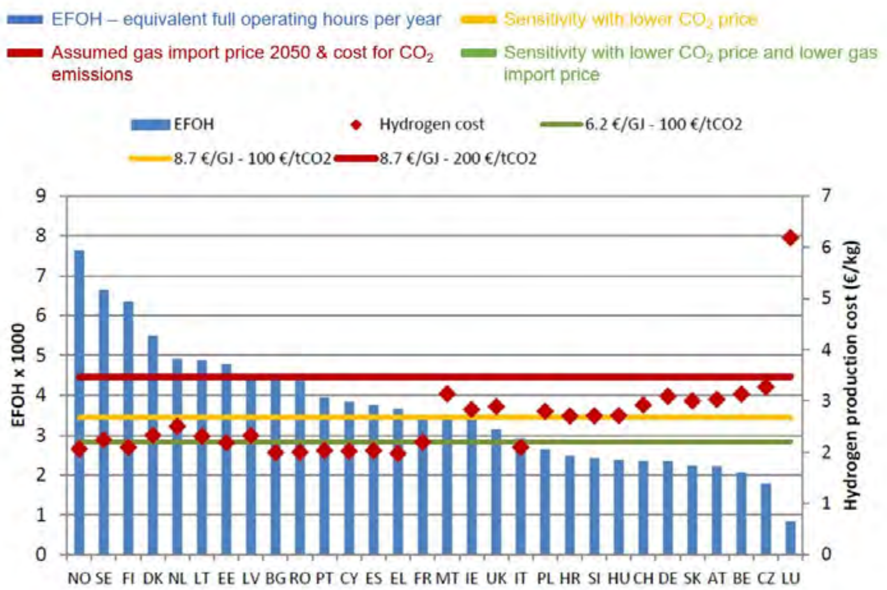
Wind and Solar power generation technologies are main elements on the path to this goal (referred as VRE for Variable Renewable Energy). Their short-term variability can be compensated by batteries, while Power to X (P2X) can act as potential seasonal storage. P2X implies the production of hydrogen from electrolysis and potential conversion downstream to synthetic fuels as final energy carriers. The authors find that the main advantages of the technology are: (1) use of existing infrastructure for transporting and storing hydrogen and synthetic fuels; (2) providing an energy vector with the potential to decarbonize other sectors; (3) supply of hydrogen that can be used in combination with CO_2 from biogenic sources (or even air) to produce synthetic fuels and feedstock for chemical industry.

The two key barriers are the high cost of electrolysers (currently at 1000-1500 €/kW) and how to ensure low electricity prices while still achieving high number of operational hours. The scenario parameters presume electrolyser cost of 400 €/kW and efficiency of 86 % (including heat recovery) by 2050. The study implemented a soft-linking of a long-term energy model (EU-TIMES) and a short-term power system dispatching model (METIS).



Installed Capacities Generation and Consumption Assets
(Source: report p. 10 original from JRC, ENTSO-E, METIS EUCO30 2030)

EU-TIMES provided the hydrogen demand considering the entire energy system, while METIS focused on the hourly operation for the power system. The report focuses mainly on the potential effect electrolysers can have in the power system in a scenario where the electrolyser capacity is the largest to establish an upper bound of the impact. This scenario is one potential future where Carbon Capture and Storage (CCS) is not widely accepted or adopted (limiting the technology portfolio and therefore with higher reliance on hydrogen).



Average Hydrogen Production Cost and Full Load Hours from Electrolysis and Comparison with Steam Methane Reforming in 2050
(Source: report p. 19 original from JRC, ENTSO-E, METIS EUCO30 2030)

The scenario has a CO_2 reduction target of 80 -95% vs. 1990 by 2050. In such a scenario around 1,000 GW of electrolysers would be required by 2050. They would be producing the hydrogen needed to supply a decarbonised (primarily steel) industry, and processes to produce synthetic fuel volumes for aviation, shipping and long-haul road transport. The scenario was picked in order to analyse the technical and economic viability of such a deployment, given the very important challenges posed by VRE integration at levels beyond 50%.

The authors found that the power market in such a system could be structurally different from the current power market in terms of roles. While supply and demand will have to be met at all times, the two roles would be switched:

(CONTINUED)

In contrast to current practise the demand side (primarily the electrolysers) would be providing energy and the essential services for balancing the power system, while the production side (mostly renewables) would represent the inelastic part of the equation, similar to the role of demand in the present power system.

A capacity of 1,000 GW requires a 24 % growth per year, which is still less than the 32 % observed for PV in the 2012-2017 period, emphasise the authors. Attaining this level of sustained growth for the entire period until 2050 would require significant investments in electrolyser manufacturing capability in Europe.

Some quantitative results of the present analysis are summarised below:

- The average electricity price renders between 27-35 €/MWh in most countries.
- This translates into a hydrogen production cost of approximately 3 €/kg.
- The annual operating hours for the electrolyser are between 2,000 and 7,500. Countries with more than 4,500 hours had the following conditions:
  - i) Total electricity production was at least 2.5 times the net electricity demand (meaning at least 60 % of the electricity demand was from the electrolysers);
  - ii) Wind was the dominant VRE technology with at least a 2.5 wind to solar production ratio;
  - iii) The electrolyser is sized between 16 and 24 % of the VRE installed capacity.

The analysed scenario has very good chances of achieving sustainability: In most countries hydrogen production with electrolysis has the potential to be competitive compared to the main alternative technology (SMR with CCS/U). As the diagram on the previous page displays, the hydrogen production costs are below the red line. The red line marks the alternative technology hydrogen production cost assuming a gas price of 8.7 €/GJ, corresponding to the import price for 2050 in the 2DS (2 ºC) scenario from IEA ETP and - given the low carbon nature of the future scenario - a CO_2 price of 200 € per tonne. At the same time all three VRE generating technologies could, in most countries, under the assumptions used, recover all or most of the capital investment cost from the day-ahead power market.

http://dx.doi.org/10.2760/540707

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International Activities for Market Uptake of Hydrogen Industry | Canada, China, Japan

Canada | Industrial Upscale with 20 MW PEM Electrolyser

Air Liquide announces the construction of the largest PEM electrolyser in the world with 20 MW capacity. Notwithstanding difficulties, the development underpins the market uptake for electrolyser technology. The upscaling of electrolyser capacity develops worldwide; genuine projects are underway also in Japan, China and Europe.

The 20 MW electrolyser increases the current capacity of the hydrogen facility located in Bécancour, Québec (Canada) by 50 % and supplies both industry and mobility with low-carbon hydrogen. This new production unit will significantly reduce carbon intensity, compared to the traditional hydrogen production process. Emissions of nearly 27,000 tonnes of CO_2 per year, equivalent to those of about 10,000 sedan cars per year, will then be prevented. The facility should be in commercial operation by the end of 2020, producing just under 3,000 tonnes hydrogen annually, according to Hydrogenics.

Air Liquide intends to utilise hydropower for electrolysis and the concept relies on continuous operation (24/7 year-round). This is a private investment from Air Liquide; possible public funding will be assessed as the project evolves. The driver of this investment is to reaffirm Air Liquide's long-term commitment to the hydrogen energy markets and its ambition to be a major player in the supply of carbon-free hydrogen. Are there any market conditions which support the decision? Air Liquide currently does not share any details supporting appraisal.

China | Developing a "Hydrogen City" until 2025

Curiosity creates a proposal in China: „a hydrogen city"? Wuhan, a Chinese city aims to develop hydrogen energy industry. The "hydrogen city" includes research and development of hydrogen production, storage and transport and improving the hydrogen infrastructure. Main focus seems to be on mobility, with 20 fuelling stations until 2020 and 30 to 100 in 2025, 3,000 running fuel-cell electric vehicles (FCEV), production facilities for fuel cells exceeding 13 billion Euro annually, and attracting 3 to 5 world leading hydrogen enterprises.

Japan | Hydrogen Production in Industrial Scale

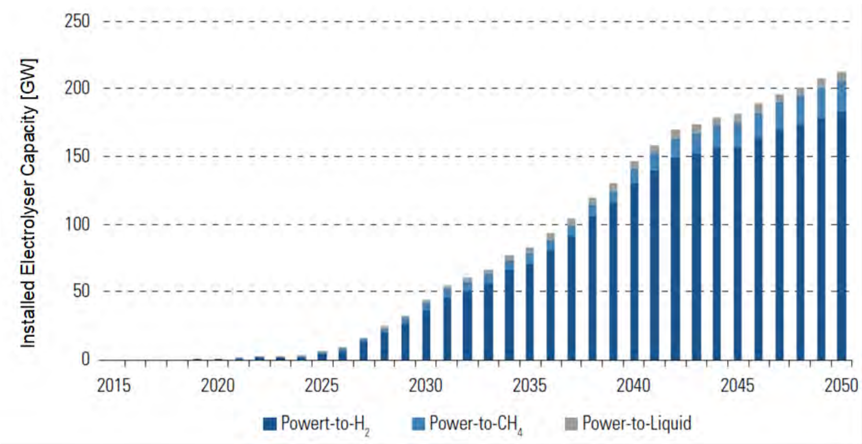
Japan plans in the sadly famous region Fukushima to build large renewable hydrogen production capacity with up to 10 MW of electricity from sun and other renewable sources. Test operations are scheduled for July 2020. The renewable hydrogen will be used – among other purposes – to power fuel -cell electric vehicles. The promotion of renewable energy in the region is guided and guarded by the Fukushima Renewable Energy Institute AIST (FREA) since 2014.

Canada: https://short1.link/8O71Ws
China: https://short1.link/Pc7FZB
Japan: https://short1.link/M1fU2r

IndWEDe Study Industrialisation of Electrolysis | Germany

Opportunities and Challenges for Sustainable Hydrogen for Transport, Electricity and Heat

The central questions of this study, commissioned by the German Federal Ministry of Transport and Digital Infrastructure, is how to ensure that water electrolysis will be available as a powerful technology in the future and what challenges exist to **build-up a gigawatt electrolysis industry** in Germany. The scenarios for the future energy system in Germany result in a corridor of 137 to 275 GW of installed electrolysis capacity by 2050 in order to achieve the national climate targets. This applies, if the hydrogen is mainly produced in Germany; without larger imported quantities. The main driver for the future demand for electrolysers in Germany is the national CO_2 reduction target; this is in line with the results of other studies.



Installed Electrolyser Capacity until 2050 in Germany

(Source: Study page 69)

The study was coordinated by the state-owned NOW, the National Organisation for Hydrogen and Fuel Cell Technology. The NOW has its main focus on the transport sector, and this is reflected in the present study. With a decreasing relative tendency towards 2050, hydrogen demand is expected mainly in the transport sector, especially in the truck sector. The fuel supply for aviation and shipping is (by definition) not provided by pure hydrogen but liquid fuels.

Feed-in into the natural gas network plays a minor role, because the target market (heat, etc.) presumably needs production cost reductions to about 1-2 €/kg_{H2}. For simple reasons from the authors' perspective: It is easier to reach production costs of the mobility market with 2.5-3.5 €/kg_{H2}. This means that the acceptable production costs for hydrogen in fuel-cell mobility are about three times higher than those for feeding it into the natural gas grid. Measures to give green hydrogen a value are not sufficient to achieve competitiveness, even with 300 €/t CO_2 savings. (The methodical approach does not take CO_2 abatement costs as central criteria for investment decisions, which might lead to divergent results as we can see in other studies.)

The study concludes, the alkaline and to a large extent the PEM electrolysis are in a **technically mature state**. The development of technology and costs as well as the optimisation of manufacturing processes are primarily driven by the industry itself, provided that the demand on the market increases permanently. The economies of scale lead the authors to expect a considerable reduction in costs. R&D and demonstration projects will provide meaningful support for the market ramp-up but are not sufficient to trigger it to the needed extend. The needed annual increase in electrolysis capacity already in the 2020's (to comply with climate goals) exceeds the realistic development, according to experts' opinions.

Main obstacle for needed market ramp-up are **stable and secure market conditions**. Specific needed actions are recommended, including a **market activation programme for green hydrogen**. We are curious to see which steps the commissioner of the study (Ministry of Transport) will take in the near future.

Partners: NOW, Fraunhofer ISE, E4tech Sàrl, Fraunhofer IPA

Roadmap for Electrolysis Development until 2030 in Germany (Excerpt)

(Source: Study page 6)

short: https://short1.link/fvgZmw (ENG)
long: https://short1.link/7oAPF7 (GER)

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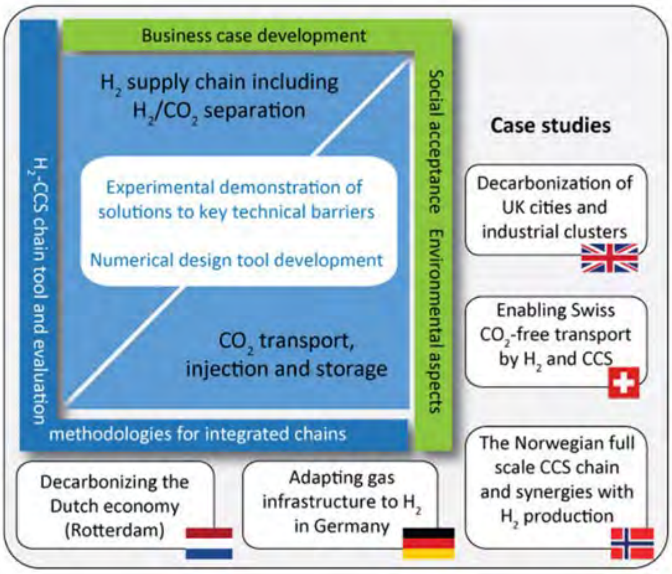
ELEGANCY - Enabling a Low-Carbon Economy via H_2 and CCS | Norway

The project ELEGANCY is aimed at fast-tracking and full-scale implementing the CCS technology in Europe, because it is deemed to be necessary for holding-up the climate change. CCS stands for Carbon Capture, Transport and Storage. ELEGANCY proposes to use synergies between CCS and H_2 and investigates possible H_2-CCS chains. The research spans the range from the phenomenon level via lab-scale experiments to the pre-pilot scale. The project focus is with CCS; the use of the gas grid for H_2 transport or admixture will be addressed with minor focus.



Overview of Key ELEGANCY Research (Source: SINTEF)

Partners	22 from industry and research institutions (see here in detail)
Coordinator	SINTEF Energy Research
Budget	15.6 million EUR
Funding	Norwegian, Dutch, German, UK & Swiss national funding agencies, the European Commission and industry
Duration	31 August 2017 - 31 August 2020

Within six work packages ELEGANCY examines the H_2 supply chain and H_2-CO_2 separation, the CO_2 transport, injection and save storage, a business case development for H_2-CCS integrated chains, a H_2-CCS chain tool and evaluation methodologies for these chains and various case studies. The origin of the gas are residual steel gases, such as basic oxygen furnace gas, blast furnace gas, and cokes oven gas. A main component is CO which is converted via a catalytic water gas shift reaction to CO_2 ($CO + H_2O \rightarrow CO_2 + H_2$); this is where H_2 comes into play. Further sources are also addressed i.e. natural gas reforming process ($CH_4 + 2H_2O \rightarrow CO_2 + 4H_2$).

https://short1.link/G8Zg3Q
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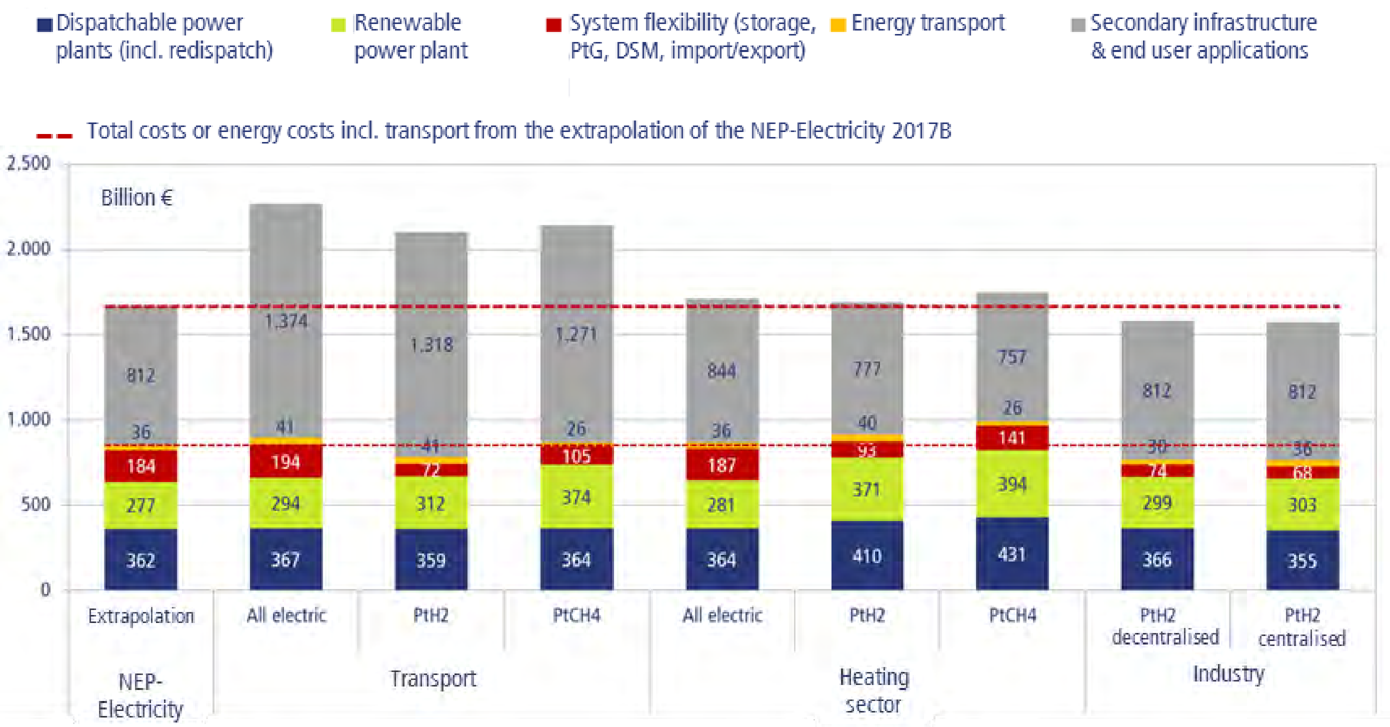
Study for Smart Sectoral Integration | Germany (1/3)

What are the Economic and Environmental Benefits of Power-to-Gas in Comparison to an "All-Electric" Approach? An Assessment for the Future Energy System in Germany.

This central question has been subject to some studies in the past. This study here supports an investment decision (~150 million Euro) of two major transmission system operators – Amprion (electricity) and Open Grid Europe (gas) – in Germany; both are project partners of the 'hybridge' project which is outlined subsequently in a separate article.

The study simulated the total costs of the German energy system consisting of the sectors electricity, transport, heat and industry including end-use applications. Three scenarios were defined for this purpose:

- "**Base Scenario**" with a climate protection target of 80 % CO_2 emission reduction by 2050 compared to 1990,
- "**Fast Energy Transition**" scenario with CO_2 emission reduction target of 95 % in 2050, reduced costs of the PtG technology, and a comprehensive portfolio of other flexibility options such as import/export, demand side management etc. and finally
- scenario "**Focus PtG**" also with the climate protection target of 95 % CO_2 emission reduction by 2050 and reduced costs of PtG technology, but at the same time with limited potential of other flexibility options and increased use of PtG in various sectors.



CUMULATIVE TOTAL COSTS 2025 - 2050 IN BASE SCENARIO FOR TRANSPORT, HEAT, INDUSTRY IN GERMANY (SOURCE: LBST, P. 56)

(CONTINUED)

In the context of this study, **sectoral integration (or coupling)** refers to the **coupling of electricity and gas networks** for the optimised integration of renewable energy (RE) sources in Germany. Even if the expansion plans in the German electricity network development plan 2030 (NEP 2017B) are successfully implemented, it will not be sufficient for electricity distribution due to constant rise in RE generation. With sectoral integration, the expansion of the electricity grid until 2050 is cost-effectively supplemented in the medium and long term by the existing gas grid (via PtG). In other words, driven by the total costs of the future energy system (until 2050), the advantages of PtG prevail over the additional costs e.g. conversion losses for gas production (see diagrams). The transport of hydrogen and synthetic methane requires significant pipeline capacities between 22-100 GW_{H2} in the PtH_2 case and 34-90 GW_{CH4} in the $PtCH_4$ case. The existing gas pipeline capacities appear sufficient to transport the quantities; and new transmission lines are not needed. The costs for the use and, if necessary, transformation of the existing pipelines remain negligible compared to the total costs for electricity grids.

The authors' summary of the core results:

1. **Flexibility advantages** of power-to-gas (i.e. storage and use of existing infrastructure) outweigh the efficiency disadvantages (i.e. conversion losses), particularly in the transport sector and industry.
2. Gas storage capacity as **seasonal energy storage** to reach CO_2 emissions reduction target (of 95 % compared to 1990 levels in 2050) is **unavoidable**, in addition to short-term battery storage capacity.
3. In the long term, i.e. beyond a share of approx. 400-450 TWh annual electricity generation from renewable energy sources, power-to-gas represents a meaningful **addition to the electricity grid expansion based on the German electricity network development plan**.
4. Power-to-gas has **negative CO_2 abatement costs** compared to "all-electric" solutions due to the lower overall investment for achieving the same CO_2 emission reduction targets; and thus, offers a cost-efficient way to achieve the climate policy goals.
5. **Costs of end-use applications are a major cost driver** towards CO_2 reduction.
6. Ambitious climate protection targets by 2050 push the advantages of power-to-gas technologies in comparison to an "all-electric" approach.

The CO_2 abatement costs are calculated by dividing absolute cumulated costs by the corresponding amount of CO_2 emission savings until 2050 (see grey/black diagrams, next page). In the "Fast Energy Transition" scenario, CO_2 abatement costs range between 220-800 €/t_{CO2} and 220-870 €/t_{CO2} in the "Focus PtG" scenario when using total costs as reference. The estimated abatement costs in the "Base Scenario" rank between 220-300 €/t_{CO2} (for the less ambitious climate goals; probably insufficient to contribute a fair share to the Paris' climate goals).

short: https://short1.link/Y4ZGPQ (GER)
long: https://short1.link/h4QJWD (GER)
short: https://short1.link/8enKNE (ENG)
abstract: https://short1.link/HGC6ND (ENG)

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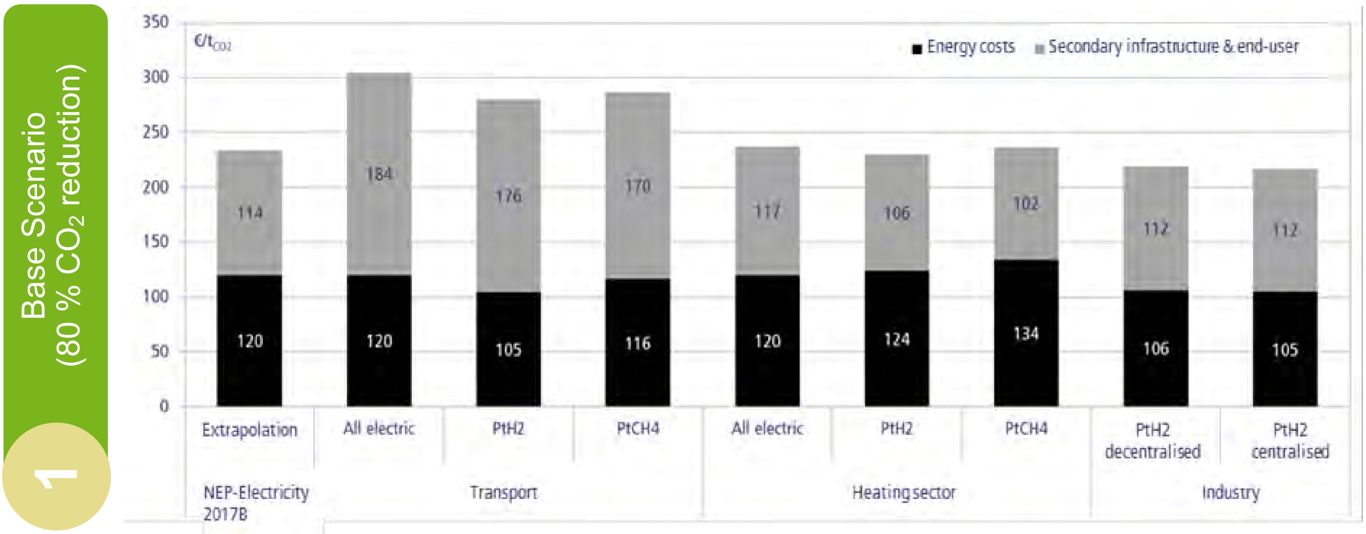
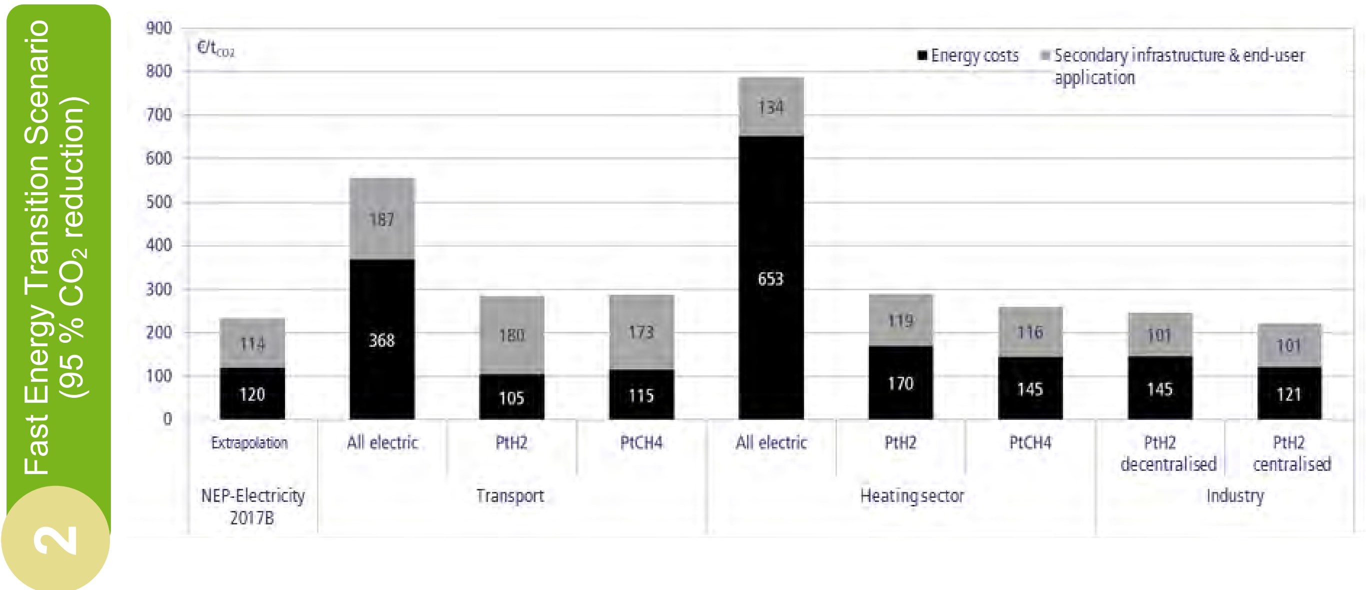
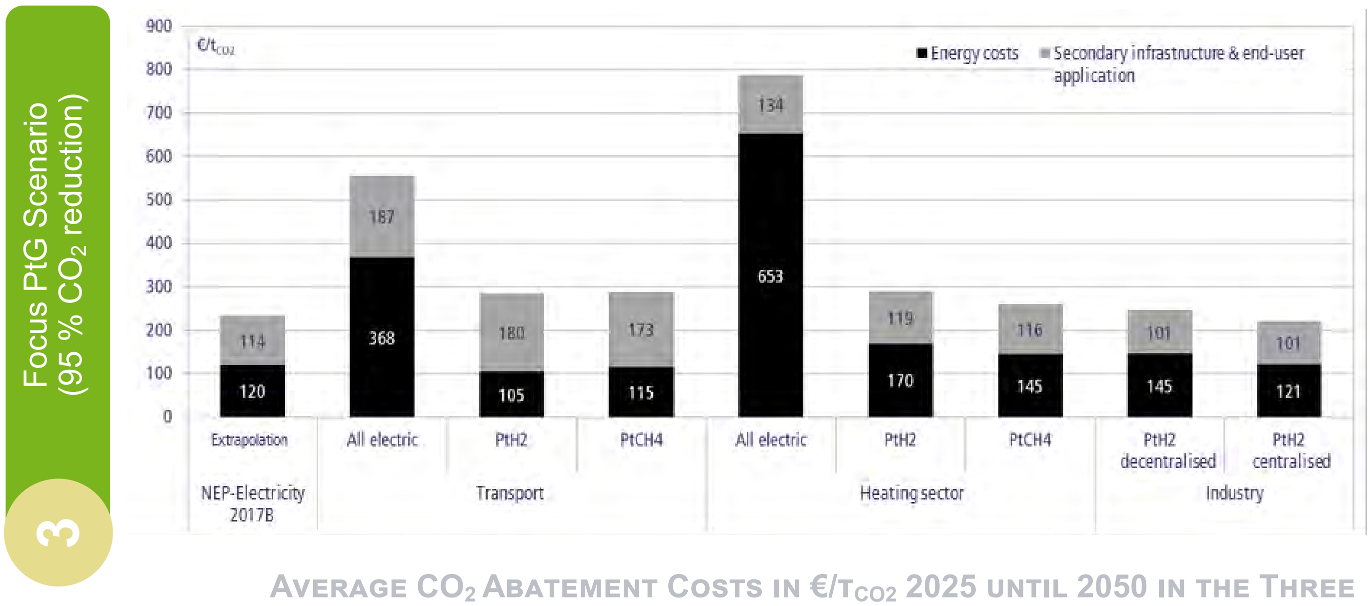






AVERAGE CO_2 ABATEMENT COSTS IN €/T$_{CO2}$ 2025 UNTIL 2050 IN THE THREE SCENARIOS (SOURCE: LBST, P. 4 - 90)

H_2-PIMS Interim Project Results - Pipeline Integrity with Hydrogen | Germany (1/2)

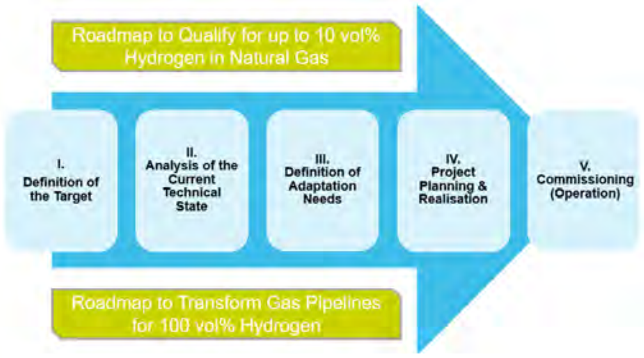
Roadmap to Qualify Gas Pipelines for 10 vol% Hydrogen Admixture & Roadmap to Transform Natural Gas Pipelines to Transport Pure Hydrogen

	Hydrogen proportion	10 vol%	100 vol%
I. upon constant transported gas capacity (e.g. MW)	Wobbe Index	- 2,5 %	- 8,9 %
	Standard volume flow	+ 7,4 %	+ 213,9 %
	Pressure loss	+ 11,0 %	+ 66,2 %
	Compressor capacity	+ 25,7 %	+ 577,6 %
	Preheating capacity	- 3,3 %	- 239,4 %
	Surface load of filter	+ 10,0 %	+ 259,0 %
II. upon constant pressure loss	Transported gas quantities	- 4,8 %	- 21,7 %
	Compressor capacity	+ 6,2 %	+ 195,4 %
	Preheating capacity	- 3,2 %	- 243,5 %

Effects of H_2 Proportion for the Operation of a Pipeline System (Source: Mischner "Wasserstoffeinspeisung in Erdgasnetze")

H_2-PIMS deals with the increased risk of embrittlement due to hydrogen exposure. PIMS stands for software-based **p**ipeline **i**ntegrity **m**anagement **s**ystems; the systems are used by gas network operators to continuously maintain pipeline integrity and determine optimised strategies for cost-efficient maintenance. We introduced the project and gave an overview of the work packages in newsletter #12, January 2017. The partners are still testing pipelines in laboratory experiments; the influence of hydrogen admixture to crack propagation behaviour is still ahead. Based on these (and further) results, PIMS will be upgraded for hydrogen admixture. It is too early to share lab results; we will keep an eye on the project progress and inform you.

In addition to the effect on the materials, the admixture of hydrogen also impacts other operational aspects during transport. Hydrogen changes the gas quality parameters and influences the capacity of pipelines; the table on the left side gives an impression how it effects the operation of a pipeline system.



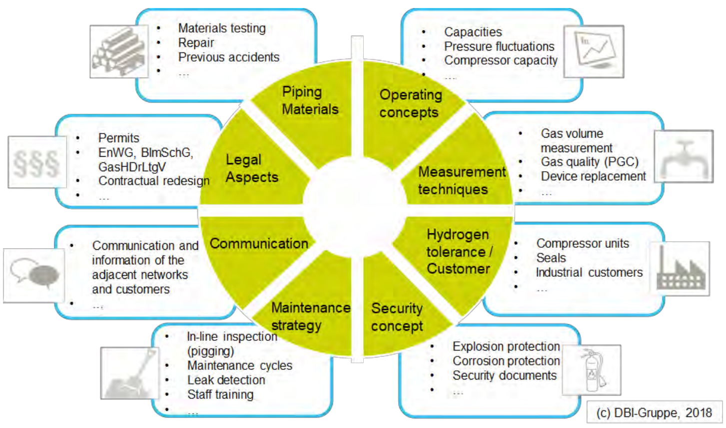
General Content of the Roadmap (Source: DBI in HYPOS H2-PIMS)

The transport of hydrogen may require therefore changes in the pipeline or compressor capacity. This is one of the questions, the project partners addressed in roadmaps. They developed two roadmaps in the past month to adapt natural gas pipelines; one for **hydrogen admixture up to 10 vol%** and one to **transport pure hydrogen** in former natural gas pipelines (the latter referred to as 'transformation'). The roadmap divides the process in five steps (see picture).

The **first step** 'only' defines the intended hydrogen / natural gas blend (10 vol% or 100 vol% hydrogen).

In the **second step** (analysis of the current technical state) detailed attention is paid to the pipe material parameters, hydraulic parameters, condition-orientated assessment, general security technic, measurement technology, gas regulation, pressure regulation facilities etc.. The project partners developed detailed checklists, necessary to define the current technical condition.

The **third step** comprises adaptation needs which are again categorised (see picture) and help to completely work through the needed aspects. Most of the categories are supported by checklists as well. Upon completion, the network operator can summarise the necessary adaptation measures, e.g. changing pressure range or compressor, adapt measurement devices, revise security plan, adapt maintenance provisions and so on. The project report will contain detailed helpful information or suggestions. For example, suggestions for maintenance intervals as shown in the table (see next page).



Roadmap for Qualification; Adaption Needs (3rd Step) (Source: DBI in HYPOS H2-PIMS)

(CONTINUED)

We selected EIGA and German DVGW maintenance intervals and the suggestions of the H2-PIMS project partners.

Eventually, the operator enters the **fourth step**. The project gives suggestions for needed steps of project planning and implementation including timelines.

The final projects results are expected towards the end of 2019.

Partners: DBI GUT, TÜV SÜD, ONTRAS, Veenker, FHI IWM, SZMF

Funding: Budget approx. 3 million Euro by „Hydrogen Power Storage & Solutions East Germany" (HYPOS); supported by the German Federal Ministry for Education and Research (BMBF) under the "Zwanzig20-Partnership for Innovation"

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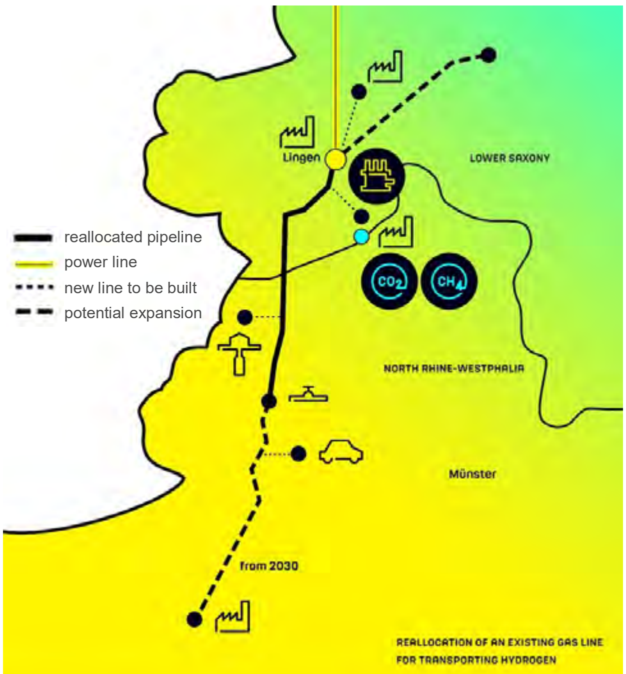
Action	DVGW G 466-1	EIGA	Suggestion
General			
in-line inspection (pigging)	upon need	upon need	24 months
documentation	in case of changes	not mentioned	12 month or in case of changes
Underground Pipelines			
pipe patrol on-foot	4 months	3 months	3 months
pipe patrol on-foot in critical areas	6 months	1 month	1 month
pipe patrol by car or plane	½ - 2 months	12 months	½ - 2 months
inspection of pipeline risers and casing	24 months	6 months	6 months
influences by mining (subsidence)	1 month	36 months	1 month
Above Ground Pipelines			1) IF CONTROLLED BY PLANE MONTHLY
pipe patrol and servicing	6 months 1)	6 months	3 months
pipe bridges (inspection and painting)	24 months	12 months	12 months
supports and anchorages	24 months	60 months	24 months

MAINTENANCE STRATEGIES AND SUGGESTION FOR MAINTENANCE INTERVAL (EXCERPT)
(SOURCE: DBI IN HYPOS H2-PIMS)

PTG IN INDUSTRIAL SCALE 2 X 100 MW PILOT PLANTS | GERMANY (1/2)

ENERGY TRANSITIONS IS NOT SOLELY SOLVED BY USING RENEWABLE ELECTRICITY SOURCES ...



MAPPING OF "HYBRIDGE" IN THE LINGEN AREA, NORTHWEST GERMANY (SOURCE: WWW.HYBRIDGE.NET)

As of 2022 and 2023 the two most powerful sectoral integration projects in Germany "hybridge" and "ELEMENT EINS" are scheduled to go into operation. Both projects plan to install a large-scale Power-to-Gas pilot plant with an electrolyser, with 100 MW_{el} capacity each. Additionally, the projects are meant to be the introduction of the hydrogen infrastructure within the gas sector in Germany. The companies that want to set a milestone in sectoral integration are the network operators *Amprion* and *Open Grid Europe (OGE)* with "hybridge" and *TenneT, Gasunie* and *Thyssengas* with "ELEMENT EINS". The requests for investment approval were submitted to the regulatory authority, the German Bundesnetzagentur (BNetzA), for both projects at the same day. The projects are now undergoing the investment permission procedure of the BNetzA. Hence, they do not depend on external financial assistance (subsidies); upon approval the investment and operating expenditures will be covered by the grid access charges. It is a brave concept; the decision of the BNetzA will be ground-breaking. As transmission system operators, all project partners are excluded to interfere with supply and generation activities.

(CONTINUED)

(Unbundling is the separation of energy supply and generation from the operation of transmission networks.) They developed a business model to obey the regulatory framework by granting unrestricted third-party access. Unbundling will be guaranteed by auctioning of the capacity of the 'sectoral transformer'; that is how they call the PtG technology devices. The auction is similar to the allocation of transmission rights and capacities in Europe. Similar mechanisms are established as for example the trading platforms Joint Allocation Office (JAO) and PRISMA. The auction revenues will reduce the grid charges.

Project "hybridge"

The electricity network operator Amprion and the gas network operator Open Grid Europe (both TSO) intend to optimise the interaction between the electricity and gas system. In addition, all future possibilities to use hydrogen will be tested. Therefore, one part of the gas grid is transformed for the transport of 100 % hydrogen. The expected total investment amounts to €150 million.

The hydrogen infrastructure of "hybridge" includes:

- transformation of a natural gas pipeline into a hydrogen pipeline and supply of pure hydrogen to consumers within 10 km distance
- industry: e.g. refineries
- storage: if necessary, transformation of existing underground gas storage
- mobility: hydrogen filling stations and train connections
- injection of hydrogen into the existing natural gas network (admixture)
- methanation and feed in to the natural gas network (residual gas quantities)

www.hybridge.net
www.element-eins.eu

Stefan Sennekamp (hybridge) at
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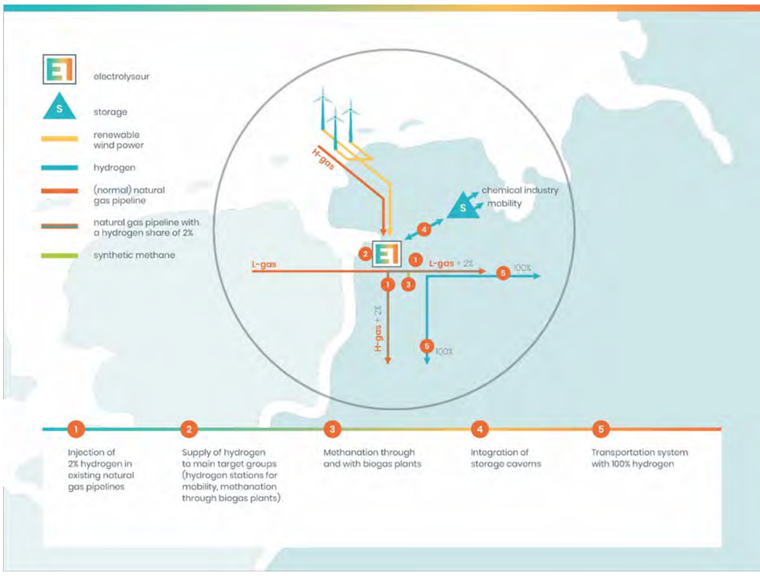
Gerhard Hülsemann (ELEMENT EINS) at
gerhard.huelsemann@thyssengas.com

Project "ELEMENT EINS"

The industrial scale 100 MW_{el} PtG plant will convert wind power from the North Sea into hydrogen in North-West Germany to transport the gas e.g. southwards to the Ruhr area (high density of industry and residents). Gasunie, TenneT, and Thyssengas are the driving forces; a project consortium of an electricity and two gas transmission system operators. The main focus is on the sectors heating, transport and industry with the following utilisation

- injection of hydrogen into the existing natural gas network (at least 2 vol% admixture)
- methanation and feed in to the natural gas network
- transformation of existing underground gas caverns for storage of pure hydrogen
- transformation of a natural gas pipeline into a hydrogen pipeline and supply of pure hydrogen to customers
- mobility: hydrogen filling stations



MAPPING OF "ELEMENT EINS" IN NORTHWEST GERMANY
(SOURCE: WWW.ELEMENT-EINS.EU)

TECHNICAL STANDARDS FOR GAS ADAPTING TO 20 VOL% HYDROGEN | GERMANY

The DVGW initiated the process to adapt the current standards for production, feed-in, admixture, transport and storage to higher hydrogen concentrations. The DVGW is a recognised standardisation body for the gas and water industry in Germany.

The future set of rules should **aim at a target value of about 20 vol% of hydrogen** feed-in. The existing DVGW standards already allow admixtures of almost 10 vol% into the existing gas network wherever there are no restrictions due to specific applications. By the year 2030, this **value of 10 vol% should be binding** on the rules and regulations **without any restrictions**.

However, the target is much higher: "20 vol% seems technically feasible to us based on current knowledge. Some parts of the gas grid will probably be able to do even better. But we always have to keep an eye on the end applications," says Gerald Linke, CEO of DVGW. "We believe that in the future the system will transport more than 50 percent of green gases in total, including biomethane." In the long-term, standards for 100 percent hydrogen are needed in addition, which will be developed in cooperation with the German Hydrogen and Fuel Cell Association DWV.

https://short1.link/83R7VJ

Zero-Emission Fuel Cell Train on the Rise to Railways | Germany

Six Federal States in Germany Opt for Fuel-Cell Train Transport

Only two years after Alstom's presentation of its zero-emission fuel cell train, the "Coradia iLint" operates regularly on the first railway line in Germany. Since September 2018, two fuel cell trains run on the route from Cuxhaven to Buxtehude (Lower Saxony – 126 km). The public transport in **Lower Saxony** will deploy 14 fuel cell trains until December 2021 (the contract includes delivery, maintenance and energy supply for 30 years). In 2021 a permanently installed hydrogen filling station in Bremervörde should be activated and operated by Linde Group. At the moment, the trains rely on a mobile filling station by Air Products, also located in Bremervörde.

Further interested German states include routes in **Thuringia** ("Schwarzatalbahn" from Rottenbach to Katzhütte – 25 km), **Hessen** ("Taunus Route" from Wiesbaden to Frankfurt – 41 km) and **Brandenburg**. Two of these possible projects would rely on regional wind power supply and on-sight electrolysis. Old windmills will fall off the public feed-in tariff system within the next years and will then supply the hydrogen production.

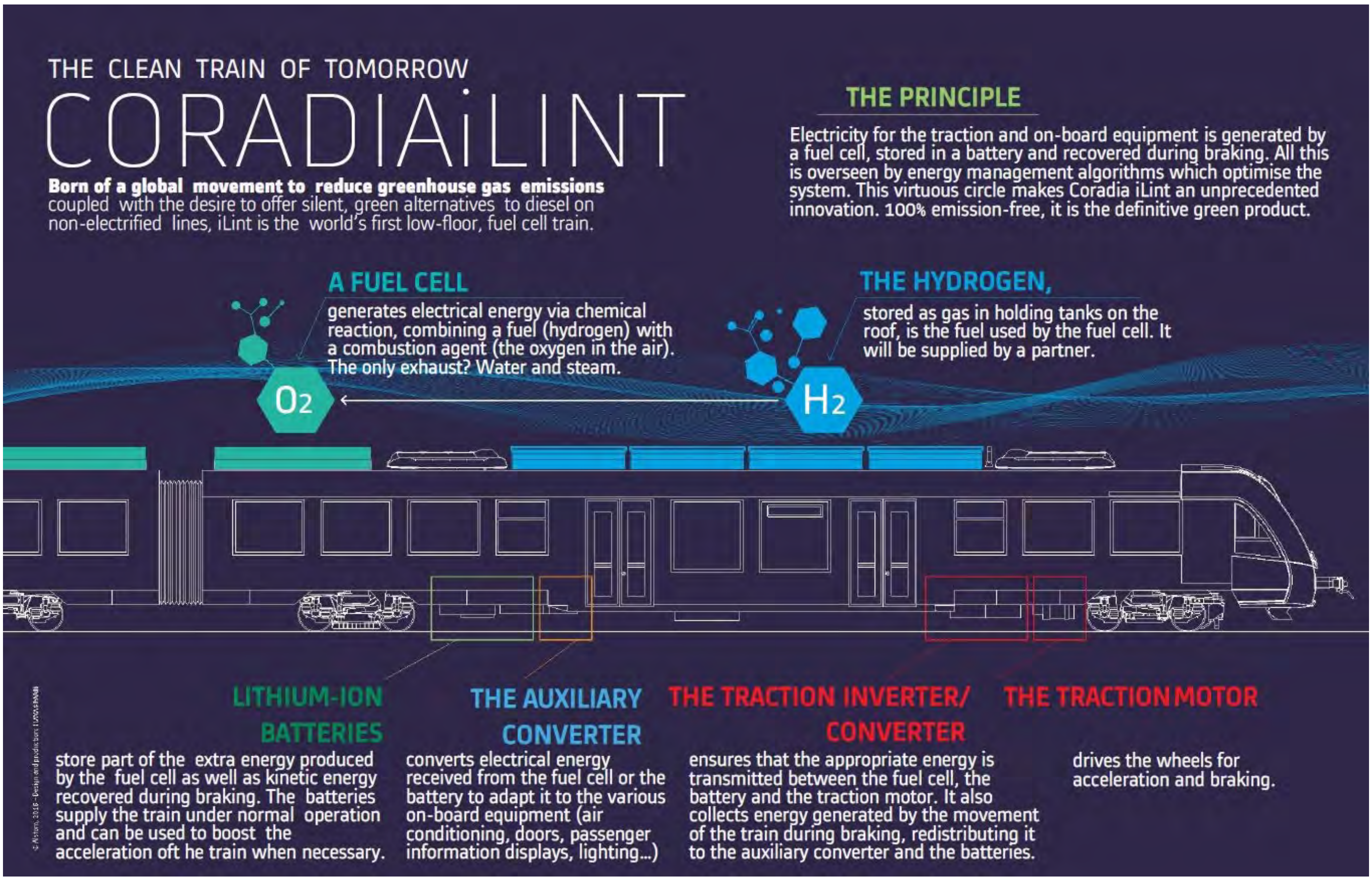
Alstom is actively negotiating the use of hydrogen trains in many German states. Especially against the background of sectoral integration, the use of hydrogen offers unique advantages. These are also gaining in importance in other countries such as Italy, Spain, England, the Netherlands and Scandinavia, but also in Canada.

Technology Background:

Each train is equipped with two hydrogen fuel cells and two battery-systems. Hydrogen for the process is stored in a tank on the roof of the train at 350 bar.

Range: 1,000 kilometres with a full tank.

Maximum speed: 140 km per hour (same speed as diesel powered engines)



Zero-Emission Fuel Cell Train "Coradia iLINT" (Source: www.alstom.com)

https://short1.link/aZKLff

Selection of Appointments

June

02-07 World Hydrogen Technology Conference | Tokyo, Japan, *http://whtc2019.jp/*

09-13 International Conference on Electrolysis | Loen, Norway, *https://www.sintef.no/projectweb/ice2019/*

13-14 GIE Annual Conference | Paris, France, *https://www.gie.eu/index.php/gie-annual-conference-2019-home*

17 Roundtable of the Global Alliance Powerfuels | Brussels, Belgium, *urlshortener.at/NWX57*

19-22 International Hydrail Conference | Hamburg, Germany, *https://hydrail.appstate.edu/*

26-27 Annual HIPS-NET Workshop | Brussels, Belgium, *https://www.dbi-gruppe.de/hips-net.html*

July

02-05 EFCF—Fuel Cells, Electrolysers and H2 Processing | Lucerne Switzerland, *https://www.efcf.com/*

10-11 US Hydrogen and Fuel Cells Energy Summit | Boston, MA-USA, *https://short1.link/hr2NeG*

September

10-11 f-cell | Stuttgart, Germany, *https://f-cell.de/*

24-26 International Conference on Hydrogen Safety | Adelaide, Australia, *http://hysafe.info/ichs2017/*

October

23-26 Hydrogen + Fuel Cells ASIA at CeMAT ASIA 2019 | Shanghai, China, *https://www.h2fc-fair.com/asia/index.html*

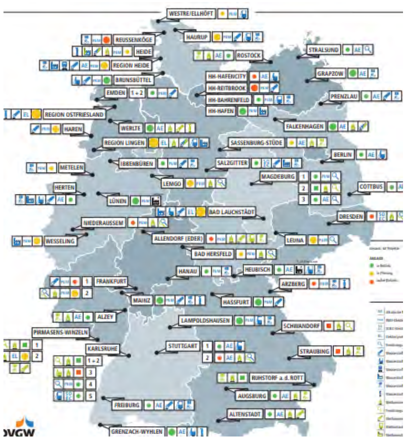
November

26-28 gat + wat 2019 | Cologne, Germany, *https://www.gat-wat.de/*

Current Partners

Alliander AG, Areva H2Gen,
Cadent, DEA Deutsche Erdoel AG,
DGC, DNV GL, Enagás,
Enbridge, Energinet.dk, ENGIE,
EWE Netz, Gasconnect GmbH,
Gasnetz Hamburg, Gasum OY,
Gasunie, GRTgaz, GRZI e.V. (FIGAWA),
Infraserv GmbH & Co. Höchst KG,
INERIS, innogy SE, ITM Power,
Joint Research Centre (JRC),
EC, KOGAS, NAFTA a.s,
Naturgy, ONTRAS, ÖVGW,
Open Grid Europe GmbH,
RAG Rohöl-Aufsuchungs AG,
Shell, Solar Turbines Europe S.A.,
Storengy, SVGW,
Synergrid, Terega,
Uniper Energy Storage GmbH,
Verband der Chemischen Industrie (VCI),
Volkswagen AG.

NEWS



Map of PtG-Projects in Germany updated and released!

The updated "PtG-Map" shows the vivid (market) activity for power-to-gas. 35 power-to-gas and methanation plants are currently in operation with a total capacity of around 30 megawatts, additionally 16 planned and 11 finalised projects. Most of them are small-scale pilot or demonstration projects for research purposes. In Hamburg, however, the first industrial plant is already generating five megawatts of green gas in a refinery, and two former municipal pilot plants have been transferred to permanent operation. The 16 planned projects show a clear trend towards higher output: around one third of the plants are to be larger than five megawatts, two of which will even have an output of 100 megawatts. Their total output of 273 megawatts will then be nine times that of the plants installed today. The update was based on the PORTAL GREEN project funded by the Federal Ministry of Economics and Technology.

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Certified DIN EN ISO 9001:2008

HIPS-NET

"Establishing a pan-European understanding of admissible hydrogen concentration in the natural gas grid"

NEWSLETTER #22 | **August, 2019**

Dear Partners and Colleagues,

Welcome to the latest edition of the HIPS-NET newsletter. On 27th of June 2019 the 6th HIPS-NET Workshop took place in the GERG headquarters in Brussels. We are grateful for your constant interest to join us in Brussels, to exchange and to share knowledge – this is your contribution for the success of the network. We included summaries of the presentations aiming to provide an overview of key information for members who were unable to attend the workshop. For those of you who attended the event, we hope that the material helps to refresh your memories. All presentations may be downloaded from the members' area on the website. (And if your access got lost "in space" in your e-mail account, please contact Josephine, she will help.)

The feature article from our current newsletter includes the latest IEA report on hydrogen, issued for the G20 group. The G20 (or Group of Twenty) is an international forum for the governments and central bank governors from 19 countries and the European Union (EU). This is support on highest governmental level … we hope for open ears. The newsletter further turns the spotlights to activities in Australia and there are various. We included an exciting project of Fiat, the project results are frankly spoken old, but worth to remember the flexibility of hydrogen admixture in natural gas driven cars.

We hope you enjoy reading and that you adopt well to the warm summer days!

Your HIPS-NET Team

Gert, Anja, Josephine & Gideon

VOTE FOR THE DATE!

2020

4th or 25th June

NEXT HIPS-NET Workshop in Brussels

CONTENT

CONTENT NEWSLETTER #22

IEA Report - The Future of Hydrogen | Worldwide (1/3)

Report prepared by the International Energy Agency (IEA) for the G20, Japan

The IEA has issued in June 2019 a landmark report to analyse the current state of play for hydrogen and to offer guidance on its future development. The findings and positions are widely supporting the employment of hydrogen, to make a significant contribution to clean energy transition. The challenge is to adopted hydrogen in sectors where it is almost completely absent, such as transport, buildings and power generation.

The IEA's 7 key recommendations to scale up hydrogen

1. Establish a role for hydrogen in **long-term energy strategies**. National, regional and city governments can guide future expectations. Companies should also have clear long-term goals. Key sectors include refining, chemicals, iron and steel, freight and long-distance transport, buildings, and power generation and storage.

2. Stimulate commercial demand for clean hydrogen. Clean hydrogen technologies are available but costs remain challenging. Policies can create sustainable markets for clean hydrogen. Scaling up supply chains will realise cost reduction potentials (economies of scale).

3. Address investment risks of first-movers. New utilisations for hydrogen stand at the riskiest point of the deployment curve. Targeted and time-limited loans, guarantees and other tools can help the private sector to invest, learn and share risks and rewards.

4. Support R&D to bring down costs. It is crucial to lower costs and improve performance. Government actions, including use of public funds, are critical in setting the research agenda, taking risks and attracting private capital for innovation.

5. Eliminate unnecessary **regulatory barriers and harmonise standards**. Project developers face hurdles where regulations and permit requirements are unclear, unfit for new purposes, or inconsistent across sectors and countries. Sharing knowledge and harmonising standards is key, including for equipment, safety and certifying emissions from different sources.

6. Engage internationally and track progress. Enhanced international co-operation is needed on standards, sharing of good practices and cross-border infrastructure.

7. **Focus on four near-term key opportunities** to scale up hydrogen supply and demand, building on existing industries, infrastructure and policies over the next decade.

The following four near-term key opportunities will stimulate demand, but every single of these opportunities will need **the support of the full policy package of point 1 – 5 listed before**.

a. Make **industrial ports** the nerve centres for scaling up the use of clean hydrogen. Today, much of the refining and chemicals production that uses hydrogen based on fossil fuels is already concentrated in coastal industrial zones around the world, such as the North Sea in Europe, the Gulf Coast in North America and south-eastern China. Encouraging these plants to **shift to cleaner hydrogen production** would drive down overall costs. These large sources of hydrogen supply can also fuel ships and trucks serving the ports and power other nearby industrial facilities like steel plants.

b. Build on existing infrastructure, such as millions of kilometres of natural gas pipelines. Introducing **clean hydrogen to replace just 5 vol% of countries' natural gas supplies** would significantly boost demand for hydrogen and drive down costs.

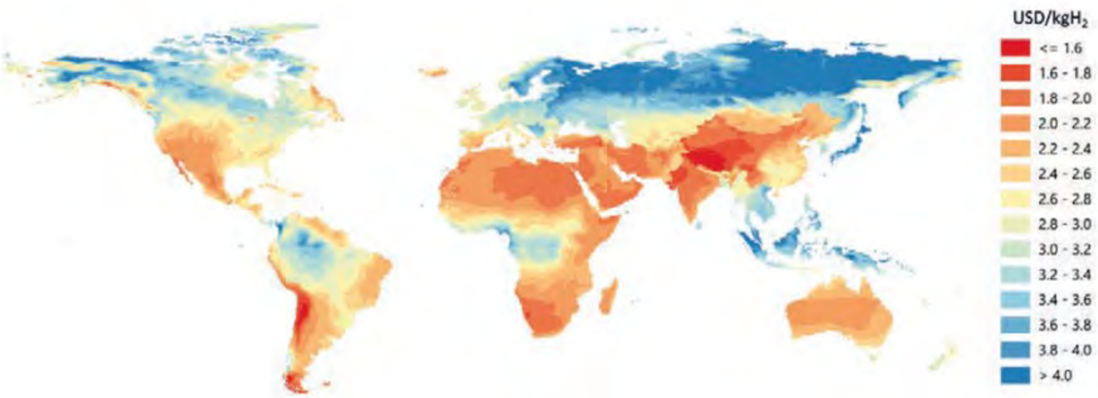
c. Expand hydrogen in transport through fleets, freight and corridors. Powering high-mileage cars, trucks and buses to carry passengers and goods along popular routes can make fuel-cell vehicles more competitive.

d. Launch the hydrogen trade's first **international shipping routes**. Lessons from the successful growth of the global LNG market can be leveraged. International hydrogen trade needs to start soon if it is to make an impact on the global energy system.

The report evaluates the entire value chain; this article concentrates on selected results, mainly focussing on infrastructure.

Blending hydrogen into the natural gas infrastructure

Blending hydrogen into the natural gas infrastructure would avoid the significant capital costs for new transmission and distribution infrastructure. Further, if blending were to be carried out at low levels, though it might increase the cost of natural gas delivery to consumers, it would also reduce CO_2 emissions.



Hydrogen Costs from Hybrid Solar PV and Onshore Wind Systems in the Long Term

(source: report p. 49 with further details ans sources)

IEA Report - The Future of Hydrogen | Worldwide (2/3)

Since natural gas is internationally traded, **setting and harmonising blend limits across borders** is a crucial step to support deployment. Standards should also account for possible changing hydrogen concentrations over time. Higher blending levels need to incorporate policy strategies for replacing equipment in homes, offices and factories. The conversion could be done progressively region by region. Implementing policies of this kind would be time-consuming and costly, but not unprecedented: the United Kingdom, Austria, Germany and the United States switched from town gas (with 50 vol% hydrogen) to natural gas in the 1960s and 1970s. The United Kingdom replaced 40 million appliances at a cost of USD 12 billion over 10 years.

There are currently 37 demonstration projects examining hydrogen blending in the gas grid. The Ameland project in the Netherlands did not find that blending hydrogen up to 30 vol% posed any difficulties for household devices, including boilers, gas hobs and cooking appliances. With only modest additional investment in infrastructure or end-use equipment, gas networks would be able to transport hydrogen at low marginal costs, reducing the cost of supplying low-carbon hydrogen until a blended share of 20 vol%. Above that share, the costs of modifying end-user equipment and the grid itself are only likely to be justified by a wholesale switch to 100 vol% hydrogen.

And, if hydrogen were blended into all natural gas use in the European Union at just 5 vol%, this would boost low-carbon hydrogen demand by 2.5 million tonnes H_2 per year. If this were supplied by electrolysers then it would require almost 25 GW of water electrolysis capacity.

Potential use in 2030

Industry: Tougher air pollutant standards could increase the use of hydrogen in refining by 7 % to 41 million tonnes H_2 annually by 2030. The demand for ammonia and methanol is expected to increase to up 14 million tonnes H_2 per year by 2030. In the long-term (beyond 2030), steel and high-temperature heat production offer vast potential for low-carbon H_2, around 2,500 TWh per annum, or around 10 % of global electricity generation today.

Heating: In 2030 up to 4 million tonnes of potential hydrogen use for heating buildings could come from low-concentration blending. The potential is highest in multifamily and commercial buildings, particularly in dense cities, where conversion to heat pumps is more challenging than elsewhere.

Mobility and power generation: There is a potential especially for aviation, shipping, rail, medium- and heavy-duty vehicles as well as passenger cars, but the report is reluctant to estimate the demand in 2030 onwards. The same reluctance applies for power generation; hydrogen can be used as a fuel in gas turbines and CCGTs (combined-cycle gas turbine) and fuel cells.

Blending: In the 2030 timeframe, full conversion is expected to be realised in fewer places than blending and only in limited parts of national grids, such as town distribution networks or specific underused transmission pipelines.

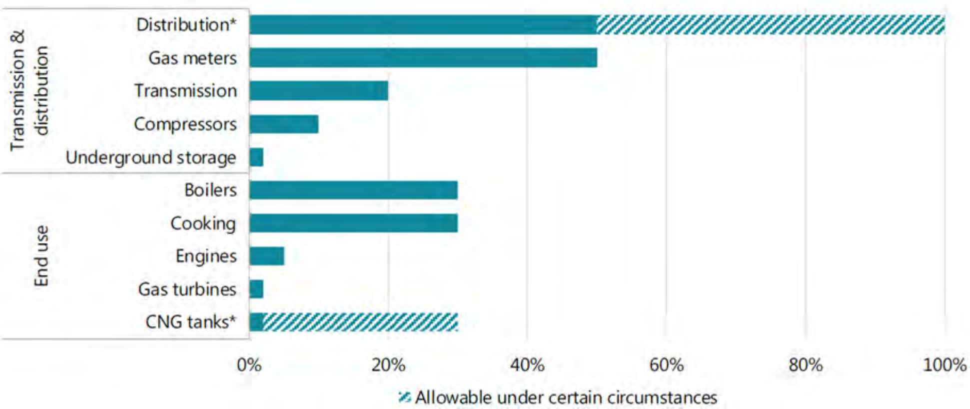
Feasible options to transport hydrogen

Despite the many uncertainties around most of the cost components, IEA analysis suggests that **for inland transmission and distribution**, newly-built hydrogen pipelines are the cheaper option for distances below 3,500 km. Above this distance, ammonia pipelines would be the cheaper option.

Comparing transport **using pipelines and ships**, transmission and distribution of hydrogen gas by pipeline is cheaper for distances below 1,500 km. Above this distance, LOHC and ammonia transport by ship, become the cheaper delivery options. (The transport and use of ammonia or some LOHCs may, however, give rise to potential safety and public acceptance issues, which could limit their application in some situations.) The analysis takes into account the costs of converting hydrogen into ammonia or LOHC and back again.

An alternative possibility is to incorporate the hydrogen into larger molecules that can be more readily transported as liquids. Additionally, hydrogen can be transmitted with small modifications **via the existing natural gas network**. The main challenge is that three times more volume is needed to supply the same amount of energy as natural gas.

Remark: Converting hydrogen to ammonia requires energy equivalent to between 7 % and 18 % of the energy contained in the hydrogen, depending on the size and location of the system. A similar level of energy is lost if the ammonia needs to be reconverted back to high-purity hydrogen at its destination. Nevertheless, ammonia liquefies at -33 °C, a much higher temperature than is the case for hydrogen, and contains 1.7 times more hydrogen per cubic metre than liquefied hydrogen, which means it is much cheaper to transport than hydrogen. While ammonia already has a well-established international transmission and distribution network, it is a toxic chemical and this may limit its use in some end-use sectors.



Tolerance of Selected Existing Elements of the Natural Gas Network to Hydrogen Blend Shares by Volume (source: report p. 72 with further sources)

IEA Report - The Future of Hydrogen | Worldwide (3/3)

There are close to 5,000 km of **hydrogen pipelines** around the world **today**, compared with around 3 million km of natural gas transmission pipelines. The United States has 2,600 km, Belgium 600 km and Germany just under 400 km. Ammonia is often transported by pipeline, and new pipelines for ammonia would be cheaper than new pipelines for pure hydrogen. **Ammonia pipelines** in the United States **currently** feed hundreds of retail points and total 4,830 km in length. In Eastern Europe the 2,400 km Odessa line pumps ammonia from Russia to fertiliser and chemical plants as far as Ukraine.

;-) Last but not least, the report acknowledges the work of technical committees and industry working groups including HyReady and HIPS-NET.

https://www.iea.org/hydrogen2019/

For GERG members, see full text on yammer.

A Hydrogen Strategy for Australia (1/2)

At the end of 2018, the Council of Australian Governments (COAG) Energy Council begun development of the National Hydrogen Strategy for Australia in recognition of the major potential for hydrogen as a decarbonised energy source. The goal of this strategy will be to support the development of a clean, innovative and competitive hydrogen industry that benefits all Australians and is a major global player by 2030.

To develop this strategy, the COAG has created a working group chaired by Chief Scientist Dr. Alan Finkel AO to liaise with key stakeholders in the energy industry and different sectors of the economy. The working group will present the finalised National Hydrogen Strategy for approval by the Australian government at the end of 2019.

Working group activities in the development of the strategy are broadly divided into six work packages:

- Developing a hydrogen export industry
- Hydrogen in the gas networks
- Hydrogen for transport
- Hydrogen to support electricity systems
- Hydrogen for industrial users
- Cross-cutting issues

In support of the development of the strategy, the Australian Renewable Energy Agency (ARENA) has allocated approx. €14 million of funding for a range of "kick-start projects". The first three projects will be carried out during 2019 and coordinated by the working group in the development of the hydrogen strategy. These projects will focus on key strategic topics and provide answers to outstanding technical, economic and regulatory issues.

	National Strategy	Kick-start projects 2019
Developing a hydrogen export industry	Infrastructure requirements (physical & market) Regulation for safety and efficiency Inter-country agreements Bulk carriers	*Co-ordinated international outreach to enhance Australia's profile with major trading partners as a potential supplier*
Hydrogen in the gas networks	Using hydrogen in the domestic gas network (initially at 10% and the potential for 100%) User and customer impacts Safety, metering and standards	*Commencing work to allow up to 10 per cent hydrogen in the domestic gas network, both for use in place of natural gas and to provide at-scale storage for hydrogen.* *Project partner: Future Fuels CRC*
Hydrogen for transport	Regulatory change assessment Refuelling infrastructure needs study Assessment of potential for use in heavy vehicle, road and rail fleets and shipping Standards and safety	*Scope potential for building hydrogen refuelling stations in every state and territory, building on work by Hydrogen Mobility Australia*
Hydrogen to support electricity systems	Potential of hydrogen to contribute to resilience of electricity markets Assessment of required regulatory changes	
Hydrogen for industrial users	Hydrogen use potential in existing industries New industries using hydrogen	
Cross-cutting issues	Standards, regulation and labelling Research and innovation Safety and community engagement Governance Hydrogen precincts and cities	

Overview of Work Packages, Strategic Aims and Kick-Start Projects for 2019

(Source: National Hydrogen Strategy and Workplan, COAG Energy Council, April 2019)

A Hydrogen Strategy for Australia (2/2)

The foundations for the current hydrogen strategy were laid by two publications. Firstly, “Hydrogen for Australia’s Future”, a position paper by the COAG Energy Council in August 2018, outlined the key role that hydrogen could play in decarbonising Australian society. Parallel to this the Commonwealth Scientific and Industrial Research Organisation (CSIRO) created the “National Hydrogen Roadmap” assessing the commercial viability of hydrogen supply in different end user sectors such as heating, industry and mobility. Both documents analyse the potential of hydrogen derived from renewable sources via electrolysis as well as hydrogen from coal or natural gas with the use of carbon capture and sequestration (CCS). This reflects the abundance of both renewable and fossil energy sources at Australia’s disposal.

Strategic Documents for Hydrogen Deployment in Australia (Source: SCIRO)

“Hydrogen for Australia’s Future”: http://www.coagenergycouncil.gov.au/publications/hydrogen-australias-future
Source “National Hydrogen Roadmap”: https://www.csiro.au/en/Do-business/Futures/Reports/Hydrogen-Roadmap

Future Fuels Cooperative Research Council | Australia

Further Hydrogen Activities in Australia (1/4)

While the Australian government is actively pursuing the development of the National Hydrogen Strategy, private enterprises are also investing in the Australian hydrogen economy. According to Energy Networks Australia, more than €93 million have been invested by both state and private actors in the past two years to support research and development projects.

By far the largest source for funding of Australian hydrogen projects is the Future Fuels Cooperative Research Council (FFCRC). The council is responsible for the coordination of funding for R&D projects involving both research centres and private enterprises in Australia. Over the next seven years, they will provide more than €57 million of funding to projects in three distinct research areas:

- Future fuels, technologies, systems and markets
- Social acceptance, security of supply and public safety
- Network lifecycle management.

To this end, as of July 2019, the FFCRC has approved and/or initiated 27 separate hydrogen-related research projects.

The FFCRC is also directly involved in a research project for the National Hydrogen Strategy to analyse the effects of blending hydrogen in gas networks. The project, which will produce its final report in August 2019 is analysing the technical, legal and regulatory hurdles to blending up to 10 vol% hydrogen, principally in distribution networks.

List of projects: https://arena.gov.au/assets/2018/09/ARENA-Media-Release_Exporting-Hydrogen-RD-Funding-Round-Awarded-FINAL-060918-1.pdf

Klaas van Alphen at klaas.vanalphen@futurefuelscrc.com

Pilot testing laboratory in Canberra researches hydrogen tolerance

Further Hydrogen Activities in Australia (2/4)

A collaboration between Evoenergy and the Canberra Institute of Technology in Australia is analysing the hydrogen tolerance of natural gas grids as part of a wider project to research the potential for hydrogen usage within the Australia gas infrastructure.

As one of the largest suppliers and grid operators for both electricity and gas in the Canberra region, Evoenergy is seeking to develop the energy system of the future by exploring the potential for sector coupling in an ambitious research project. Together with the Canberra Institute of Technology

(CIT), they have created a hydrogen testing facility at CIT's Fyshwick campus where they are investigating the feasibility of hydrogen supply through existing gas infrastructure. The research project began at the start of this year and will last 12 months. Activities are divided into three phases (see table).

Results from the first phase of the project were particularly encouraging. Evoenergy reported no adverse effects from the transport of 100 % hydrogen on nylon and polyethylene pipes, including no leaking or permeability. Test results for the safe transport of hydrogen-methane blends has not yet been made available. Evoenergy sees the potential for hydrogen as a zero-emission energy source not just in the Canberra region but across Australia.

https://www.evoenergy.com.au/emerging-technology/hydrogen-test-facility

Media@evoenergy.com.au

	Focus
Phase 1	Testing existing Australian network components, construction and maintenance practices on 100 % hydrogen application. Testing also includes blends of hydrogen and natural gas.
Phase 2	Testing hydrogen as a broader energy storage source to support coupling the electricity network to the gas network.
Phase 3	Appliance testing and to be adjusted to accept various fuels. Appliances will be tested on a range of hydrogen and natural gas blends.

Jemena H2GO Power-to-Gas Pilot Facility | Australia

Further Hydrogen Activities in Australia (3/4)

A joint research project between the Australian Renewable Energy Agency (ARENA) and the Jemena gas network in Sydney is building a pilot power-to-gas facility to showcase the potential for hydrogen as a renewable fuel.

The 500 kW electrolyser will exclusively use excess intermittent renewable electricity to produce hydrogen for an on-site hydrogen refuelling station. A portion of the hydrogen will also be used for electricity generation via a gas engine generator. At the same time, the Jemena gas network – New South Wales' largest gas distribution network – will inject hydrogen from the facility into their network to demonstrate the hydrogen tolerance of the existing gas distribution infrastructure.

The project is scheduled to start 2020 and to run five years.

The total cost is €9.3 million, of which 50 % was provided by ARENA.

Jemena's Managing Director Frank Tudor feels that power-to-gas is the ideal technology to harness the growing amounts of intermittent renewable energy in Australia's energy mix. He said that "(i)n the future Australians will need to decide what to do with excess renewable energy on very windy or very sunny days. Jemena's Project H2GO will demonstrate how existing gas pipeline technology can store excess renewable energy for weeks and months, making it more efficient than batteries which can only store excess renewable energy for minutes or hours."

https://arena.gov.au/news/hydrogen-to-be-trialled-in-nsw-gas-networks/

mike.davis@jemena.com.au

Hydrogen Park SA | Australia

Further Hydrogen Activities in Australia (4/4)

The Australian Gas Infrastructure Group (AGIG) is constructing a power-to-gas demonstration plant in Adelaide. The 1.25 MW PEM electrolyser will produce hydrogen using electricity from the grid and potentially from additional on-site solar generation.

The electrolyser is at the centre of a project to illustrate the potential for hydrogen in the state of South Australia. The hydrogen produced at the facility will be injected into the local distribution grid at an admixture of 5 vol% H_2 for the next five years. 5 vol% H_2 is within Australian gas quality standards and is considered to have a negligible effect on gas behaviour and combustion qualities.

Senior Strategy Manager Andrew Pym stated that AGIG is working towards a goal of 10 vol% H_2 injection in the medium term, with the ultimate goal of providing 100 % hydrogen to end-consumers. To support the injection into the gas network, AGIG is undertaking a comprehensive appliance testing program together with the Future Fuels Cooperative Research Council (FFCRC).

Further Hydrogen Activities in Australia (4/4)

In addition, the electrolyser will become part of a Centre of Excellence for hydrogen at the site. The centre will serve as a hub for education and training as well as research and innovation.

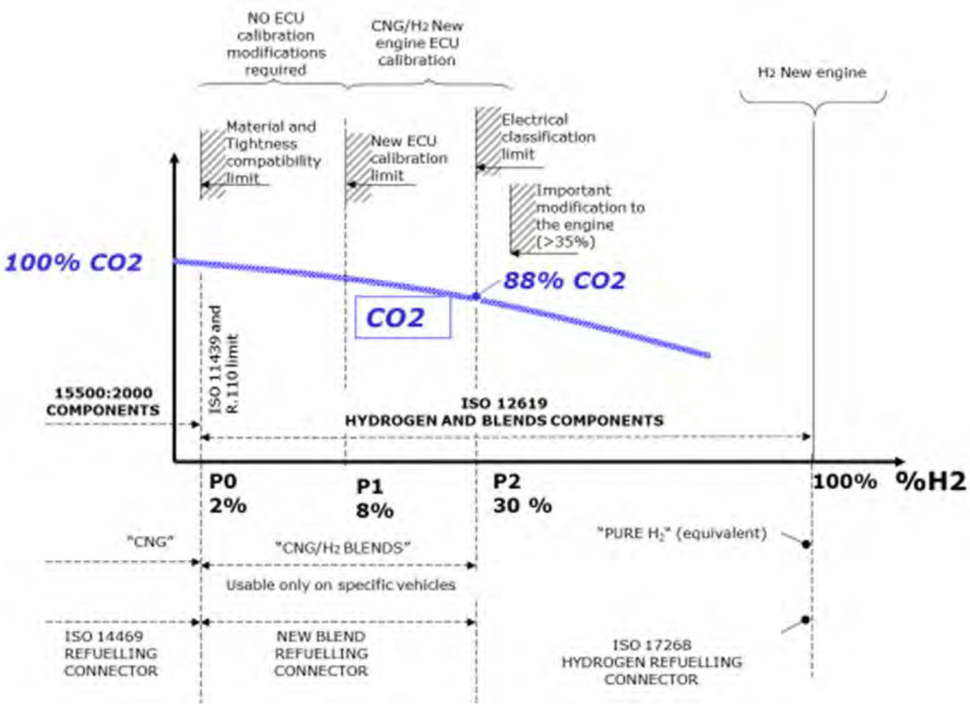
https://www.australiangasnetworks.com.au/our-business/about-us/media-releases/australian-first-hydrogen-pilot-plant-to-be-built-in-adelaide

The project will cost approximately €7 million of which some €3 million has been provided as a grant from the South Australia Renewable Technology Fund. AGIG's partners in the project are Siemens (constructors of the PEM electrolyser), SA Power Networks and KPMG. Hydrogen production is expected to begin in mid-2020.

Development and Operating Experiences of CNG Vehicles for up to 30 vol% of Hydrogen | Italy (1/2)

The Italian project "Biomethair" with its 19 partners, funded by the region Piemonte, had the aim to develop a solution for environmentally friendly urban mobility using biomethane or methane-hydrogen mixtures. In the process material specifications, e.g. for gas tanks and valves, were defined and converted into prototypes. Over three years (2010 – 2013) 20 CNG vehicles (Fiat Panda) were tested with an admixture up to 30 vol% of hydrogen. The safe operation could be proven for a total distance of about 400,000 km. The test results are still relevant even though they are some years old.

For the experimentation the design of the cylinders and the engine was adopted. The tanks (total capacity of 72 litres; R110 standard; working pressure of 200 bar) from FABER were made of the same carbon steel (34CrMo4, type 3) coated with carbon fiber but getting modified according to the heat treatment.



Technical and Regulatory Limits for H_2 Admixture for CNG Mobility
(Source: Annex – CNG-Hydrogen blends Position Paper ISO/TC22/SC25/WG5 N003 Rev. 2)

Development and Operating Experiences of CNG Vehicles for up to 30 vol% of Hydrogen | Italy (2/2)

The result was a greater ductility and a decrease of the susceptibility to hydrogen embrittlement. This was at the expense of strength, which became lower. Therefore, the cylinder walls were made thicker and the weight gained 8 kg.

The engine was designed to handle biomethane as well as natural gas with up to 30 vol% hydrogen admixture. A built-in sensor determines the gas composition. With this information the engine control unit (control, regulation and monitoring of engine functions) optimises the engine performance and the "3-way" catalyst. The vehicle performance was improved with the admixture of hydrogen due to higher combustion efficiency and a lower energy requirement of the system (2-3 %). Hydrogen exposure did not influence the material, neither the tank nor other components. The maintenance interval was the same as for a normal CNG vehicle. This interval was also sufficient, as occurring need for repair was not due to hydrogen exposure. In addition, the emissions of carbon dioxide and carbon monoxide decreased but the emission of nitrogen oxides increased. However, the latter can be managed by adjusting the ignition advance.

These positive project results - as shown in the diagram - were also tried to be included in the standardisation (ISO/TC 022/SC 41/WG 05):

- Up to 2 vol% hydrogen: Modifications to the engine are not necessary.
- Up to 8 vol% hydrogen: Appropriate upgrades and use of a specific refuelling connector necessary.
- Up to 30 vol% hydrogen: Calibration of the engine control unit. Structural changes of the engine are required not until 35 %.

Currently, only the 2 vol% threshold is confirmed by standardisation.

http://www.biomethair.it (Italian only)

Stefania Zandiri at stefania.zandiri@crf.it

Summary of the 6th HIPS-NET Workshop (1/3)

	Welcome
	Introduction - Robert Judd (GERG), Gert Müller-Syring (DBI)
I	„Hydrogen Backbone in the Netherlands" Adriaan de Bakker (Gasunie)
	Part 2
II	"The hydrogen distribution grid on The Green Village; a platform for tests and demonstrations" Elbert Huijzer (Liander)
III	"Power-to-Gas: enabling the expansion of renewables" Prof. Marcus Newborough (ITM Power)
	Part 3
IV	"Public policy for deploying power-to-gas: insights from the debate in Germany" Dr. Christian Friebe (Thüga)
V	„Transformation path towards a GHG neutral energy system – and outlook on the recently commissioned H_2-grid in the frame of HYPOS" Gert Müller-Syring (DBI)
	Part 4
VI	Organisational Aspects HIPS-NET, Gert Müller-Syring (DBI)
	Conclusions - Robert Judd (GERG), Gert Müller-Syring (DBI)
	Closure of the Meeting

An **evaluation of the questionnaires** for our HIPS-NET newsletter was made. Thank you very much for all the feedback and your promising ideas. We will present the best (feasible) ones in one of the next newsletter.

The first one we should try is to make a **shorter and more frequent newsletter**. The suggestion is to publish four to five articles every two months. If someone opposes this idea please let Josephine know until August 30th (josephine.glandien@dbi-gruppe.de).

SUMMARY OF THE 6TH HIPS-NET WORKSHOP (2/3)

I ADRIAAN DE BAKKER (GASUNIE)

Hydrogen Backbone in the Netherlands

We would like to emphasis here three important points Adriaan included in his presentation. First, hydrogen grids is not rocket science, about 1,600 km exist in Europe and are running for decades. Gasunie refitted (transformed) an existing 16'', 66 barq, 12 km natural gas pipeline to hydrogen which is in operation since 2018 and saves 20-40 kton CO_2 per year. And second, a study proposes to connect 5 large industrial centres as hydrogen network by extending existing hydrogen infrastructure with a capacity of 5-29 GW. And third, Adriaan explained joint activities of gas and electricity TSO to develop “energy networks”. The Dutch regulator requires joint planning by 2021. The study with outlook to 2050 provides evidence that the power-to-gas applications need to be located close to electricity generation to support the balance between production and demand. See on page 17 of the presentation the huge impact on grid bottlenecks; the picture on the right side shows the situation if electrolysis is build close to gas customers (demand) on a warm windy summer day.

II ELBERT HUIJZER (LIANDER)

The GREEN VILLAGE - Hydrogen Distribution Grid in the Netherlands

Elbert gave us insights to the project in The Green Village. The small hydrogen grid provides knowledge and experience in building and operating a network. The project is part of a wider field testing including home appliances. We would like to highlight two experiences. First, back looking it has been important and valuable that own engineers from Liander, Enexis and Stedin projected the gas grid, went through the safety questions and discussed the layout as well as technical details. Eventually, they decided to build it just as an ordinary “natural gas grid”, of course with some adjusted equipment. The acceptance and learning process inside the companies is valuable, because the ‘hands on experience’ was gained and forwarded by skilled colleagues. This helps to tackle internal resistance as the colleagues from the field are perceived as “reliable” in what they say and think. And second, the permit process is long-lasting and suffers from lack of experience on the side of the administration and the grid operator. This clearly shows how important a standard process is for the near future.

III PROF. MARCUS NEWBOROUGH (ITM POWER)

Recent U.K. Developments & Insight in ITM Activities

With the overview Marcus gave us, he shared the hope that by 2023 the threshold for blending hydrogen to natural gas (of 20 vol% or less) will be determined by the HyDeploy project activities. This will support strategic decisions in a country that is currently focussing on CCS and steam reforming of natural gas for decarbonisation, rather than producing green hydrogen via electrolysis. In addition to fuelling stations on the main land, the Orkney islands off the north coast of Scotland are actively using hydrogen from stranded renewables for mobility, heat and power applications. See the presentation for further projects, feasibility studies and details.

With partners of the Refhyne project, a 10 MW PEM electrolyser is currently being deployed with sub-second response. The electrolyser conforms with the requirements of the fastest primary response service in Europe called enhanced frequency response. The CAPEX of electrolysers are declining to currently 800 €/kW for a 10 MW unit and are expected to reduce further as manufacturing volumes and capacities increase.

Summary of the 6th HIPS-NET Workshop (3/3)

IV Dr. Christian Friebe (Thüga)

Public Policy for Deploying Power-to-Gas in Germany

Christian invited us with a provoking view on the power-to-X market entrance (https://www.ptx-allianz.de/markteinfuehrungsprogramm/). Neither CAPEX nor OPEX reduction nor measures, which create an obligatory demand like quotas, will further a widely spread market entrance that supports the energy system. Looking beyond conventional solutions, he explained us a combined approach for power-to-X products that suggests using renewable electricity, OPEX reduction only in times of grid electricity support, tender for public support in three different categories, while public support is limited to 4,380 hours per year for a period over 12 years plus consumer benefits to rise the incentive to pay more for power-to-X products. This has been a vivid example for simple and though distinctive communication approach which is now under consideration in the German government.

V & VI Gert Müller-Syring (DBI)

H2-Netz a Hydrogen Network and Advancing Hydrogen Tolerance in Germany

Similar to the experience Elbert shared in the morning, the **hydrogen network** advanced the experience of the operational forces of the network operator in the field; they gained hands-on experience. Here as well, the network was built mainly on natural gas standards. Gert points out that having a technical testing authority (in Germany TÜV) as project partner, helped to ease the process of certification. The H2-Netz project entered testing of different pipe materials, installations and odorants.

Gert introduced hard facts for transforming the natural gas network to hydrogen admixture. The estimated figures for network and underground storages (without end consumer devices) show the need to use natural equipment turning cycles to install hydrogen-ready equipment already today. Delaying this another five years, will result in high additional costs (estimated 57 billion €) for gas customers, which is mainly due to long life cycles (or amortisation periods). The additional costs are highly sensitive; one surprising example is that capping it at 2 vol% hydrogen does not result in lower costs for the entire system but causes estimated 110 billion € additional costs. Look for further results in Gert's presentation.

HIPS-NET Organisational Aspects

We are running well with the mandatory scope for the current network year, though newsletters are delayed which we are planning to catch up. Additional scope for 2018/19 is running such as maintaining website and networking activities. We are underway to update the worldwide power-to-gas map, the results are expected this year; JRC (Dominika Klassek) will support (thank you!).

Gas Connect Austria, Gasnetz Hamburg and Polymer Consult Buchner (both Germany) joined the network and we welcomed their representatives in Brussels personally. HIPS-NET grew to 39 partners! We hope to continue this moderate growth and target at 40-42 partners. If you know companies who's profile fits to the network, please let Gert, Josephine and Anja know.

The dates for the HIPS-NET workshop 2020 will be determined by a poll as in the previous years but it is scheduled again for June in Brussels at the GERG office. Please help to avoid public holidays or other important events by taking part in the poll Josephine will issue soon. The mandatory scope for 2019/20 is set as usual. Additional budget is available due to further partners we attracted already for the running year. We considered different possibilities/actions:

- Update of HIPS-NET website – AGREED
  - ⇒ check the frequency of use (clicks on the website) – adjust effort accordingly
  - ⇒ consider target group and adjust content
- Create a list with name and link of all studies of the HIPS-NET newsletters – AGREED
  - ⇒ simple format is sufficient; helps finding content
- Consideration of communication platform – we check possibilities (convenience); Yammer, Linked-in etc. were mentioned – discussion will follow once the proposal is a bit clearer.
- Advanced open communication with HIPS-NET materials such as newsletters etc. – not agreed

Selection of Appointments

August

27-28 BDEW-Fachtagung Wasserstoff | Frankfurt a.M., Germany, *www.ew-online.de*

September

10-11 f-cell | Stuttgart, Germany, *https://f-cell.de/*

24-25 DBI-Fachforum Energiespeicher | Berlin, Germany, *www.dbi-gut.de/veranstaltungen.html*

24-26 International Conference on Hydrogen Safety | Adelaide, Australia, *http://hysafe.info/ichs2017/*

October

8-10 Energy Storage World Forum | Rome, Italy, *www.energystorageforum.com*

22-23 13th Conference on Gaseous-Fuel Powered Vehicles| Stuttgart, Germany, *www.fkfs-veranstaltungen.de*

October

23-24 Power2Gas-Conference | Marseille, France, *www.p2gconference.com*

23-24 International Hydrogen Symposium | Hamburg, Germany, *www.h2hamburg.de*

23-26 Hydrogen + Fuel Cells ASIA at CeMAT ASIA 2019 | Shanghai, China, *https://www.h2fc-fair.com/asia/index.html*

29-30 Innovationsforum Wasserstoff | Freiberg, Germany, *www.dbi-gut.de/veranstaltungen.html*

November

5-6 HYPOS-Forum | Dresden, Germany, *www.hypos-eastgermany.de*

12-14 PowerGen | Paris, France, *www.powergeneurope.com*

26-28 gat + wat 2019 | Cologne, Germany, *https://www.gat-wat.de/*

Current Partners

Alliander AG, Areva H_2Gen, Cadent, DEA Deutsche Erdoel AG, DGC, DNV GL, Enagás, Enbridge, Energinet.dk, ENGIE, EWE Netz, Gas Connect Austria GmbH, Gasnetz Hamburg, Gasum OY, Gasunie, GRTgaz, grzi e.V. (figawa), Infraserv GmbH & Co. Höchst KG, INERIS, innogy SE, ITM Power, Joint Research Centre (JRC), EC, KOGAS, NAFTA a.s, Naturgy, ONTRAS, ÖVGW, Open Grid Europe GmbH, Polymer Consult Buchner, RAG Rohöl-Aufsuchungs AG, Shell, Solar Turbines Europe S.A., Storengy, SVGW, Synergrid, Teréga, Uniper Energy Storage GmbH, Verband der Chemischen Industrie (VCI), Volkswagen AG.

NEWS

And the Winner is… Real Laboratories of the Energy Transition

In 20 real laboratories within whole Germany, companies will be testing new hydrogen technologies on an industrial scale and in a real environment.

The Federal Minister of Economics Peter Altmaier announces the winners of the ideas competition "Reallabore der Energiewende". He said: "We want to become number one in the world in hydrogen technologies. Hydrogen technologies offer enormous potential for the energy transition and for climate protection as well as for new jobs. …" (press release 07/18/2019).

For the ideas competition a total of 90 proposals were submitted. The response has far exceed expectations! The Federal Ministry of Economics and Energy supports the winners annually with a total of 100 million euros.

HIPS-NET CONTACT

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GERG groupe européen de recherches gazières the european gas research group

DBI GUT Gas- und Umwelttechnik GmbH

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CEO: Prof. Dr. Hartmut Krause, Olaf Walther

Certified DIN EN ISO 9001:2008

HIPS-NET

"ESTABLISHING A PAN-EUROPEAN UNDERSTANDING OF ADMISSIBLE HYDROGEN CONCENTRATION IN THE NATURAL GAS GRID"

NEWSLETTER #23 | **NOVEMBER, 2019**

Dear HIPS-NET Partners,

following the suggestion from our last workshop, the HIPS-NET newsletter will from now on be released every two months with four to five articles. The 23rd newsletter is the first of those shorter but more frequent publications. We are curious how you will like the changes. The 23rd edition includes five articles, which talk about:

- results of the Marcogaz Taskforce H_2 with a condensed practical overview on H_2 readiness of the gas system
- the next project phase of the "Compendium on Hydrogen in Gas Distribution Networks" that will provide product-specific fact sheets as well as supplier's declarations for the hydrogen compatibility of the distribution network;
- the launch of a British Gigastack feasibility study for bulk, low-cost and zero-carbon hydrogen;
- the launch of an experiment for blending 5 vol% hydrogen into an Italian transmission grid;
- and for this edition an unusual minor focus on mobility from street over rail to aviation - we picked randomly activities out of a wide variety of projects out there.

Enjoy reading!

Your HIPS-NET Team

Gert, Anja, Josephine and Charlotte

Please note: Our next workshop will take place on the 4th of June 2020 in Brussels. As usual, a casual dinner is planned on the evening before.

SAVE THE DATE!

2020

3rd/4th

June

NEXT HIPS-NET Workshop in Brussels

CONTENT

CONTENT NEWSLETTER #23

Technical Readiness for Hydrogen Admission | Europe

Overview of available test results and regulatory limits for hydrogen admission into existing natural gas infrastructure and end use

The MARCOGAZ task force on hydrogen injection in the natural gas system has finalised the infographic on "*Overview of available test results and regulatory limits for hydrogen admission into existing natural gas infrastructure and end use*" after one year of intensive working on technical issues and consolidation.

The infographic condenses a comprehensive set on information for hydrogen admission into the existing natural gas infrastructure including underground gas storages and end use devices. A working groups with technical experts of the European gas industry in collaboration with other European gas associations collected and assessed existing knowledge to maintain a save and reliable gas supply (with hydrogen admixture). The results reflect the state of the art today (based on test results and regulatory limits from 64 sources). The infographic has been presented by Prof.-Dr. Gerald Linke (Marcogaz President) and Jos Dehaeseleer (Secretary General, Marcogaz) on the 33rd Madrid Forum in October 2019. The document, a presentation and the list of references are available in open access as source for policy makers, grid operators and others.

Summary

Natural gas infrastructure and residential appliances:

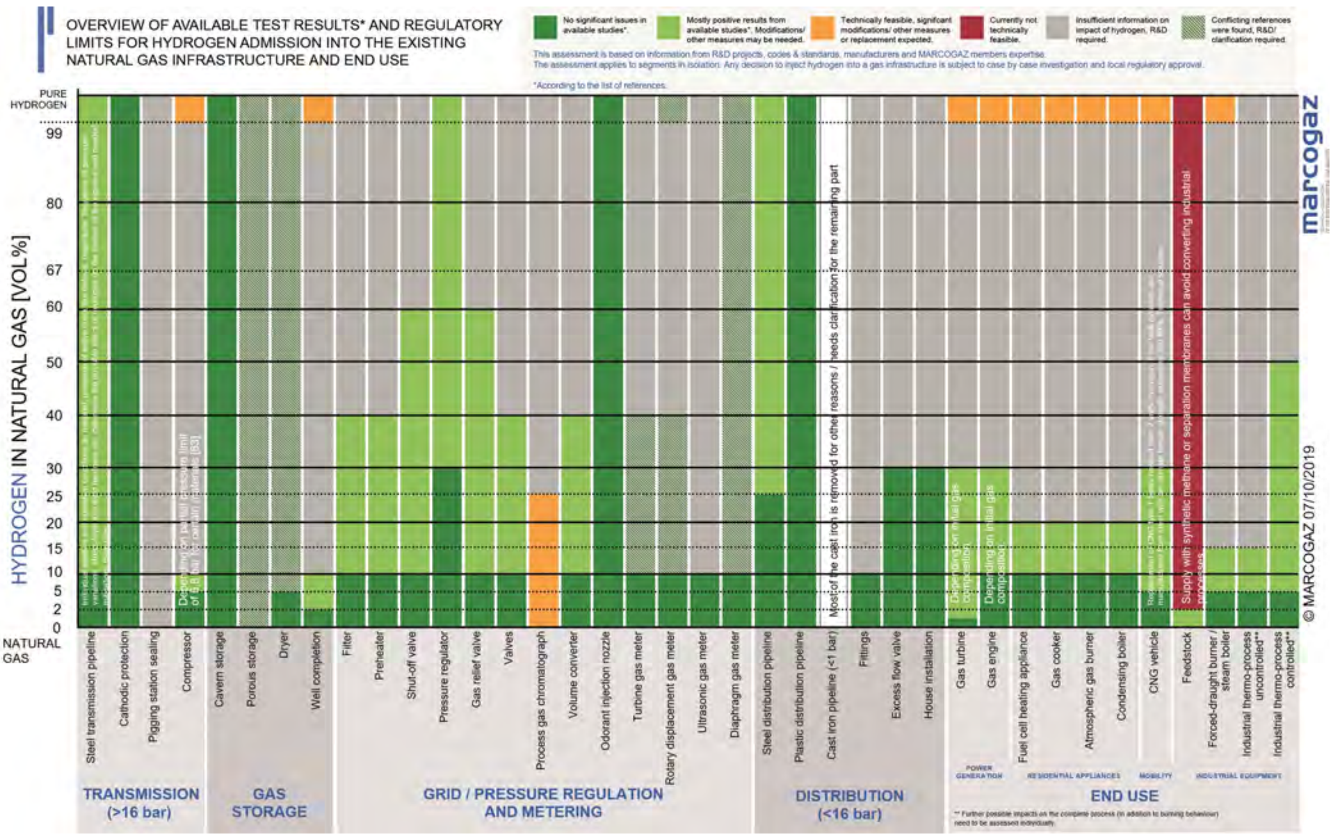
- Major elements of the gas transmission, storage and distribution infrastructure and residential gas appliances are expected to be able to accept 10 vol% H_2 in natural gas without modification.
- Some networks and residential appliances are already being operated with 20 vol% of hydrogen.
- Major elements of the infrastructure and residential appliances are expected to be able to accept 20 vol% H_2 with modification*.
- Higher concentrations (> 20 vol% H_2) can be reached through R&D by further measures or replacement.

Industrial processes:

- Many industrial processes (except feedstock) are expected to be able to accept 5 vol% H_2 in natural gas without modification.
- Current power plant gas turbines, industries using natural gas as feedstock and also CNG steel tanks are assessed to be sensitive to even small quantities of hydrogen and need further R&D/mitigation measures when planning to convey higher hydrogen concentrations.
- Thermoprocessing equipment (such as furnaces and burners) are expected to be able to accept 15 vol% H_2 with modifications.
- Higher concentrations (> 15 vol% H_2) can be tolerated through R&D, further measures or replacement.

The experts collected needed research & development issues briefly and straightforward as next steps. This expert group of the European gas industry developed a joint understanding - a decisive step forward to show the H_2 readiness of the infrastructure today and short-term potential for development.

Gert Müller-Syring (Task force-H2 Chairman) at gert.mueller-syring@dbi-gruppe.de
marcogaz@marcogaz.org



Compendium on Hydrogen in Gas Distribution Networks - Next Project Phase Launched | Germany

(More) product-specific fact sheets as well as supplier's declarations of conformity to be obtained by engaging with DSO component manufacturers

In a current industry project DBI continues its past work in the field of hydrogen gas in the gas networks once more. After having completed the first compendium project phase end of March this year with the E.ON and Thüga group, DBI launched the next project phase with an extended consortium with about 25 German Gas Distribution System Operators (DSO).

The compendium is designed as a reference work of the state-of-the-art knowledge on hydrogen compatibility of the distribution network. In this function it shall facilitate the next step towards a more extensive utilisation of the gas infrastructure with hydrogen after the phase of PtG pilot plants. This includes both: hydrogen admixtures with a certain share of hydrogen in the natural gas as well as pure hydrogen.

At its core and in present state, the compendium consists of condensed fact sheets issuing the hydrogen compatibility of the distribution network by its components and system level aspects (see the picture below).

The main activity of the current project phase is to get DSO component manufacturer involved by means of a dedicated online survey, workshops and bilateral contact. At least three workshops are about to take place in Leipzig. Finally, it is intended to have up to 150 product-specific fact sheets issuing their hydrogen compatibility in terms of - among others - *material*, *function* as well as *technical documentation*. Beyond that, the project partners are optimistic to obtain a remarkable number of *suppliers' declarations of conformity (issuing operation of natural gas products with NG H2 mixtures and pure hydrogen)* as well. In combination, both products shall provide DSOs sufficient certainty to allow higher hydrogen contents in their assets.

The project start was at the beginning of August 2019 and it will be finalised by the end of 2020. See for results of the previous project the presentation of Gert during the workshop 2019 in Brussels.

Stefan Schütz at stefan.schuetz@dbi-gruppe.de

Fact Sheets for the Hydrogen Compatibility of the Distribution Network and its Components (Source: DBI)

Delivery of Bulk, Low-Cost and Zero-Carbon Hydrogen Through Gigawatt Scale PEM Electrolysis | U.K. (1/2)

The UK Government is funding a project for a Gigastack feasibility study carried out through ITM Power, Ørsted and Element Energy.

Gigastack will demonstrate the delivery of bulk, low-cost and zero-carbon hydrogen through gigawatt scale polymer electrolyte membrane (PEM) electrolysis, manufactured in the UK. The project aims to dramatically reduce the cost of electrolytic hydrogen through:

- Development of a new 5 MW stack module design to reduce material costs.
- A new semi-automated manufacturing facility with an electrolyser capacity of up to 1 GW/year.
- Deployment of very large scale and hence low cost 100 MW+ PEM systems using multiple 5 MW units.
- Innovations in the siting and operation of these large electrolysers to exploit synergies with large GW scale renewable energy deployments.

Delivery of Bulk, Low-Cost and Zero-Carbon Hydrogen Through Gigawatt Scale PEM Electrolysis | U.K. (2/2)

In **phase one** (feasibility), ITM Power will develop the designs and finalise the material requirements to deliver a low-cost 5MW stack. They will also refine concepts to maximise the throughput of the proposed semi-automated manufacturing facility to meet the demands of bulk hydrogen supply. Ørsted will investigate potential synergies between offshore wind farms and electrolysers to identify scenarios that can provide affordable electricity and a sufficient load factor to allow economic operation of the electrolysers. Finally, Element Energy will conduct market analysis of potential end users, explore business models for the operation of large electrolysers in the energy system and define a roll-out strategy for the first 100 MW electrolysers.

Power Electrolyser (Source: ITM Power)

In **phase two**, the 5 MW stack would be built and tested both in-house and in a representative wind-hydrogen scenario. Construction of the semi-automated manufacturing facility would also begin. Finally, the business case for large electrolysers would be refined, enabling commercialisation.

Rebecca Markillie at rlm@itm-power.com

http://www.itm-power.com/news-item/gigastack-feasibility-study-with-orsted

Supply of H2NG into Transmission Network to Industrial Users | Italy

Project Launch (Source: Snam)

Snam launched an experiment of introducing a 5 vol% hydrogen and natural gas blend (H2NG) into the Italian gas transmission network. The experiment is being conducted in Contursi Terme, in Southern Italy, and involves the supply of H2NG to two industrial companies in the area: a pasta factory and a mineral water bottling company. The experiment has lasted for one month and was successful.

Applying a proportion of 5 vol% of hydrogen to the total gas transported annually by Snam, 3.5 billion cubic meters could be injected into the network each year, equivalent to the annual consumption of 1.5 million households.

Snam CEO, Marco Alverà, said: *"Europe's first injection of hydrogen into a transmission network directly supplying industrial customers projects Snam and our country into the future of clean energy. […] Hydrogen will become increasingly important in Snam's strategy and we have the skills and technology to become leaders in this sector. We felt compelled to begin this innovative project in Southern Italy and Campania due to our strong connection with the territory".*

Snam is planning to increase the hydrogen share to 10 vol% in the coming months. For the moment the same part of the network and the same two companies are involved.

Salvatore Ricco at Salvatore.ricco@snam.it

http://www.snam.it/en/Media/Press-releases/2019/Snam_Europe_first_supply_hydrogen_natural_gas_blend.html

H2 Mobility News for Street, Rail, Aviation | China & U.K.

Hydrogen has an energy density per unit mass that is 2.8 times higher than traditional jet fuel (kerosin), but a lower energy density per unit of volume. Even in liquid condition, the volume of hydrogen is 4 times higher than kerosin. Hydrogen powered aircrafts will produce fewer greenhouse gases (water vapor and a small amount of nitrogen oxide) than current ones.

World's First Hydrogen-Electric Passenger Plane | China

H2-Electric Passenger Plane

The plane is called Element One and it is set to take to the skies by 2025. The company spent more than 12 years developing hydrogen propulsion systems for small aircrafts. Element One is designed to fly 4 passengers for 310 to 3,100 miles (500 to 5,000 kilometres) depending on whether hydrogen is stored in gaseous or liquid form – on top of that, it will only take up to 10 minutes to refuel. [Remark editors: Well, maybe it's not the first H2 plane but one of the first.]

https://www.hes.sg/element-one

Hydrogen Refuelling Station | China

Upscaling is underway: SAIC Motor opened a hydrogen refuelling station with a capacity of **2 tons hydrogen per day** in June this year. They rate it as "the world's largest and most advanced" hydrogen refuelling station.

http://www.saicgroup.com/english/latest_news/saic_motor/51938.shtml

Hydrogen Powered Medium and Heavy Commercial Vehicles | U.K.

H2Van™

H2Truck™

HVSystems offers state-of-the-art technology as van and truck. Both are eyecatchers due to futuristic design and aiming to disrupt the vehicle market with conventional technologies. Thanks to the use of ultra-economic hydrogen, fuel-efficient aerodynamics and reduced breakdown and serving requirements, operating costs are up to 19 % lower. Additionally, the vehicles pay neither road tax nor congestion charge in the U.K.. Commercial sale will commence in 2022.

https://hv-systems.co.uk/vehicles/h2van/ & https://hv-systems.co.uk/vehicles/hv-truck/

Adjusting Conventional Train Fleet to H_2 | U.K.

Hydrogen Train "Breeze"

Alstom and Eversholt Rail have unveiled the design of a new hydrogen train for the UK market. The train, codenamed 'Breeze', will be a conversion of existing Class 321 trains, reengineering some of the UK's most reliable rolling stock, to create a clean train for the modern age. These trains could run across the UK as early as 2022.

https://www.alstom.com/press-releases-news/2019/1/alstom-and-eversholt-rail-unveil-new-hydrogen-train-design-uk

H2PORTS - Fuel Cells and Hydrogen in Ports | Italy

The Port of Valencia implemented a strategy to decarbonise port-logistics, reduce the port's carbon footprint and adopt alternative fuels to transform ports towards zero-emission operations. The initiative H2Ports is the first European project focused on testing heavy-duty port equipment powered with Hydrogen Fuel Cells, being also the first port in Europe able to supply this alternative fuel by means of Hydrogen supply infrastructures.

The project will demonstrate and validate by means of real life trials in two cargo terminals of the port of Valencia (MSC Terminal Valencia and Valencia Terminal Europe), an integrated set of two innovative equipment based on FC technologies implemented in last-generation port machinery besides a hydrogen mobile supply station specifically designed for the project. The prototypes selected are a container handling reach stacker and a terminal tug master used in ro-ro operations.

The project is funded by the Fuel Cells and Hydrogen Joint Undertaking (FCH JU) with 4 million €.

Project partners are: Fundación Valenciaport (project leader), Port Authority of Valencia, MSC Terminal Valencia, Grimaldi Group, Spanish Hydrogen Centre, Hyster-Yale, Enagás, Ballard Power Systems, Atena

José Andrés Giménez Maldonado at JAGimenez@fundacion.valenciaport.com

https://sustainableworldports.org/project/port-of-valencia-h2ports/

Selection of Appointments

November 2019

13-14 Storenergy Congress | Offenburg, Germany, *https://www.storenergy.de/*

19-21 FCH JU Programme Review Days and Stakeholder Forum 2019 | Brussels, Belgium, *www.fch.europa.eu/*

20-21 Power ON Gas 2019 Conference | Copenhagen, Denmark, *https://fortesmedia.com/power-on-gas-2019-conference,4,en,2,1,2.html*

26-28 gat + wat 2019 | Cologne, Germany, *www.gat-wat.de/*

December 2019

03 STORE&GO Parliamentary Evening Power-to-Gas | Brussels, Belgium, *www.storeandgo.info/*

February 2020

04-05 HyVolution - energy, industry and mobility | Paris, France, *www.hyvolution-event.com/en*

11-13 E-WORLD 2020 | Essen, Germany, *https://www.e-world-essen.com/de*

March 2020

10-12 Energy Storage Europe | Düsseldorf, Germany, *https://www.eseexpo.de/*

April 2020

07-08 Hydrogen Summit | Munich, Germany, https://gasworldconferences.com/conference/hydrogen-summit-2020/

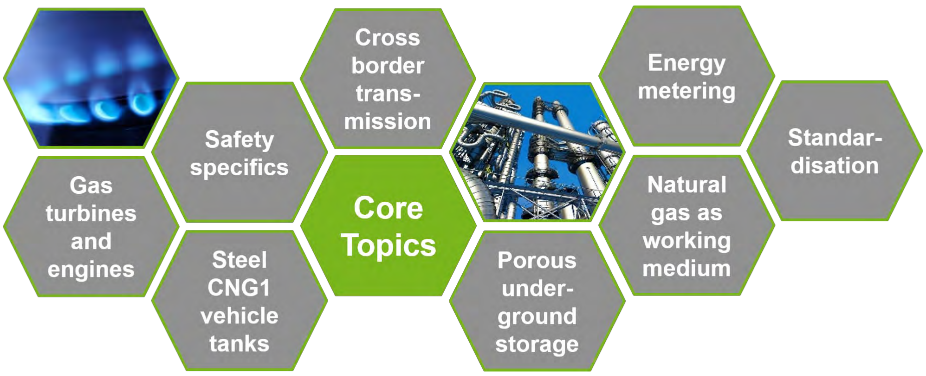
Current Partners

Alliander AG, Areva H_2Gen, Cadent, DGC, DNV GL, Enagás, Enbridge, Energinet.dk, ENGIE, EWE Netz, Gas Connect Austria GmbH, Gasnetz Hamburg, Gasum OY, Gasunie, GRTgaz, GRZI e.V. (FIGAWA), Infraserv GmbH & Co. Höchst KG, INERIS, innogy SE, ITM Power, Joint Research Centre (JRC), EC, KOGAS, NAFTA a.s, Naturgy, ONTRAS, ÖVGW, Open Grid Europe GmbH, Polymer Consult Buchner GmbH, RAG Rohöl-Aufsuchungs AG, Shell, Solar Turbines Europe S.A., Storengy, SVGW, Synergrid, Teréga, Uniper Energy Storage GmbH, Verband der Chemischen Industrie (VCI), Volkswagen AG, Wintershall Dea AG.

HIPS-NET CORE TOPICS

We gather and disseminate the latest available knowledge to improve the understanding of hydrogen/natural gas blends in pipeline systems with emphasis on the core topics:

We additionally keep a minor focus on the general development of power-to-gas, hydrogen networks, and further topics around the utilisation of (renewable) hydrogen.



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GERG groupe européen de recherches gazières the european gas research group

DBI GUT Gas- und Umwelttechnik GmbH

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CEO: Prof. Dr. Hartmut Krause, Olaf Walther

Certified DIN EN ISO 9001:2015

HIPS-NET

"Establishing a pan-European understanding of admissible hydrogen concentration in the natural gas grid"

NEWSLETTER #24 | **December, 2019**

Dear HIPS-NET Partners,

we continue the trial with shorter but more frequent newsletters as suggested the workshop in June. The 24th edition includes articles, which introduce

- a new trial project to mix up to 20 vol% to a gas distribution network
- results of an IRENA study
- the initiative 'Gas for Climate' in Europe and results of a study to promote the role of green gases
- a short note about future cooperation between the EIB and the Hydrogen Council to support (large-scale) hydrogen projects
- an update of activities around H21 project team which are consequently following a path to decarbonise the gas infrastructure with blue hydrogen

We hope you find interesting information and enjoy reading.

Your HIPS-NET Team

Gert, Anja, and Josephine

SAVE THE DATE!

2020

3rd/4th

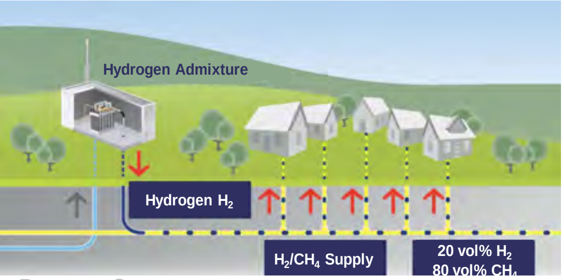
June

NEXT HIPS-NET Workshop in Brussels

CONTENT

CONTENT NEWSLETTER #24

Pilot - 20 vol% Hydrogen in Distribution Network | Germany



PROJECT SKETCH (SOURCE: AVACON)

Preparations are underway for a unique project: Avacon, an E.ON subsidiary, plans to raise the hydrogen admixture for its natural gas grid to 20 vol%. This is the first trial in German gas distribution networks.

The project aims to show that it is technically feasible to blend hydrogen into natural gas grids at much higher rates than today's maximum concentration of up to 10 vol%. Apart from showing that the network installations can cope with higher concentrations, it will be important to demonstrate the hydrogen compatibility of end-use devices including household appliance. Up to 400 heating systems and other customer devices will run through the stress test. The chosen grid section is ideal for the project because the grid infrastructure installed there is representative for the entire Avacon service area.

This means the results are scalable. It is a gas network with medium pressure range and 35 km length that supplies six villages. The grid has about 350 residential and commercial clients without industrial customers or natural gas filling stations. The hydrogen supply is planned via trailers. An electrolyser will not be used due to time and budget constraints. Avacon will extend the gas distribution station to handle the hydrogen admixture until the end of 2019.

Risk management and technical planning is finished; communication with customers are about to commence. Feed-in of hydrogen will presumably start in autumn 2020 and run until winter 2021/22 including two heating seasons. The hydrogen concentration will increase continuously, starting with 10 vol% and rising in two steps to 15 vol% and later to 20 vol%. Fluctuating hydrogen concentrations are not planned.

Partners: Avacon, DVGW, DVGW-EBI, GWI

Angela Brandes at angela.brandes@avacon.de http://bit.ly/34ddRYP

Hydrogen: A Renewable Energy Perspective (IRENA) | worldwide (1/2)

The International Renewable Energy Agency IRENA published in September 2019 the report: "Hydrogen – A Renewable Energy Perspective". IRENA prepared the report for the 2nd Hydrogen Energy Ministerial Meeting in Tokyo, Japan.

This IRENA report provides a more in-depth perspective on the nexus (connection) between hydrogen and renewable energy, on hydrogen supply economics in light of the rapidly falling cost of renewables and the role of hydrogen in the energy transition. The report addresses the following questions:

- What are the specific economic characteristics of green hydrogen (from renewables) and blue hydrogen (from fossil fuels with CCUS) today and in the future?
- How can hydrogen accelerate the deployment of renewable energy, and how can renewable energy accelerate the deployment of hydrogen?
- What aspects of the "green" hydrogen supply chain should be the main focus of research and development (R&D) and innovation?
- How can hydrogen contribute to the decarbonisation of end-uses in various sectors?
- What will be the characteristics of future hydrogen trade?

The main focus of the study seems on economic viability and strategic questions. One part addresses questions around the infrastructure. Although this isn't a focus in the report, we will **focus here on the infrastructure results**. The authors rely with their findings on literature review and use a surprisingly wide variety of sources, few of them are not publicly available. This raises the impression: the authors are well connected to experts in the field of hydrogen tolerance of the gas infrastructure.

According to the report,

- the development of hydrogen infrastructure is a challenge and is holding back widespread adoption. New and upgraded pipelines require further development and deployment.
- **experience with gas grid conversions exists**. Originally many natural gas systems were operated with hydrogen-rich town gas (from coal). In Germany, the gas grid is undergoing a 10-year, EUR 7 billion renovation to switch 30 % of its customers from natural gas with lower methane content (L-gas) to gas with higher methane and higher calorific content (H-gas).

Hydrogen: A Renewable Energy Perspective (IRENA) | worldwide (2/2)

- the infrastructure should be assessed, but for most components a share of **10-20 vol%** seems to be **achievable without major investments**.
- **early adoption** of the assets installed in the "natural" renewing cycles towards hydrogen-tolerant products will **reduce the costs greatly**. Delaying the starting point for installing tolerant products by five years, will lead to additional transition costs of around EUR 12 billion for the German gas infrastructure, including gas grids and underground storage.
- further **hydrogen embrittlement** research has shown that this is **not of large influence**. However, a careful assessment is needed to see if end-use equipment such as boilers, gas turbines and cook stoves could sustain such a gradual transition.
- the first stage involves multi-megawatt-capacity hydrogen facilities to directly feed large consumers, such as medium - to large-scale industries and specific transport fleets leveraging on the use of existent gas grids, and eventually their conversion to hydrogen grids. This approach would ensure long-term off-take for hydrogen system developers.
- moving to 100% hydrogen, most appliances – as well as most of the transmission and part of the distribution system for natural gas – will need major upgrades.

The authors summarise remaining questions for transition to (increasing shares of) hydrogen:

- How such a transition would play out: whether it would involve switching one gas distribution system at a time from natural gas to 100% hydrogen, switching 0-20% of systems or switching potentially 100% of systems simultaneously.
- How can the hydrogen share be kept below the technical limits in the transmission system? Perhaps this means first moving all transmission to 100% hydrogen tolerance, then starting to convert one distribution system at a time while increasing the hydrogen share in transmission.
- How can the hydrogen share be kept constant throughout the network and at different times of the year? For example, if production comes from solar and wind power, would levels of hydrogen injected into the gas grid also be variable?

https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Sep/IRENA_Hydrogen_2019.pdf

Future Cooperation of Hydrogen Council and European Investment Bank | worldwide

The Hydrogen Council and the European Investment Bank (EIB) signed an advisory agreement to collaborate on the development of innovative schemes to finance hydrogen projects in early December 2019.

The EIB will provide strategic financial advice through the InnovFin Advisory programme, and support to companies to deploy large-scale hydrogen projects, making such solutions more readily available to consumers around the world.

Source: https://hydrogencouncil.com/en/eib-agreement/

Initiative 'Gas for Climate - A Path to 2050' | Europe

'Gas for Climate: a path to 2050' is a group of nine leading European gas transport companies (Enagás, Fluxys, Gasunie, GRTgaz, Open Grid Europe, Snam, Ontras, Energinet and Teréga) and two renewable gas industry associations (European Biogas Association and Consorzio Italiano Biogas). The gas transport companies operate in six EU Member States and are collectively responsible for 75% of total natural gas consumption in Europe.

The initiative is committed to achieve net zero greenhouse gas emissions in the EU by 2050 and is convinced that renewable and low carbon gas used through existing gas infrastructure will help to reach net zero emissions at the lowest possible costs and maximum benefits for the European economy.

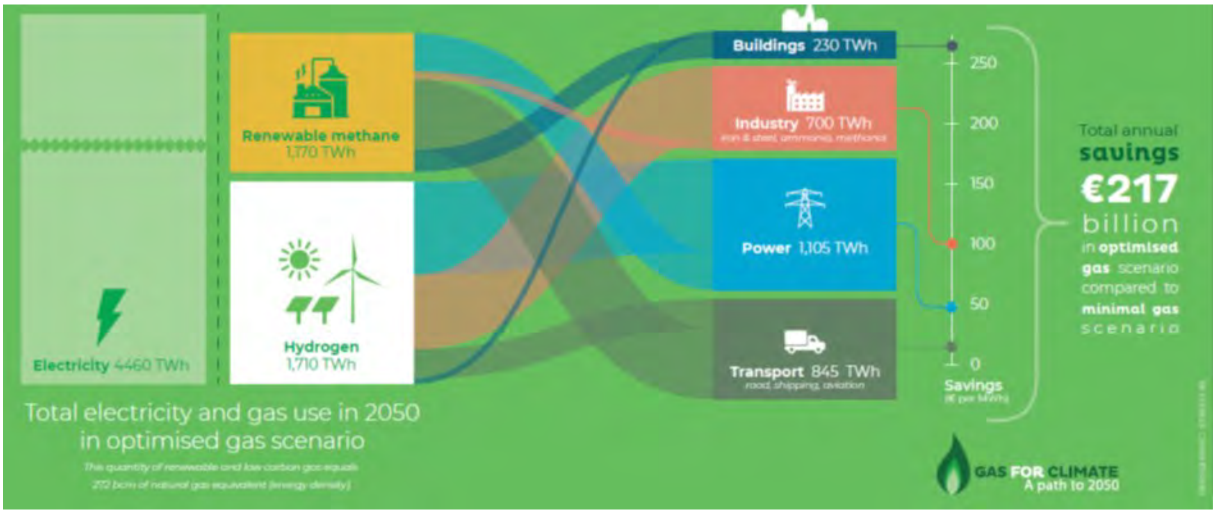
'Gas for Climate' assesses and creates awareness about the role of renewable and low carbon gas in the future energy system. We introduce one of the reports on the next page.

Sources: Initiative, Action Plan 2030

GAS FOR CLIMATE
A path to 2050

Study Gas for Climate (update 2019) | Europe (1/3)

The optimal role for gas in a net-zero emissions energy system



Well-balanced electricity and gas use in 2050 with high annual savings (Source: http://bit.ly/2EchBPH)

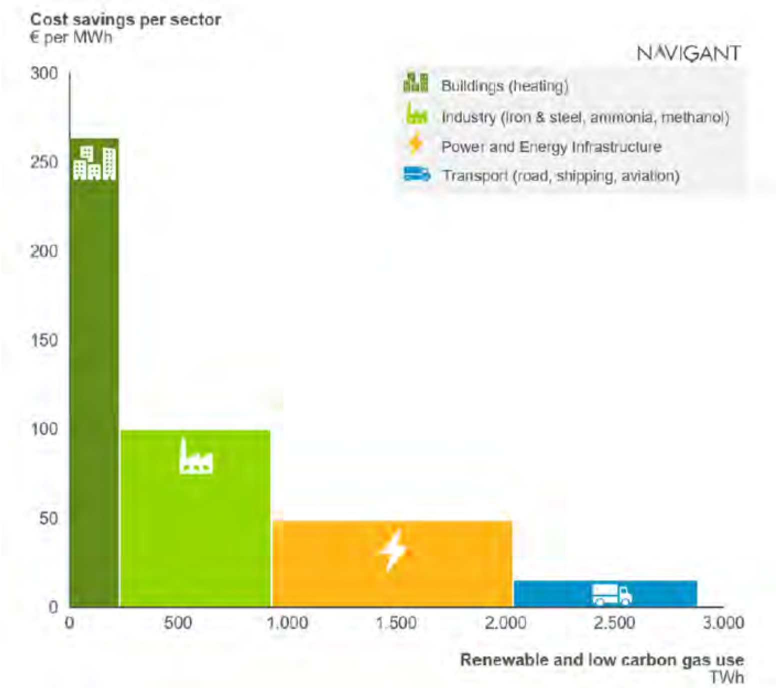
Navigant (now called Guidehouse) published an update of the study "Gas for Climate" in March 2019 on behalf of the 'Climate for Gas' initiative. The purpose of this study is to assess the cost-optimal way to fully decarbonise the EU energy system by 2050 and to explore the role and value of renewable and low-carbon gas used in existing gas infrastructure.

Full decarbonisation of the entire EU energy system requires large quantities of renewable energy. Renewable gas is not only indispensable to achieve full decarbonisation in combination with renewable power, it is also cost-effective due to the relatively low costs to store and transport gas through the existing gas infrastructure. Renewable gas is also cost-effective to fully decarbonise the buildings sector in hybrid heat pumps.

The study compares a "minimal gas" scenario with an "optimised gas" scenario and concludes that by 2050 about 60% of all energy consumed in the EU will be renewable electricity, with much of the remaining energy to be hydrogen and biomethane.

The **"optimised gas" scenario** allocates **1,170 TWh/yr renewable methane and 1,710 TWh/yr hydrogen** to the buildings, industry, transport, and power sectors. This equals about 270 billion m³ of natural gas (energy content). Compared to the "minimal gas" scenario, the use of gas through the gas infrastructure saves the society €217 billion annually across the energy system by 2050 (see infographic).

The diagram shows, the cost savings per unit of energy are highest in the heating of buildings, where renewable gas is used combined with electricity in hybrid heat pumps in buildings that are connected to gas grids today. Also, the use of renewable gas in electricity production generates significant energy system savings because it avoids costly investments in solid biomass power or even costlier battery seasonal storage.



Quantities of gas used per sector and resulting energy system cost savings in the "optimised gas" scenario versus the "minimal gas" scenario (Source: report page 93)

Study Gas for Climate (update 2019) | Europe (2/3)

The optimal role for gas in a net-zero emissions energy system

The **total annual costs amount to more than two trillion euro in both scenarios**. Most of these **costs are not additional costs related to decarbonisation** but are regular energy system costs and transport vehicle costs that exist today as well. For all relevant uses of energy, the authors chose fair costs for comparing the two scenarios. This means for example that they included all energy production costs for both scenarios, yet for road transport they included road vehicle and fuel costs, while for aviation they only included fuel costs because the costs for aeroplanes will be similar in both scenarios. Also, cost for upgrades in the electricity transmission grid are fully included, while low voltage distribution is not because strong electrification in both scenarios would result in similar grid replacement costs. It can safely be concluded that the €217 billion euro cost savings in the "optimised gas" scenario are a substantial share of additional costs beyond 'business as usual' energy system costs.

The cost to **decommission existing gas grids** are uncertain but may cost many billions of euros. The "minimal gas" scenario needs little gas infrastructure. In this scenario, most of the existing gas grid will need to be decommissioned. Based on Navigant's experience with TSO gas infrastructure decommissioning, they assumed associated costs of around 30 % of the CAPEX initially required to build the infrastructure. **The total decommissioning cost for the TSO gas infrastructure would be €156 billion.** To allow for comparison with other infrastructure investment costs in our scenarios, the authors annualised these costs over a period of 10 years, which results to €15.6 billion per year. Importantly, the DSO network is even more extensive, but the associated costs were not estimated. The authors expect these to be potentially substantial and higher than the total TSO decommissioning costs.

Blending hydrogen with biomethane (or natural gas) is possible but according to the authors not likely to happen in the future because of technical and economic difficulties. They acknowledge admixture of **up to 10 vol%** hydrogen in the existing infrastructure is technically possible and assume transition from a natural gas to a 'retrofitted' hydrogen infrastructure. The reason why the authors don't expect admixing to be a viable option is because hydrogen end-consumers will want to have hydrogen rather than a methane-hydrogen mix.

Delivery option	Costs [€/MWh/ 600km]	Technology maturity	Comments
Retrofitting existing gas infrastructure for 100% hydrogen	3.7	Pilot-tested	Calculated by Navigant based on literature
New hydrogen pipelines	4.6	Commercial	Calculated by Navigant based on literature
Liquid organic hydrogen carriers (LOHC) per pipeline	19[184]	Pilot-tested	Not yet commercial. LOHC could be an option to transport hydrogen but more expensive than gas pipes
Liquified transport per truck, train, ship	58-62 (ship)[185]	Commercial with trucks, trains; ship-bound under development	Not deemed a promising option as major additional energy losses are incurred by liquefaction (over 30% of the hydrogen LHV)[186] and this option is currently very expensive.
Compressed gas containers per truck	Not considered[187]	Commercial	Not suitable for large-scale hydrogen transport.
Hydrogen blending with methane per pipeline	Low cost at <10% blends, at higher blends costs depend on pipeline quality/topology.[188]	Pilot-tested	Assumed only to play a role up to 2030 or 2040 with small shares of hydrogen blended in methane.
Metal Hydrides per truck or train	Unknown at industrial scale	Under development	Becoming commercially available to store small quantities of hydrogen. Large-scale storage costs unknown.

Hydrogen conversion, transport and distribution options and estimates of their costs (Source: report page 86)

Study Gas for Climate (update 2019) | Europe (3/3)

The optimal role for gas in a net-zero emissions energy system

Costs for	"Optimised gas"	"Minimal gas"	Savings
renewable methane infrastructure maintenance	6	0	-6
Gas infrastructure decommissioning	0	16	16
Biomethane connection to gas grid	9	0	-9
Transporting hydrogen in retrofitted gas infrastructure	10	0	-10
Electricity distribution infrastructure	31	37	6
Electricity transmission infrastructure	73	95	22
Total infrastructure costs			**19**

Annual costs of the gas and electricity infrastructure in the "minimal gas" and "optimised" gas scenarios and the cost difference between the scenarios by 2050 (billion € per year). (Source: report, page 89)

The authors introduce a further idea: A substantial **network of oil pipelines** exists in Europe, consisting of 33,000 km through many EU Member States. If liquid oil products will not be used in a net-zero emissions energy system, this network may be obsolete by 2050 and could be repurposed to transport hydrogen.

The study further illustrates the advantages of **blue hydrogen** (with CCS) for a transition period because scaling up is faster and for a certain period cheaper than installing the needed power-to-gas capacity. The "optimised gas" scenario, however, includes only renewable gas to show that it is possible to achieve net zero emissions by 2050, with no remaining role for low-carbon gas.

Domestic Energy Production vs. International Trade

Today, the EU imports more than 50 % of its energy. In theory, it is feasible to produce all required energy in both study scenarios domestically within the EU by 2050. However, producing renewable energy in other parts of the world can be an attractive alternative, and it is more likely that international trade in energy will continue to exist.

http://bit.ly/2PBxvZs Daan Peters at daan.peters@guidehouse.com

Navigant also published a Gas for Climate Employment study in November 2019. We will introduce the results with the following newsletter. For curious colleagues, please look here: http://bit.ly/2ruiYH2

H21 - Update and Further Research | U.K. (1/2)

More than two years ago, in July 2016, the H21 Leeds City Gate report was launched. Some might remember the enthusiastic presentation by Dan Sadler - lead author and project manager - at the HIPS-NET workshop in June 2017. One year ago, in November 2018, the H21 North of England report was launched.

The partners of the H21 project are continuously working on the introduction of hydrogen with further projects. We selected a few here with very brief information.

H21 NIC - Safety Evidence for H_2 in Gas Networks | U.K.

The **H21 NIC work** will deliver the quantified safety evidence necessary to inform a government policy decision on hydrogen for use in the existing gas network. The work is split into two phases:

Phase 1a: Establishing whether there will be any changes in leakage levels to the U.K.'s gas distribution network assets when pressurised with 100 % hydrogen. A test facility has been built for controlled testing of network pipes, valves, joints and fittings, at the Health and Safety Executive's Science & Research site in Buxton.

H21 - Update and Further Research | U.K. (2/2)

Phase 1b: 'Consequence' testing at DNV GL's Testing & Research facility, examines various characteristics of how hydrogen behaves in comparison to natural gas.

The testing has been split into five packages, each requiring a distinct build, analysis and experimental phase.

- WP 1 - Small release testing – to observe the dispersion of hydrogen through a variety of soil and building materials.
- WP 2 - Large release testing – to measure consequences where the breaking of ground surface is likely.
- WP 3 - Ignition potential – a converted natural gas ignition chamber will measure ignition potential on known sources when hydrogen is introduced.
- WP 4 - Explosion severity testing – decommissioned governor houses will help compare the point where hydrogen becomes more reactive than natural gas.
- WP 5 - Operational safety testing – demonstrating techniques, operations and equipment in live scenarios.

Partners: All U.K. Gas Distribution Network Operators (GDNs), DNV-GL, HSE

Funding: £9 (~€10.6) million Network Innovation Competition (NIC) funding, total budget £10.3 (~€12.2) million

Duration: 2018 until summer 2020

https://www.h21.green/projects/h21-nic-phase-1/

Field trials in a decommissioned section of network | U.K.

Follow-up: Supporting the knowledge from Phases 1a and 1b of the H21 NIC project, this second project will involve essential network research trials on an unoccupied part of the network. Testing will deliver the evidence on critical devices, an essential pre-requisite for live trials.

Collaboration: All UK GDNs, National Grid Transmission, DNV GL, HSE

Funding: £6.8 (~€8) million Network Innovation Competition funding, total budget £7.5 (~€8.9) million

Duration: 2 years | 2020 - 2022

https://www.h21.green/projects/phase-2-h21-field-trials/

H21 Domestic and commercial metering | U.K.

This project will determine the suitability of existing domestic and commercial meters for operation on a hydrogen network. The scope of the project will involve an initial review of hydrogen meter technologies and applications worldwide. After the design of the metering test facility is finalised, the data is gathered in a final report. The report is available upon request.

Partners: NGN, Cadent

Funding: Network Innovation Allowance (NIA)

Duration: 2017 - 2019

https://www.h21.green/projects/h21-domestic-and-commercial-metering/

H21 Social Science Research | U.K.

Public perceptions of hydrogen: At the moment, there is no clear picture of how communities and individuals would respond to the prospect of a 100 % hydrogen conversion, which could change the look and feel of daily core practices e.g. cooking and heating.

As part of the H21 NIC project, a programme of social science research is being undertaken by Leeds Beckett University. This research will ensure that some of the issues regarding perceptions of hydrogen are confronted and new knowledge generated.

Researchers from the Leeds Beckett University will:

- generate insight into public perceptions of the safety of hydrogen and other energy technologies/vectors.
- generate insight into how people respond to the possibility of using 100 % hydrogen in the three-key, gas-fuelled social practices (heating, cooking, travelling).
- Understand how public perception of the safety of hydrogen changes when considering the results of the H21 NIC project.
- build a hydrogen research network of social scientists across the U.K. who may then become involved in the delivery of the proposed research activity or who may play advisory roles in the development of a body of research, data and expertise around the opportunities and challenges of hydrogen.

The analysis will also show how social acceptance varies by a range of socio-demographic and geographic variables.

Partners: Leeds Beckett University

Funding: Ofgem Network Innovation Competition

Duration: 2019 - 2020

https://www.h21.green/projects/h21-social-science-research/

Selection of Appointments

February 2020

04-05 HyVolution - energy, industry and mobility | Paris, France, *www.hyvolution-event.com/en*

04 Introduction course to Hydrogen | Brussels, Belgium, *http://bit.ly/h2introcourse1*

05 Expert training on water electrolysis| Oevel, Belgium, *http://bit.ly/P2HExpert1*

06 Power-to-X site visit: Colruyt| Halle, Belgium, *http://bit.ly/P2Xsitevisit1*

March 2020

04-05 Hydrogen & Fuel Cells Energy Summit | Lisbon, Portugal, *https://www.wplgroup.com/aci/event/hydrogen-fuel-cells-energy-summit/*

10-11 World Hydrogen Fuels Summit | Amsterdam, The Netherlands, *https://www.worldhydrogenfuels.com/*

25-26 Hydrogen & Fuel Cells for Heavy Duty Transport Conference | Brussels, Belgium, *https://www.h2-transport.com/*

April 2020

03 STORE&GO Parliamentary Evening Power-to-Gas | Brussels, Belgium, *www.storeandgo.info/*

07-08 European Zero Emission Bus Conference | Paris, France, *https://zeroemissionbusconference.eu/*

07-08 H2 VIEW Hydrogen Summit | Munich, Germany, *https://gasworldconferences.com/conference/hydrogen-summit-2020/*

Current Partners

Alliander AG, Areva H2Gen, Cadent, DGC, DNV GL, Enagás, Enbridge, Energinet.dk, ENGIE, EWE Netz, Gas Connect Austria GmbH, Gasnetz Hamburg, Gasum OY, Gasunie, GRTgaz, GRZI e.V. (figawa), Infraserv GmbH & Co. Höchst KG, INERIS, innogy SE, ITM Power, Joint Research Centre (JRC), EC, KOGAS, NAFTA a.s, Naturgy, ONTRAS, ÖVGW, Open Grid Europe GmbH, Polymer Consult Buchner GmbH, RAG Rohöl-Aufsuchungs AG, Shell, Solar Turbines Europe S.A., Storengy, SVGW, Synergrid, Teréga, Uniper Energy Storage GmbH, Verband der Chemischen Industrie (VCI), Volkswagen AG, Wintershall Dea AG.

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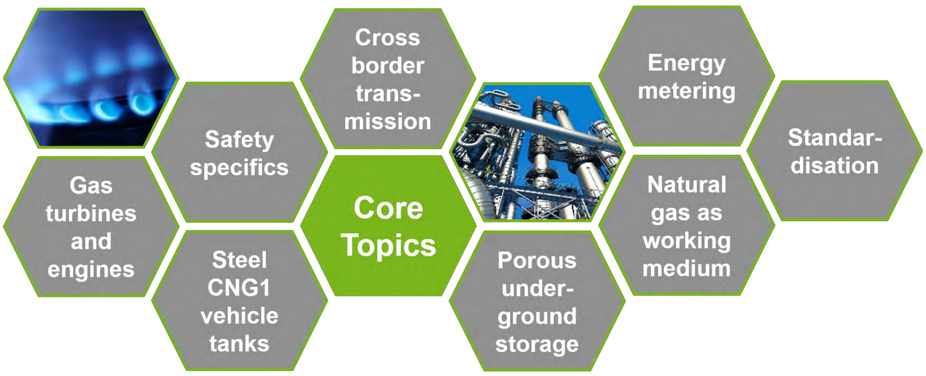
We gather and disseminate the latest available knowledge to improve the understanding of hydrogen/natural gas blends in pipeline systems with emphasis on the core topics:

We additionally keep a minor focus on the general development of power-to-gas, hydrogen networks, and further topics around the utilisation of (renewable) hydrogen.



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GERG groupe européen de recherches gazières the european gas research group

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CEO: Prof. Dr. Hartmut Krause, Olaf Walther

HIPS-NET

“ESTABLISHING A PAN-EUROPEAN UNDERSTANDING OF ADMISSIBLE HYDROGEN CONCENTRATION IN THE NATURAL GAS GRID”

NEWSLETTER #25 | **MARCH, 2020**

Dear HIPS-NET Partners,

we are currently preparing the 7th HIPS-NET workshop (4th June 2020) and are searching for exciting project results. Do you know about projects or topics that could be of interest for our workshop (external speakers) or are there any exciting developments in your company or country that you would like to present yourself? Please contact Anja or me until 13th March!

We are continuing the trial phase with shorter but more frequent newsletters since the workshop in June. The 25th edition includes articles, which introduce

- a vision of the German gas transmission system operators for a hydrogen infrastructure in Germany
- an overview of a new report from the Hydrogen Council about the competitiveness of hydrogen
- the Gas for Climate employment study
- a summary of a study calling for a climate-neutral industry in Germany, and
- a project announcement of HEAVENN, a hydrogen valley in the Netherlands.

We hope you find interesting information and enjoy the reading.

Your HIPS-NET Team

Gert, Anja, Josephine, and Melanie

SAVE THE DATE!

2020

3rd/4th

June

NEXT HIPS-NET Workshop in Brussels

CONTENT

CONTENT NEWSLETTER #25

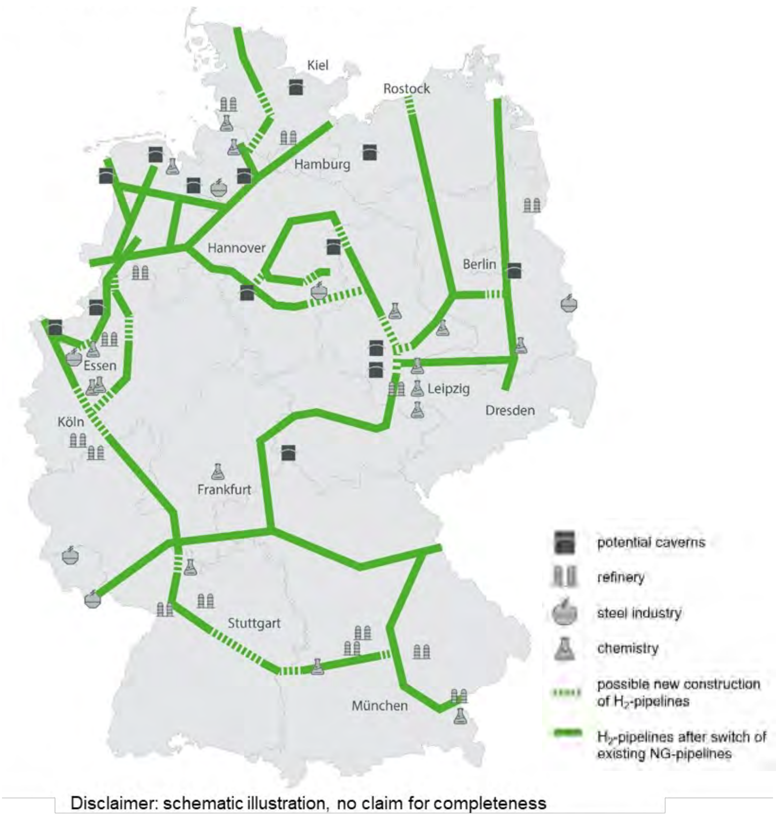
Future Hydrogen Transmission Network | Germany

The German gas transmission system operators (TSO) presented their vision for a hydrogen infrastructure. This visionary pipeline system is based to more than 90 % on the existing natural gas network and has a total length of about 5,900 km. A large part of the future hydrogen consumers in the sectors industry, mobility and heat as well as numerous underground storage facilities can be connected to the main sources of supply via the envisaged pipeline system.

The visionary hydrogen network aims to contribute to the hydrogen strategy announced by the German Government and demonstrates a first step towards the future hydrogen economy. The transmission system operators are committed to use the existing gas infrastructure for hydrogen as well. They are working on technical solutions and network planning to ensure that integration can succeed.

In addition, future hydrogen production and hydrogen demand are, for the first time, included in the current modelling of the Network Development Plan (NEP) Gas 2020-2030. The NEP, once confirmed by the national regulator, is the base for investments in the natural gas network. Hydrogen is integrated as an additional gas quality (in addition to H-gas and L-gas).

Inga Posch at inga.posch@fnb-gas.de http://bit.ly/39zny6Y

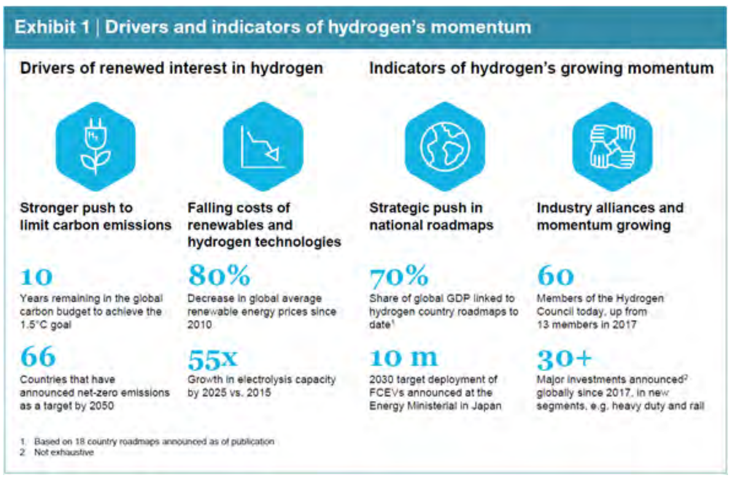


Vision for a German H_2 Transmission Network (Source: FNB Gas)

Report Demonstrates Hydrogen Competitiveness | worldwide (1/4)

Up to 50 % Cost Reduction by 2030 Achievable

The new report, published by the Hydrogen Council in January 2020, shows that the cost of hydrogen solutions will fall sharply within the next decade, sooner than previously expected. As scale up of hydrogen production, distribution, as well as of equipment and component manufacturing continues, cost is projected to decrease by up to 50 % by 2030 for a wide range of applications, making hydrogen competitive with other low-carbon alternatives and, in some cases, even conventional options. “Path to Hydrogen Competitiveness: A Cost Perspective” is the report’s title and the authors admit, to reach this scale, it needs investment but also policy alignment and stimulation of further demand.



Drivers and Indicators of Hydrogen’s Momentum (Source: study, page 3)

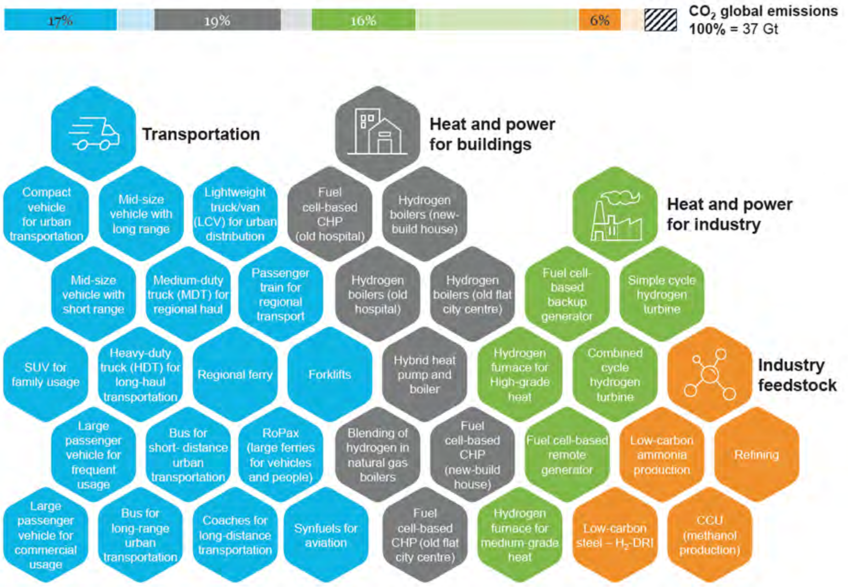
The motivation to deploy clean hydrogen is rising. 66 countries announced their intent to meet net-zero carbon emission targets by 2050. Governments are recognising hydrogen’s ability to decarbonise sectors that are otherwise impossible or difficult to abate – such as logistics, industrial heating and industry feedstock – and its role in energy security. 18 governments, whose economies account for 70 % of global GDP, have developed detailed strategies for deploying hydrogen energy solutions. The figure (left) lists the drivers and indicators for hydrogen’s growing momentum.

Report Demonstrates Hydrogen Competitiveness | worldwide (2/4)

Up to 50 % Cost Reduction by 2030 Achievable

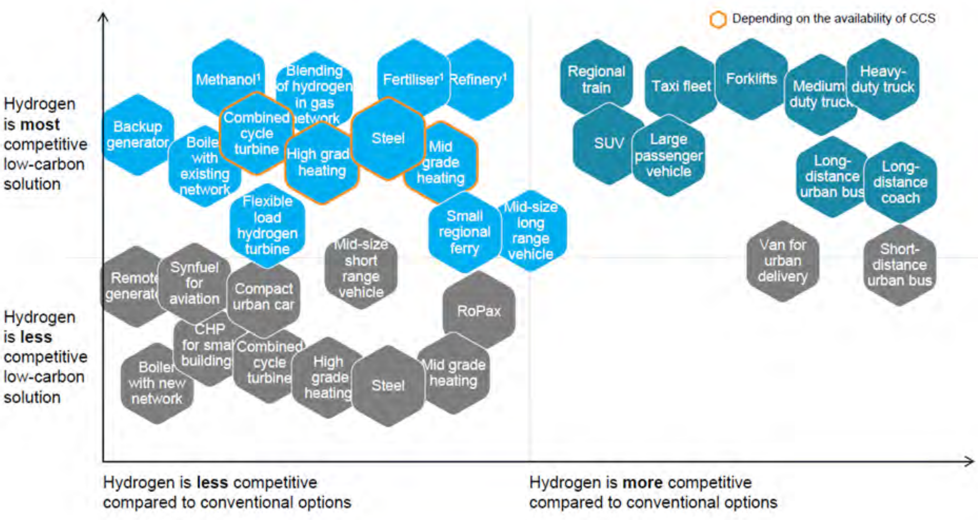
The Hydrogen Council is a global initiative of CEOs of leading global businesses that invites policymakers, investors and civil society stakeholders to acknowledge the contribution and potential of hydrogen as a key element of the energy transition. "The time to act is now."

The authors provide an evidence base on the path to cost competitiveness for 40 hydrogen technologies used in 35 applications derived from real industry data, with 25,000 data points gathered and analysed from 30 companies. For policymakers, such a perspective provides firm ground to prioritise investments and non-financial support to unlock the economic value of hydrogen. For decision-makers in industry, it offers a comprehensive understanding of value chain cost dynamics and interrelationships, allowing them to put their own efforts into a broader perspective.



Overview of 35 Hydrogen Applications and Current Share of global CO_2 Emissions (Source: study, page 8)

The calculations include 35 hydrogen applications across four segments from 2020 to 2050 – in transportation, heat and power for buildings, heat and power for industry, and industry feedstock. They include both new and existing applications currently responsible for 60 % of the world's energy- and process-related emissions (see figure above). Most applications are compared with other low-carbon solutions (e.g. battery vehicles, heat pumps) and conventional technologies (e.g. diesel-powered vehicles, gas boilers). In some applications, hydrogen is practically the only low-carbon solution. For example, in feedstock applications such as ammonia production and hydrocracking in refining, low-carbon and renewable hydrogen competes with hydrogen produced from unabated fossil resources. In such cases, the study compares conventional alternatives with different hydrogen sources.



1. Hydrogen is the only alternative and low-carbon/renewable hydrogen competing with grey (optimal renewable or low-carbon shown)

Competitiveness of H_2 Applications vs. Low-Carbon and Conventional Alternatives (Source: study, page 9)

As visible in the figure (below), in 22 out of 35 applications hydrogen can become a cost-competitive low-carbon solution before 2030 under the right conditions and assumed scale-up. Examples of these include long-distance transport applications and regional trains, which are highly competitive with low-carbon alternatives. These 22 hydrogen applications account for up to 15 % of global energy consumption (17,500 TWh). This does not imply that hydrogen will satisfy all this energy demand by 2030, but it shows that hydrogen is expected to play a significant role in the future energy mix.

In four of the reviewed applications, the competitiveness of hydrogen depends on the availability of CCS. If CCS resources for those applications are not available, hydrogen offers the only way to decarbonise the application. Examples include combined cycle turbines, steel production, high-grade heating for cement and medium-grade heating for plastics production.

Report Demonstrates Hydrogen Competitiveness | worldwide (3/4)

Up to 50 % Cost Reduction by 2030 Achievable

Compared with conventional alternatives, several applications are highly competitive to both low-carbon and conventional alternatives, requiring zero- or low-carbon prices for hydrogen to break even. This is true for nine applications, including trucks, trains, long-range passenger vehicles, and long-distance buses. Conversely, for several other applications, including use in turbines, industry feedstock, or synthetic fuel for aviation, a carbon tax of at least 100 US$/$t_{CO2equivalent}$ would be required to make hydrogen competitive with conventional fuels.

According to the report, this cost trajectory can be attributed mainly to scale-up that positively impacts the three main cost drivers. To deliver on this opportunity, supporting policies will be required in key geographies, together with investment support of around 70 billion US$ in the lead up to 2030 in order to scale up and achieve hydrogen competitiveness. While this figure is sizable, it accounts for less than 5 % of annual global spending on energy. For comparison, support provided to renewables in Germany totalled roughly 30 billion US$ in 2019.

Need for investment: approximately 70 billion US$ required to become competitive

Specifically, the gap between the costs of hydrogen technologies and their lowest cost low-carbon alternative will require funding in order to bring hydrogen to scale and, consequently, cost parity. In the identified areas investment until 2030 would make the biggest difference and will achieve competitive renewable (or low carbon) hydrogen:

- In **production**, aggregated 70 GW of electrolyser capacity, with an implied cumulative funding gap with grey production of 20 billion US$ until 2030. To implement low-carbon hydrogen (natural gas reforming with CCS), 6 billion US$ is required to fund the additional production costs versus grey hydrogen until 2030, assuming the usage of existing reservoirs
- In **transport**, the refuelling and distribution networks required plus the economic gap between fuel cells, hydrogen tanks and low-carbon alternatives imply additional investment of 30 billion US$ by 2030
- In **heating** for buildings and industry, the financial gap between hydrogen and natural gas plus the investments to build or repurpose the first gas pipeline networks for hydrogen amount to 17 billion US$ by 2030.

Need for policy alignment: level playing field to accelerate scale-up

Suggested are six ways that **governments** can level the playing field to support scaling-up:

- **National strategies** with national targets. 18 are already there across the globe.
- **Coordination**. Governments are well positioned as neutral conveners of industry stakeholders to mediate potential local investment opportunities.
- **Regulation**. Removing barriers that may exist to invest in the hydrogen economy today, e.g. by facilitating the process to obtain permits for new refuelling stations and developing internationally consistent regulation to limit market specificities.
- **Standardisation**. Supporting industry to coordinate national and international standards, e.g. around pressure levels and safety
- **Infrastructure**. Investing in the deployment of new infrastructure and re-use, where relevant, of existing networks (e.g. natural gas networks).
- **Incentives**. Applying incentives, e.g. tax breaks or subsidies to encourage the initial acceleration of hydrogen.

Need for demand creation: five enablers to establish a market

- **Reduce market uncertainty**. Stakeholders can look to already installed renewables for inspiration: (1) long-term offtake agreements removed market risk, leaving only technical risk. (2) shift to company-owned end-to-end zero-emission fleet logistics.
- **Focus on scaling applications and technologies that create the biggest ‘improvement-for-investment’**. Critical tipping points – after which costs fall sharply – are irrespective of any major technological breakthroughs. For example, scaling fuel cell production from 10,000 to 200,000 units can reduce unit costs by 45 %. Scaling up to 70 GW of electrolysis will lead to electrolyser costs of less than 400 US$/kW.

Report Demonstrates Hydrogen Competitiveness | worldwide (4/4)

Up to 50 % Cost Reduction by 2030 Achievable

- **Seek complementarity in hydrogen solutions (multiple use)**. For example, leveraging hydrogen airport heating, local industry feedstock and potentially in the future, airplane refuelling, will reduce the costs of each individual application.
- **Prioritise increasing utilisation rates in distribution networks**. Moving from 20 to 80 % utilisation rates in distribution and refuelling networks can reduce distribution costs by up to 70 %, which could, for instance, reduce the costs of hydrogen-based home heating by 20 %. This will require deploying a minimal threshold of infrastructure to ensure the network serves user demand.
- **Invest in low-carbon and renewable hydrogen production**. Low-cost hydrogen is among the top three cost reductions for every hydrogen application and will be the single most important factor to creating demand.

Hydrogen is already scaling up and considerable investments are being made globally. However, hydrogen's development still requires suitable financial, infrastructural and policy support to allow it to achieve a wide deployment and scale-up through commercial projects. Given the urgency of the global decarbonisation challenge, society must capitalise on hydrogen's advantages now. The hydrogen industry can help enable the energy transition to a net-zero world, and this report identifies the cost trajectories of its many applications, presenting numerous opportunities.

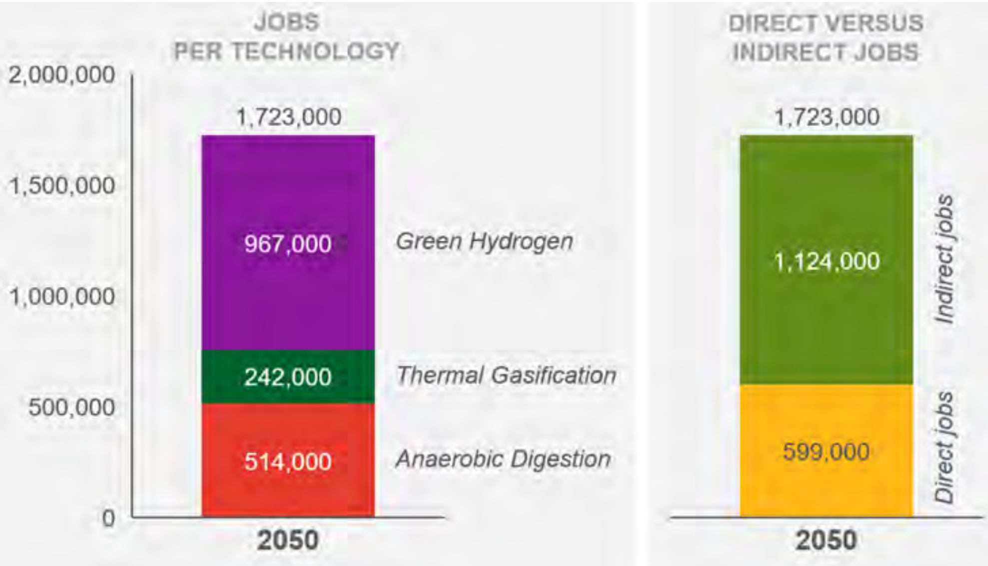
The Hydrogen Council wrote the report with analytical support from McKinsey and, for selected technical areas, E4tech. It was also reviewed by an independent advisory group comprised of recognised hydrogen and energy transition experts.

https://hydrogencouncil.com/wp-content/uploads/2020/01/Path-to-Hydrogen-Competitiveness_Full-Study-1.pdf

Gas for Climate Employment Study | Europe (1/2)

Job Creation by Scaling Up Renewable Gas in Europe

As promised with the previous newsletter, we introduce another publication of Gas for Climate – the employment study – released in November 2019. The study relies on the "optimised gas" scenario of the earlier publication "Gas for Climate" (see newsletter #24). The "optimised gas" scenario allocates 1,170 TWh/yr renewable methane and 1,710 TWh/yr hydrogen to the buildings, industry, transport, and power sectors in Europe by 2050.



Total Jobs | Jobs per Technology (left) and Direct vs. Indirect (right) (Source: study, page 11)

"The smart combination of renewable gases and electricity is essential in achieving the decarbonisation of the EU energy system. Decarbonisation will strengthen employment throughout the EU economy, bringing additional employment opportunities. These opportunities will shift to more local and high skilled jobs in both the energy sector and through the overall energy technology supply chain. Scaling up renewable gases […] is estimated to create ***600,000-850,000 additional direct jobs*** *and* ***1.1-1.5 million indirect jobs*** *by 2050."*

Gas for Climate Employment Study | Europe (2/2)

Job Creation by Scaling Up Renewable Gas in Europe

This report explores the possible employment effects of an EU-wide scale-up of renewable gas. It focuses on the employment effect from the supply of **biomethane** through anaerobic digestion and thermal gasification, and the supply of **hydrogen by electrolysis** using renewable electricity. Please see the diagram for lower bound values.

The employment opportunities result from investments in and operation of biomethane and hydrogen production facilities and include many rural jobs and high-skilled technical positions. Especially in rural areas where employment opportunities are scarce, collection of feedstock and operation of digesters create local jobs. High-skilled technical jobs are expected to emerge in sectors related to manufacturing, installation, and the operation of biomethane and green hydrogen plants, as well as in the renewable electricity generation sector to produce green hydrogen. **Most of these jobs are stable European jobs that cannot be outsourced or relocated.**

The employment factor (the number of jobs created per unit of energy produced) for **biomethane production through anaerobic digestions and thermal gasification** in 2050 is around 700–1,050 jobs/TWh. About two-thirds of the jobs are related to operation and maintenance of the plants, creating long-term employment opportunities. For **hydrogen**, the employment factor is lower than for biomethane, with about 575–775 jobs/TWh. This is due to the large share of electricity costs, which is predominantly in relation to capital investment.

The authors additionally expect, in the short term, increasing quantities of blue hydrogen (produced from natural gas in combination with carbon capture and storage [CCS]). This transition requires the retrofit of existing steam methane reforming plants with CCS units, also resulting in new employment opportunities because of R&D and technical implementation.

The study's focus is on the renewable gas supply chains only and does not estimate the net employment effects across the overall energy system. More job opportunities might be created on the demand side, for example, related to the refurbishment of buildings to enable the use of renewable gases.

Wouter Terlouw at wouter.terlouw@guidehouse.com http://bit.ly/2uKum2Y

HEAVENN - Hydrogen Valley with the Entire Hydrogen Chain in one Geographical Area | Netherlands (1/2)

HEAVENN stands for **H**$_2$ **E**nergy **A**pplications (in) **V**alley **E**nvironments (for) **N**orthern **N**etherlands and consists of 31 public and private parties from six European countries.

The Fuel Cell and Hydrogen Joint Undertaking (FCH-JU) designed the "Hydrogen Valley's" call, for which the Northern Netherlands under the lead of New Energy Coalition were rewarded with the HEAVENN proposal. The Hydrogen Valley's call is one of the largest grants the public-private partnership ever rewarded.

Last year, the region presented the Investment Agenda Hydrogen Northern Netherlands. This provided a strong foundation upon which the HEAVENN project is constructed. The aim of the Hydrogen Valley in the Northern Netherlands is to develop and operate a fully functioning green hydrogen value chain in the region. From large-scale production of green hydrogen to filling stations, buses, trucks and cars, as raw material for the industry and in the energy sector. With this project the Northern Netherlands want to become one of Europe's leading hydrogen regions.

The European Union has identified the Northern Netherlands as Hydrogen Valley, because sustainable energy sources (e.g. wind farms in the North Sea), generation, storage, transport as well as applications in industry and mobility are in close distance to each other.

HEAVENN - Hydrogen Valley with the Entire Hydrogen Chain in one Geographical Area | Netherlands (2/2)

The project comprises of four clusters:

1. Storage and infrastructure
2. H2 for industry
3. Heat and power
4. Green mobility

For the infrastructure, existing natural gas pipelines will be repurposed to transport green hydrogen. Additionally, new pipelines will be built at the Chemical Park in Delfzijl and between a hydrogen plant and the industry & business park in Emmen. The produced hydrogen should be stored at the hydrogen storage facility HyStock in Veendam.

Hydrogen as a feedstock for the industry will be used in Delfzijl and Emmen, where a chemical and an industry park are located. Hydrogen for heating for residential houses and municipal buildings will be applied in Hoogeveen and Groningen.

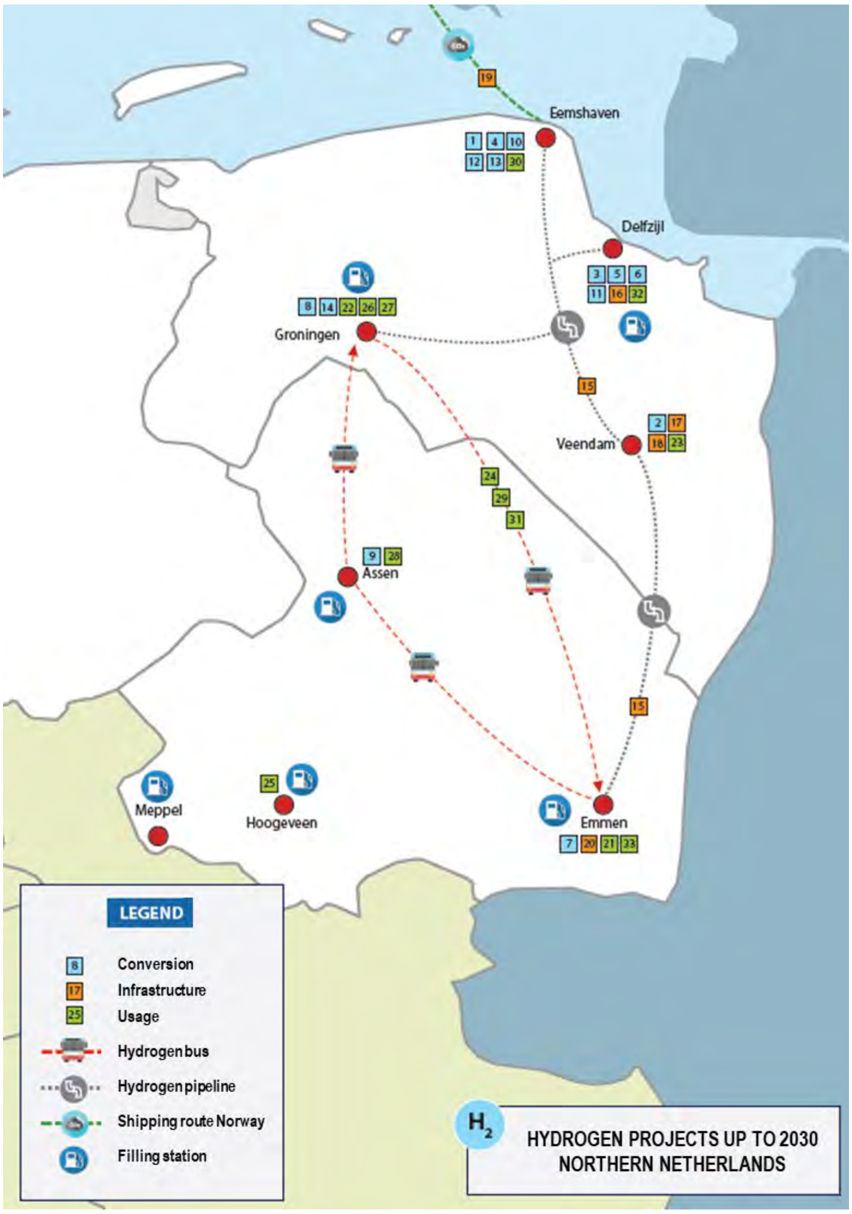
In the mobility sector, hydrogen will be used for buses, light and heavy-duty vehicles and cars. Filling stations for hydrogen are planned to be built in Groningen, Emmen and Pesse. One station is already operational in Delfzijl. Moreover, hydrogen will be used as fuel for an inland water vessel and to produce e-kerosene for aviation.

The project will set important implications for society and economy. For example, reducing greenhouse gas emissions improves air quality and health, and additionally creates a significant number of new jobs by transforming the energy system. This will contribute to the climate change objectives and strengthen the economic position of the Northern Netherlands.

Luuk Buit at l.buit@provinciegroningen.nl

Video: https://newenergycoalition.org/hydrogen-valley/

Press release: http://bit.ly/2UXUv90



Map of Locations in the Hydrogen Valley (Source: New Energy Coalition & FCH JU)

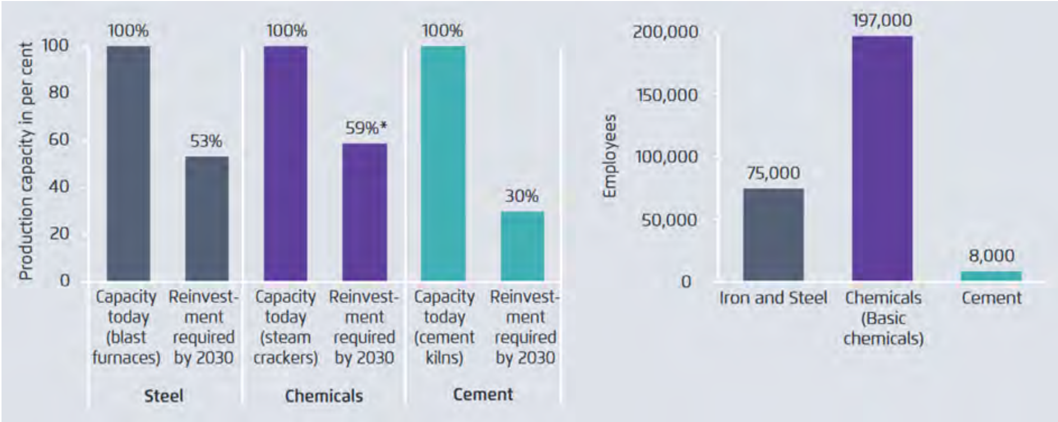
Subsidy: 20 million euros from the Fuel Cells and Hydrogen Joint Undertaking (FCH-JU) of the EU

Public-private cofinancing: 70 million euro

Duration: 2020 – end 2025

Partners: New Energy Coalition, Gasunie, QBuzz, Municipality of Groningen and Emmen, Nouryon, HyEnergy TransStore, and others

Study Calling for a Climate-Neutral Industry | Germany (1/2)



Reinvest Requirement by 2030 of Primary Production Capacities in the Steel, Chemical, and Cement Sectors (Source: Wuppertal Institute, study, page 8)

The study addresses the critical question: "How can the primary industry in Germany become climate-neutral by 2050 and at the same time keep their strong position in the international competitive environment?"

The authors focus on primary industry, such as steel production, chemical industry and cement production. The necessary technologies for a climate-neutral industry are already available - or close to market maturity. Green hydrogen plays a central role. The study includes a detailed analysis of 13 breakthrough technologies that will likely play a key role in achieving a climate-neutral primary industry.

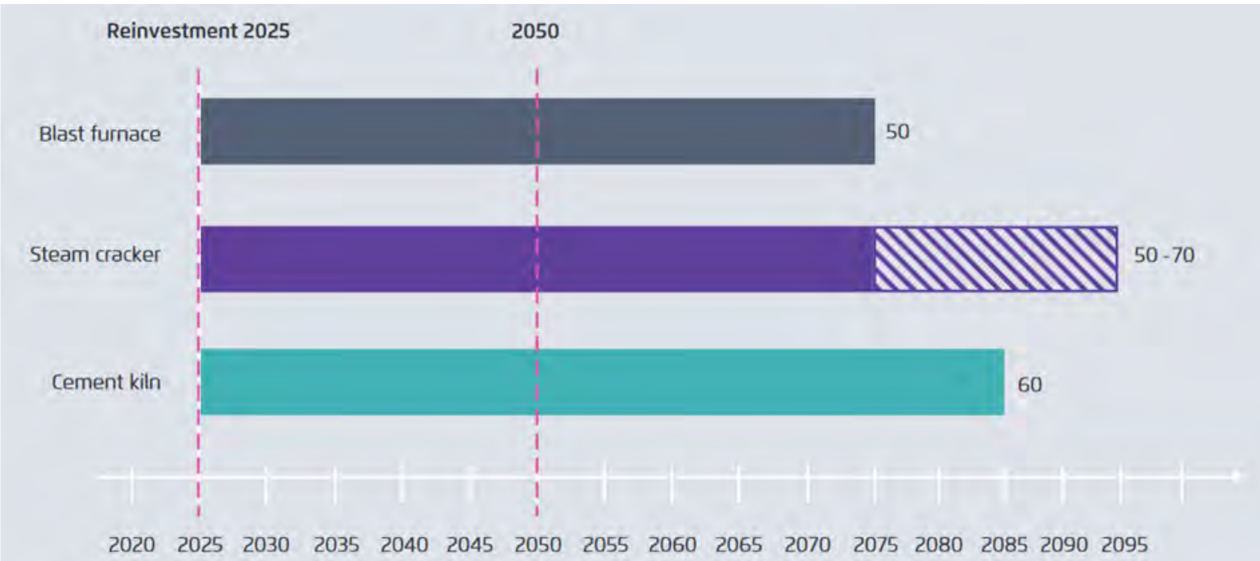
A new legal and political framework is essential because major reinvestments are due in this decade 2020-2030 (see figure above). Investing in conventional technologies may turn out as stranded assets due to technical lifespans of up to 50 to 70 years that would contradict the political goal of climate-neutrality by 2050 (see figure below). The situation is alarming.

A rational acting company needs to invest in climate-neutral technologies or foresee possibilities to retrofit them, but the current investment framework does not sufficiently support investing in advanced technologies. The authors strongly postulate a "climate-proof" framework for the industry.

One major pillar of the study is the extensive discourse with all relevant stakeholders. Numerous workshops were held between January 2019 and July 2019 on topics such as:

- sustainable steel production,
- the chemical industry of the future,
- the cement and building materials industry of the future, and
- year 2030 climate target achievement scenarios for the industrial sector.

These workshops were attended by numerous well-known industrial companies from the steel, chemical and cement sectors, their associations, the responsible federal ministries and subordinate authorities as well as trade unions and led to controversial debates at times.



Technical Lifetime of Selected Primary Production Plants with Reinvestment 2025 (Source: Wuppertal Institute. study, page 9)

Study Calling for a Climate-Neutral Industry | Germany (2/2)

Ten policy instruments that are intended to make key low-carbon (climate friendly) technologies available on a large scale as quickly as possible are discussed within the study (see table).

Policy Instrument	Description	Suitability
CO_2 minimum price with border adjustment regime	An increasing CO_2 minimum price is introduced in the EU ETS as a predictable price signal. In addition, CO_2-based levies will be levied on imports; exports to regions without a comparable CO_2 price will be compensated in the amount of the additional CO_2 costs.	
Carbon Contract for Difference (CfD)	When investing in key low-carbon technologies, companies receive project-related operating grants for avoided CO_2 emissions, thereby reducing risks. The amount of the subsidy is determined by auction, but in the future, it should be available to all companies.	+++ (pilot recommended)
green financing instruments	Financing costs for investments in low-carbon technologies are reduced by lowering loan interest rates for borrowed capital below the market level and/or by providing state guarantees for the risk of technology development in the final stages of development.	
climate surcharge on end products	To refinance other instruments, a charge is levied on selected materials (steel, plastic, aluminium and cement) - regardless of the CO_2 emissions of their manufacture.	+++ (to finance i.e. CfD)
Carbon price on end products	When products are sold to end consumers, a levy is charged based on the CO_2 content of the materials, which compensates for the cost disadvantage of low-carbon products. The proceeds can be used to refinance other instruments.	
green public procurement	The state and state-owned companies are required to apply high sustainability criteria in the construction (for example, of buildings, bridges and railways) and procurement of vehicles. This creates secure sales markets for sustainably produced basic materials and end products (especially steel, cement and vehicles).	+++ (to trigger the market demand)
quota for low-carbon materials	Producers of consumer goods are obliged to use fixed proportions of low-carbon materials in their end products, which guarantees companies secure sales markets for these materials.	
quota for green hydrogen	Green hydrogen will be made mandatory for natural gas traders to scale Power-to-X technologies for long-term decarbonization. Suggestion: 0.5 % in 2020 rising to 10 % in 2030; imports accepted.	+++
changes in construction and product standards	Regulations and standards will be fundamentally revised and continuously adapted to simplify material efficiency and substitution as well as the use of new construction materials (e.g. cement based on alternative binders) in construction.	
standards for recyclable products	Manufacturers are obliged to design products in such a way that recycling is simplified in order to close material cycles and to reduce CO_2-intensive primary production.	+++ (by adjusting the EU-Ecodesign Directive)

In the analysis, attention was paid to different sectoral conditions, development status of the technologies, interactions with other instruments, and legal and political implementation issues. This study did not investigate in detail the hydrogen tolerance of specific industrial end consumers. It simply states: a mandatory admixture of hydrogen into the natural gas grid is not recommended, since hydrogen will be used primarily in pure form in industry and heavy-duty traffic. The quota could be (virtually) fulfilled by buying and selling H_2-certificates regardless of the physical delivery of gas traders. The authors recognise that methane in pure form is required in many industrial processes and fluctuating gas qualities are problematic in many end applications. They nevertheless acknowledge the possibility to add hydrogen to the natural gas network.

in English: http://bit.ly/2OOo755 (executive summary)

in German: http://bit.ly/2UMuGsG (study), http://bit.ly/37xB360 (analysis), http://bit.ly/38tFmAv (legal study)

Selection of Appointments

March 2020

10-11 World Hydrogen Fuels Summit | Amsterdam, The Netherlands, *https://www.worldhydrogenfuels.com/*

10-12 Energy Storage Europe | Düsseldorf, Germany, *https://www.eseexpo.de/*

19 H2.0-Conference | Husum, Germany, *https://www.wattzweipunktnull.de/h20-konferenz/*

25-26 Hydrogen & Fuel Cells for Heavy Duty Transport Conference | Brussels, Belgium, *https://www.h2-transport.com/*

25-26 DBI-Fachforum Wasserstoff & Brennstoffzellen | Duisburg, Germany, *http://bit.ly/2Nde20O*

25-27 **Hydrogen Days 2020: "Hydrogen on the move"** | Prague, Czech Republic, *https://www.hydrogendays.cz/2020/*

April 2020

01-02 f-cell+HFC - The Hydrogen and Fuel Cell Event | Vancouver, Canada, *https://hyfcell.com/*

03 STORE&GO Parliamentary Evening Power-to-Gas | Brussels, Belgium, *www.storeandgo.info/*

07-08 European Zero Emission Bus Conference | Paris, France, *https://zeroemissionbusconference.eu/*

07-08 H2 VIEW Hydrogen Summit | Munich, Germany, *https://gasworldconferences.com/conference/hydrogen-summit-2020/*

20-24 Hydrogen + Fuel Cells EUROPE | Hannover, Germany, *https://www.h2fc-fair.com/*

June 2020

21-24 IAEE Conference | Paris, France, *https://iaee2020paris.org/*

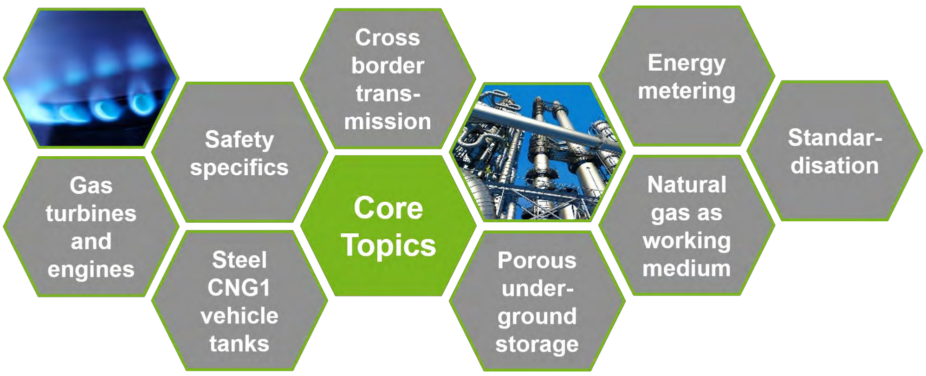
Current Partners

Alliander AG, Areva H_2Gen,
Cadent, DGC, DNV GL, Enagás,
Enbridge, Energinet.dk, ENGIE,
EWE Netz, Gas Connect Austria GmbH,
Gasnetz Hamburg, Gasum OY,
Gasunie, GRTgaz, GRZI e.V. (figawa),
Infraserv GmbH & Co. Höchst KG,
INERIS, innogy SE, ITM Power,
Joint Research Centre (JRC), EC,
KOGAS, NAFTA a.s,
Naturgy, ONTRAS, ÖVGW,
Open Grid Europe GmbH,
Polymer Consult Buchner GmbH,
RAG Rohöl-Aufsuchungs AG,
Shell, Solar Turbines Europe S.A.,
Storengy, SVGW,
Synergrid, Teréga, TNO,
Uniper Energy Storage GmbH,
Verband der Chemischen Industrie (VCI),
Volkswagen AG, Wintershall Dea AG.

HIPS-NET CORE TOPICS

We gather and disseminate the latest available knowledge to improve the understanding of hydrogen/natural gas blends in pipeline systems with emphasis on the core topics:

We additionally keep a minor focus on the general development of power-to-gas, hydrogen networks, and further topics around the utilisation of (renewable) hydrogen.



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Certified DIN EN ISO 9001:2015

HIPS-NET

"ESTABLISHING A PAN-EUROPEAN UNDERSTANDING OF ADMISSIBLE HYDROGEN CONCENTRATION IN THE NATURAL GAS GRID"

NEWSLETTER #26 | **APRIL, 2020**

Dear HIPS-NET Partners,

given the special circumstances worldwide — we hope this newsletter finds you well. We selected and summarised current developments, research, projects around

- H_2Ready heating appliances
- Upcoming field trial with 30 vol% hydrogen admixture
- Emissions of different hydrogen production
- further plans to install hydrogen production offshore
- steps towards future hydrogen storage in a salt caverns
- updates on the certification of low-carbon / green hydrogen

We are currently considering what is going to happen with our **annual meeting**. Will we meet online for presentations and exchange in June? Or will we postpone the HIPS-NET meeting for another date in Brussels? Shall we try to produce simple podcasts instead of the presentations with the speakers? Or any other idea, we did not think of, yet? How important is the networking opportunity? And how important the information shared in the annual meeting?

Although, we would like to meet you all in the beginning of June in Brussels as scheduled, we doubt at the moment that this will be possible (appropriate). Your feedback would help us to find the best way forward and is very much appreciated.

Laughing and smiling belongs to one of the best medicines in the world. May it be a regular part of your days!

We hope you enjoy reading!

Your HIPS-NET Team

Gert, Anja, and Josephine

CONTENT

CONTENT NEWSLETTER #26

H2Ready - Laboratory Tests of Existing Heating Appliances | Germany (1/2)

In laboratory experiments, DBI tested the hydrogen tolerance of domestic gas appliances. The aim was to investigate under real conditions the influence of hydrogen admixtures of up to 40 vol% on existing systems. In particular, fluctuating injection of hydrogen were analysed.

First, they tested the appliances when running at fixed admixtures of 10, 20, 30, and 40 vol% hydrogen. Afterwards, the devices were operated with different, volatile (fluctuating) hydrogen concentrations. The test gas is Russian H-gas, a methane-rich gas, which is very similar to the German standard test gas.

Increasing hydrogen concentrations have an impact on various gas characteristics; the table shows a selection. The analysis also revealed, each appliance has an individual set of parameters due to different nozzle geometries, pipe diameter and air supply.

2. Gas Engine (20 kWel)

Current tests show a suitability of gas engines (CHP) for up to 40 vol% hydrogen in natural gas. Besides an increase in NOx, an increasing knocking behaviour can be observed. This is related to the decreasing methane number (recommended range of devices 75 - 80). In principle, natural gas engines can be converted to high maximum hydrogen quantities by adjusting ignition timing and lambda control. The upper heating value increases by approx. 5 vol% when the hydrogen content increases. Due to the increased heating output, the electric efficiency drops slightly (by approx. 1.5 %). The engine works appropriately up to 10 vol% hydrogen without technical adaptations. After adjusting ignition time and lambda control, the tested engine regulates the burning process automatically up to 40 vol% as the diagram on the next page shows. The adaptations at the CHP are ‘only’ necessary to decrease NOx emissions to the permitted level and do not have any impact on safe operations.

The noise increases with rising hydrogen content (see table below). At first, the noise drops at 10 vol% by 1 dB(A) but rises by about 2-3 dB(A) at 40 vol%.

Fluctuating hydrogen concentrations affect the energy conversion efficiency, especially if the hydrogen content changes rapidly (see diagram next page). Upon minor change rates, the engine regulates the efficiency and fuel-air ratio smoothly

Thermodynamic Calculations with CHEMCAD

mixture natural gas / hydrogen [vol%]	100/0	99/1	98/2	95/5	90/10	75/25	50/50	0/100
hydrogen share [vol%]	0	1	2	5	10	25	50	100
lower heating value [MJ/m³]	36.61	36.36	36.11	35.36	34.12	30.38	24.16	11.74
fuel-air ratio [m³/m³]	9.53	9.46	9.39	9.18	8.82	7.74	5.95	2.38
alteration of lower heating value [%]	0.00	1	1	3	7	17	34	68
flame velocity [cm/s]	38.39	38.63	38.87	39.64	40.92	45.95	60.06	200
ignition delay [ms]	46.16	41.01	36.48	25.95	15.367	4.296	0.933	0.0461

Source: DBI

1. Condensing Boilers

The condensing boiler with forced-air burner (20 kW_{th}) and the one with matrix burner (100 kW_{th}) performed without increasing emissions or efficiency losses up to 15 vol% hydrogen. Due to the higher shares of water vapour in the exhaust gas, the efficiency slightly increases. With 25-40 vol% hydrogen, noise emissions went up by 3 dB(A). The flames did not strike back until 40 vol%. Even without the testing here, the operation is known to be safe until a concentration of 23 vol% hydrogen. Why? According to DIN EN 437, appliances need to prove, before they are legally permitted to the market (market approval), that the flames do not strike back with a test gas containing 23 vol% hydrogen. This standard applies for all appliances which received market approval since 2000.

Results of noise level measurement at CHP with different hydrogen concentrations

hydrogen concentration [vol%]	0	10	20	30	40
noise level front side [dB(A)]	55	54	55	56	57.3
noise level left side (gas supply) [dB(A)]	59	58	60	60.5	62.4
noise level right side [dB(A)]	54	54.5	54.5	54.8	56

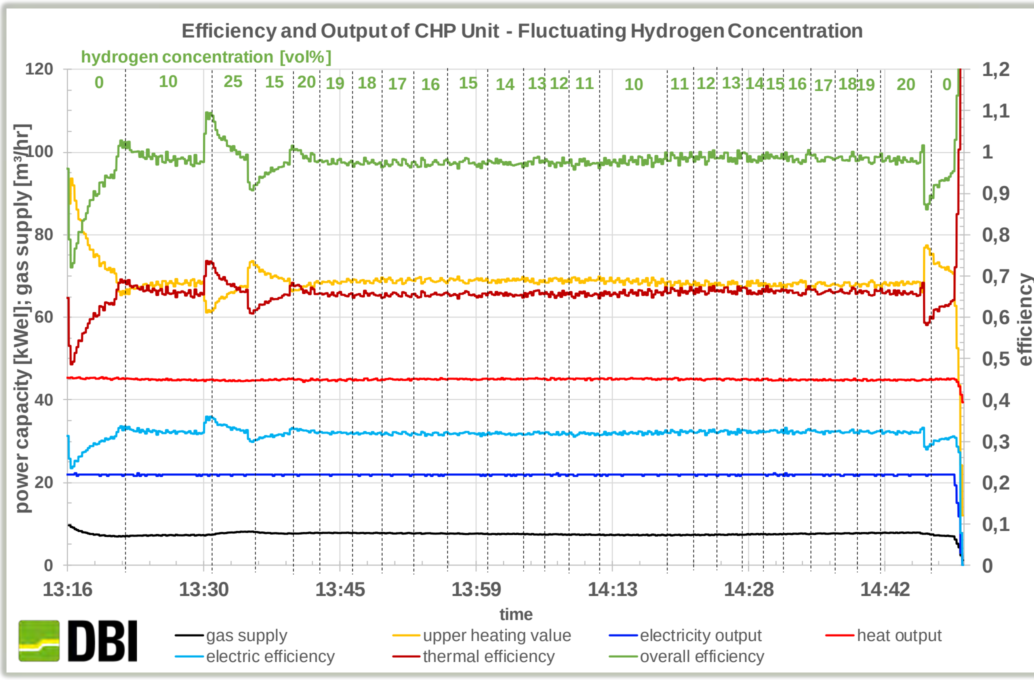
Source: DBI

H2Ready - Laboratory Tests of Existing Heating Installations | Germany (2/2)

Summary

The tests did not identify any safety-related issues upon hydrogen admixture up to 40 vol%. The investigations revealed that each tested unit relies on different control strategies:

- neither compensation of power/heat output nor air ratio (condensing boiler 20 kW_{el})
- with compensation of power/heat output but without compensation of air ratio (condensing boiler 100 kW_{el})
- with compensation of power/heat output and air ratio (CHP 20 kW_{el})



The different technical control strategies influence the hydrogen tolerance of the appliances and further tests are recommended to gain a clearer picture. The exhaust gas measurements proof decreasing CO_2 emissions which supports decarbonisation intentions.

For further reading: We described the impact on security parameters detailed in newsletter #11 (Sept 2016).

Philipp Pietsch at
philipp.pietsch@dbi-gruppe.de

https://bit.ly/2VBjmOY
(German only)

30 vol% Hydrogen Admixture Field Trial | Germany (1/2)

The gas network operator in the south of Germany, Netze BW, will prove: "*Our natural gas distribution network can transport a natural gas-hydrogen mixture. The gas supply will remain for the consumer just as conveniently as pure natural gas today. For the first time in Germany, a gas mixture with a hydrogen content of up to 30 percent in real network operation will be used*".

In a local area, the hydrogen share in the natural gas network is gradually increased to up to 30 vol%.

Content | Central Questions of the Project

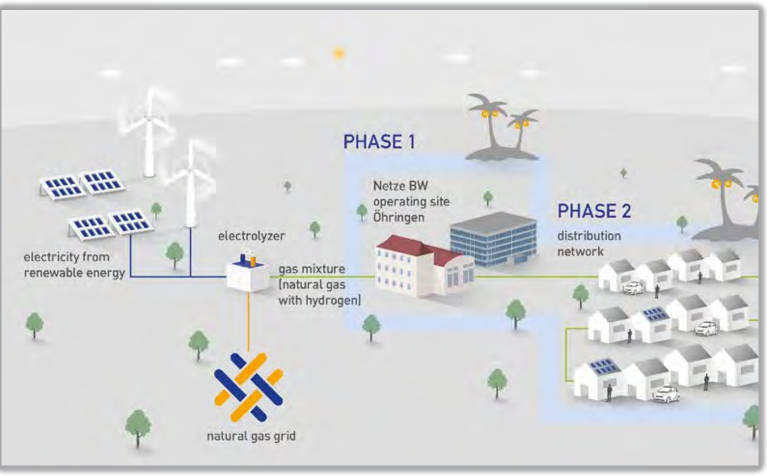
- What share of H_2 can be mixed in a natural gas network and operate permanently and stable to guarantee a secure supply?
- How to equip and convert a natural gas distribution network for increasing proportions of hydrogen?
- Demonstrating and verifying a mixed gas supply in a real overall system (distribution network and customer appliances).

Goal of the Project

- injection and transport of gas mixtures in the existing gas distribution network
- metering, billing, materials, network operation, safety engineering
- customer acceptance
- safe and stable operation
- developing a strategy for a future network operation with increasing hydrogen shares

The test phase of the multi-year project is planned to start at the end of 2020 within the own property of Netze BW. The testing will then be extended to neighbouring streets

30 vol% Hydrogen Admixture Field Trial | Germany (2/2)



Project Sketch (Source: Netze BW)

and houses. The selected section of the natural gas network will be decoupled from the surrounding supply infrastructure and operated as a so-called island network ("Hydrogen Island"). The hydrogen required for this is generated using a climate-friendly electrolyser. Changing hydrogen concentrations – fluctuations – are not considered within the project. The decisive question for Netze BW is not whether, but **how** everything works. Before the "hydrogen island" could become a comprehensive solution in the future, the technical framework and regulatory conditions need adaptions. Netze BW expects to gain important insights. The project started 2019 and will run until December 2022.

Dr. Heike Grüner at h.gruener@netze-bw.de

https://bit.ly/2KiE1li

Greenpeace Report on Limited Emission Reduction by Blue Hydrogen | Germany, Europe (1/2)

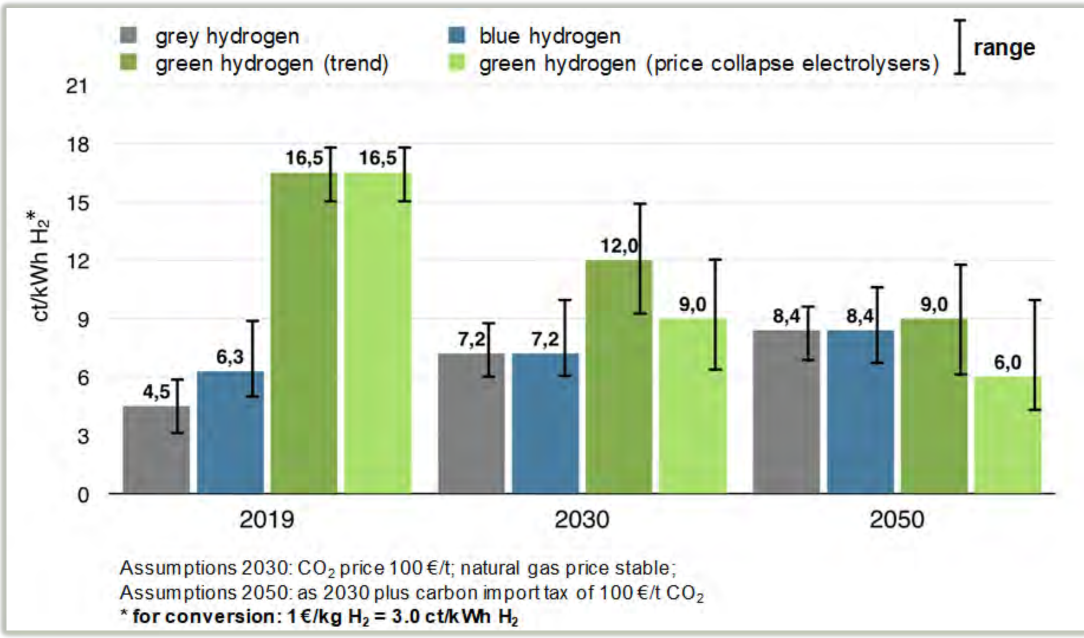
'Blue hydrogen' has a carbon footprint of 143 $g_{CO2/kWh}$ and is not suitable to support German climate targets. With these clear words, Greenpeace Energy sends an alert to decision makers in the recently released study. The author acknowledges that green hydrogen is an effective decarbonisation strategy and can support regenerative electrification.

Let's check the definitions first. The World Energy Outlook 2019 defines **low-carbon hydrogen** and includes production by:

1. electrolysis using low-carbon electricity, (also called 'green' hydrogen), or
2. from the gasification of biomass (also called 'green' hydrogen), or
3. from **natural gas** equipped **with CCUS** (also called **'blue' hydrogen**) or,
4. potentially, through "methane splitting" meaning **methane pyrolysis** (also called **'blue' hydrogen**)

Greenpeace Energy's report from January 2020 considers the production of blue hydrogen (only) when hydrogen is produced with natural gas and the CO_2 is captured with CCS.

Another production path - methane pyrolysis - is mentioned, but is not analysed since it is still in an early stage of technical maturity.



Hydrogen Production: Costs and Cost Trends (Source: EnergyComment, report p. 8)

Greenpeace Report on Limited Emission Reduction by Blue Hydrogen | Germany, Europe (2/2)

'Blue hydrogen' may be produced via two paths, first using a **steam reformer (SMR)** und second using **autothermal reforming (ATR)**. Autothermal reforming is not as common and technically more complex than steam reforming but separating CO_2 is easier and higher deposition rates are likely. You may see the difference in the mean emission values in the diagram below.

Central numbers for the greenhouse gas emissions (including upstream emissions) in the report are (average values):

26 g_{CO2}/kWh_{LCV} for green hydrogen (electrolysis + **renewable** electricity)

691 g_{CO2}/kWh_{LCV} for hydrogen production via electrolysis but using the **current German electricity mix**

143 g_{CO2}/kWh_{LCV} for blue hydrogen (natural gas + CCS) in **modern** plants (ATR)

218 g_{CO2}/kWh_{LCV} for blue hydrogen (natural gas + CCS) in **retrofitted** plants (SMR)

398 g_{CO2}/kWh_{LCV} for grey hydrogen with steam reforming

The carbon footprint of blue hydrogen is too high to achieve climate goals. Around 25 % of the total emissions are generated by upstream emissions of natural gas before it even reaches the hydrogen production plant.

Further, hydrogen production generates significant emissions although the CO_2 is captured (see diagram).

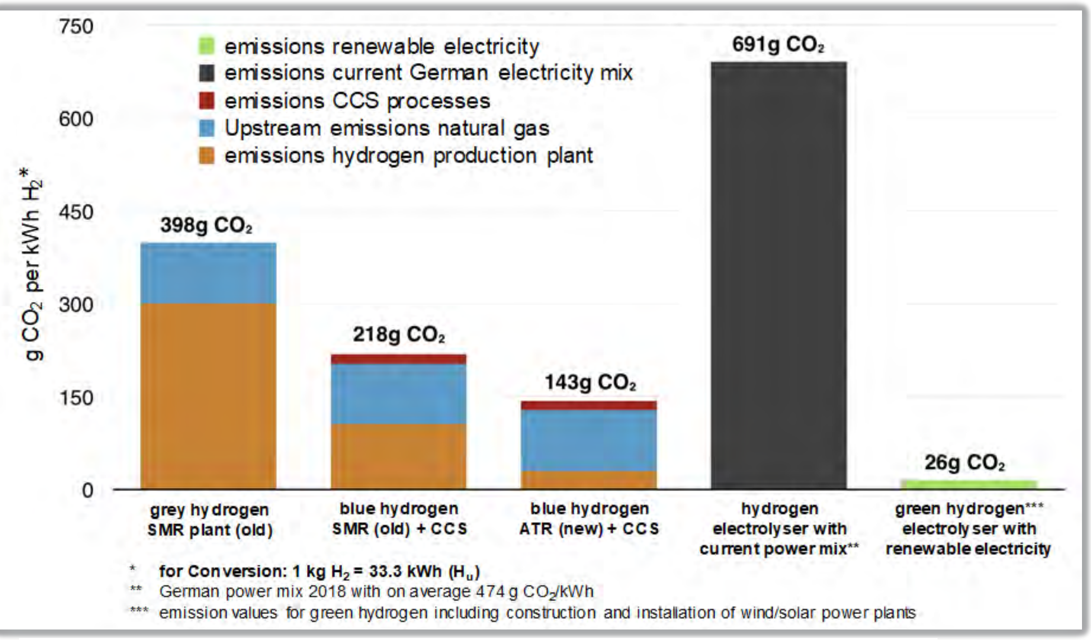
Blue hydrogen shows a clear cost advantage, the average production costs are 6.3 ct/kWh_{H2}, while green hydrogen costs 16.5 ct/kWh_{H2}. Green hydrogen has more than two times higher production costs. However, projects for blue hydrogen show risks:

- cost risks: Natural gas prices, CO_2 prices and CCS prices are difficult to calculate for the long term.
- project risks: The development of a nationwide CO_2 infrastructure might likely cause public resistance.
- capacity risks: CCS is only an interim solution because the storage possibilities for CO_2 are limited. High-quality storages would be exhausted after only a few decades.

The author expects that the production costs for green hydrogen will align with blue hydrogen in early 2030. In 2050, green hydrogen at 6-9 ct/kWh is likely to outstrip blue hydrogen (8.4 ct/kWh) at many sites.

The import of hydrogen, e.g. from North Africa or the Persian Gulf, is not likely to be cheaper and is associated with additional risks.

The report was paid by Greenpeace Energy and written by EnergyComment. It is a literature review and names its various sources well. Since the topic blue hydrogen is still fairly new and has not been subject to many research projects yet, we can recommend further reading.



Greenhouse Gas Emissions of Hydrogen Production (Source: EnergyComment, report p. 11)

Dr Steffen Bukold at
bukold@energycomment.de

https://bit.ly/2wP9E2V (in German)

PosHYdon - Offshore Production of Green Hydrogen | Netherlands

Q13a - A Unique Electric Powered Platform (Source: Neptune Energy)

The Dutch climate agreement aims for a 95 % reduction in CO_2 emissions by 2050. A way to reduce these emissions is to create a new, flexible and integrated energy system. This is the aim of the North Sea Energy program – a public-private research consortium of more than 30 parties from or related to the energy sector collaborating to develop the North Sea as a clean source of energy for North West Europe. One of the options studied is hydrogen production from offshore wind and transport of hydrogen via existing pipelines to shore.

The North Sea is the first place in the world where a pilot project to build an offshore hydrogen plant is planned. This PosHYdon project will produce green hydrogen from renewable electricity fed into the platform. During the first test phase, the fluctuations in offshore wind production will be simulated. While currently powered by a subsea cable providing green electricity from shore, the platform can be directly powered by offshore wind in the future.

The sea water will be pumped on the oil and gas platform and desalinised with a reverse osmosis (RO) unit to be converted into demineralised water. This water is used in the electrolyser which is placed in a 40 inch (12 meter) sea container on the platform. The green hydrogen is blended into the oil and gas export line and transported to land via the existing gas infrastructure, which has more than enough capacity.

The PosHYdon project is a follow-up of the 3P2Go project (Pre-Project Power2Gas Offshore) executed by TNO, Nexstep and 4 operators, which consisted of a screening and feasibility analysis for offshore green hydrogen production.

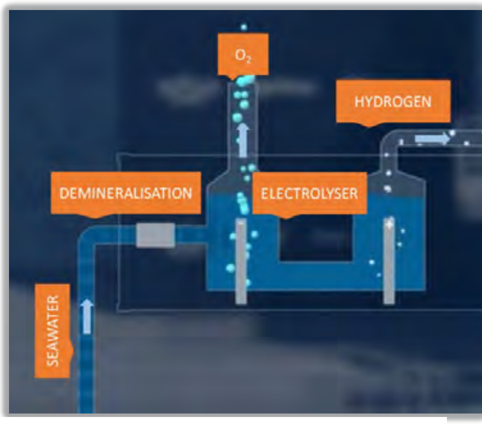
Neptune Energy's Q13a oil and gas platform was identified as the most suitable location for implementation. This is located 13 km from the coast of Scheveningen and it is the first fully electrified oil and gas platform in the Dutch North Sea. TNO devised the concept and will be carrying out the test programme. The conditions for the offshore production of green hydrogen are very different to the onshore conditions: long distances, saltwater, strong winds, higher wear, higher installation costs and more expensive maintenance.

This pilot project for the offshore production of green hydrogen brings many advantages:

- Wind energy can be transported from sea to land without investing into expensive cables or other power infrastructure (cost advantages for transport and storage of wind energy)
- Second life for old platforms because there is a new business model (many reached the end of their life cycle and would otherwise have to be demolished).
- Enables long term North Sea offshore gas production with zero emission platforms
- Electrolyser manufacturer can develop a new generation of electrolysers especially for the use at sea
- Intermittent wind power can be stored and balanced by means of hydrogen
- H_2 can be used as fuel gas on other nearby platforms

The platform currently handles 4,000 barrel oil per day and 40,000 m³ natural gas per day.

The pilot project also creates environmental benefits: for every 1 kg of sustainably produced hydrogen, 10 kg of CO_2 are saved, compared to hydrogen produced from natural gas via steam reforming.



Sketch of Off-Shore Hydrogen Production (Source: video)

Partners: Neptune Energy, Nexstep, TNO, EBN and operators NAM, TAQA Energy and Total

Timeline: start-up 2021, pilot testing until end 2023

Estimated costs: 12 mln EUR incl. EU and national subsidies

René Peters at rene.peters@tno.nl https://bit.ly/34KzPEB (video, Engl. subtitle)

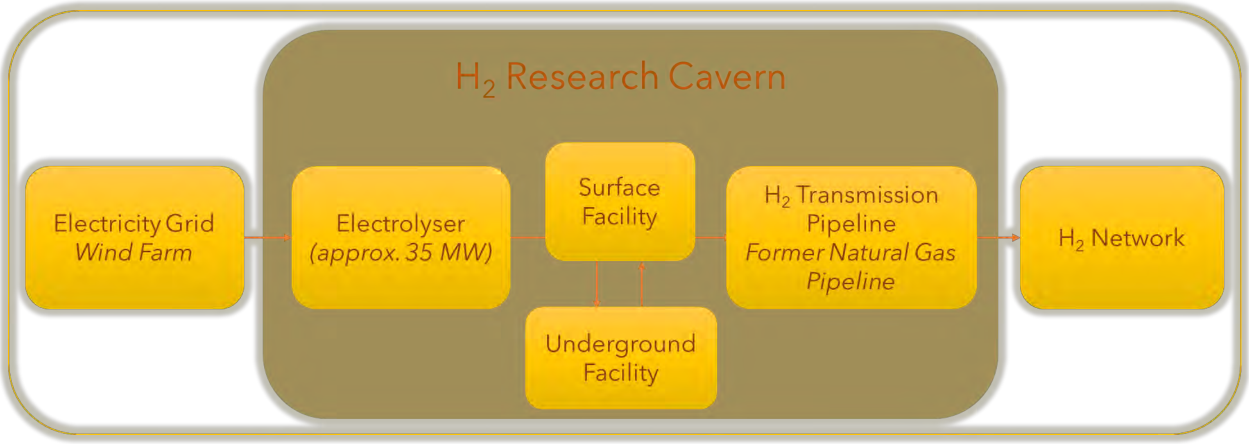
Preparations of Storing Hydrogen in a Salt Cavern | Germany

Salt caverns are currently used for natural gas storage. The storage of hydrogen is still subject to several technical and operational preconditions and challenges.

The project “H_2-Forschungskaverne” translates as “H_2 Research Cavern” is phase 1 on the way to develop the world's largest hydrogen filled salt cavern at the Bad Lauchstädt site of VNG Gasspeicher GmbH (VGS). The aim of phase 1 is to gain the official permit for the underground gas storage incl. above ground plant and rededication of an existing natural gas transmission pipeline. Furthermore, the project will develop and define the system concept as well as process the approval planning for future field-research operations. This project is scientifically based on the H_2-UGS project (see 18th newsletter in October 2018); both are funded under the roof of the HYPOS initiative.

Technical details H_2 storage

The chosen underground salt cavern has a storage volume of 65 million m³. The H_2 cushion gas volume is about 15 million m³ and the working gas volume is about 50 million m³. It works at pressures between 30 to 140 bar(g). The above ground storage facility allows for a maximum feed-in and exit rate of approx. 11.000 m³/h. The installed measuring section for volumetric and gas analytic detection will be designed for bidirectional operation. Additionally, the system works with a two-stage reciprocating compressor and a gas purification, which guarantees a gas purity on 99,96 %.



Simplified Project Sketch (Source: DBI)

The research project “H_2-Forschungskaverne” includes the following tasks:

- developing different economic concepts; evaluating and deciding for a future business model
- drafting a rough basic engineering (for approval submission) including equipment and operating technologies for
  - ⇒ large-scale electrolysis (approximately 35 MW_{el})
  - ⇒ H_2 storage in an underground salt cavern and developing the above ground storage facility
  - ⇒ H_2 transport in an existing natural gas transmission pipeline
- developing, preparing and submitting of approval documents to file a request for official approval
- assisting the authorities during the official approval process e.g. answering questions or public hearings and adjusting documents

Technical details H_2 transport

The H_2 storage cavern is connected to ONTRAS’ natural gas pipeline, which is to be repurposed. The pipeline has a length of approximately 20 km (DN500) and the scoped operating pressure for H_2 is 30 bar(g). It leads to the H_2 pipeline of central Germany’s chemistry triangle (150 km).

Duration: 2 years, May 2019 until mid-2021

Partners: DBI, VGS, ONTRAS, Fraunhofer IMWS, IfG

Funding: German Federal Ministry for Education and (BMBF) within the HYPOS initiative

zwanzig20 Partnerschaft für Innovation

Sponsored by the Federal Ministry of Education and Research

Marco Henel at marco.henel@dbi-gruppe.de https://bit.ly/3bn4pGW

CertifHy - Certifying the Carbon Footprint of Hydrogen in Dual Certification System until 2021 | Europe (1/2)

The application areas of hydrogen vary widely – as common feedstock in the chemical industry and refining processes, as future long-term storage for renewable electricity, gas supply for heating, cooking etc. or as fuel in fuel cell electric mobility. The demand of hydrogen is expected to increase in the future. The production of hydrogen, though, causes different amounts CO_2 emissions. To abate emissions, the origin of hydrogen from renewable and low carbon energy sources, so called “premium hydrogen”, is important for end-users. A Guarantee of Origin can proof the carbon footprint of hydrogen transparently and comprehensively. Accordingly, in 2014 a consortium of European companies, research centres and a broad set of European and global stakeholders initiated the project “CertifHy – Designing the 1st EU-wide green and low-carbon certification system". The partners developed a European-wide Guarantee of Origin (GO) for hydrogen.

CertifHy 1

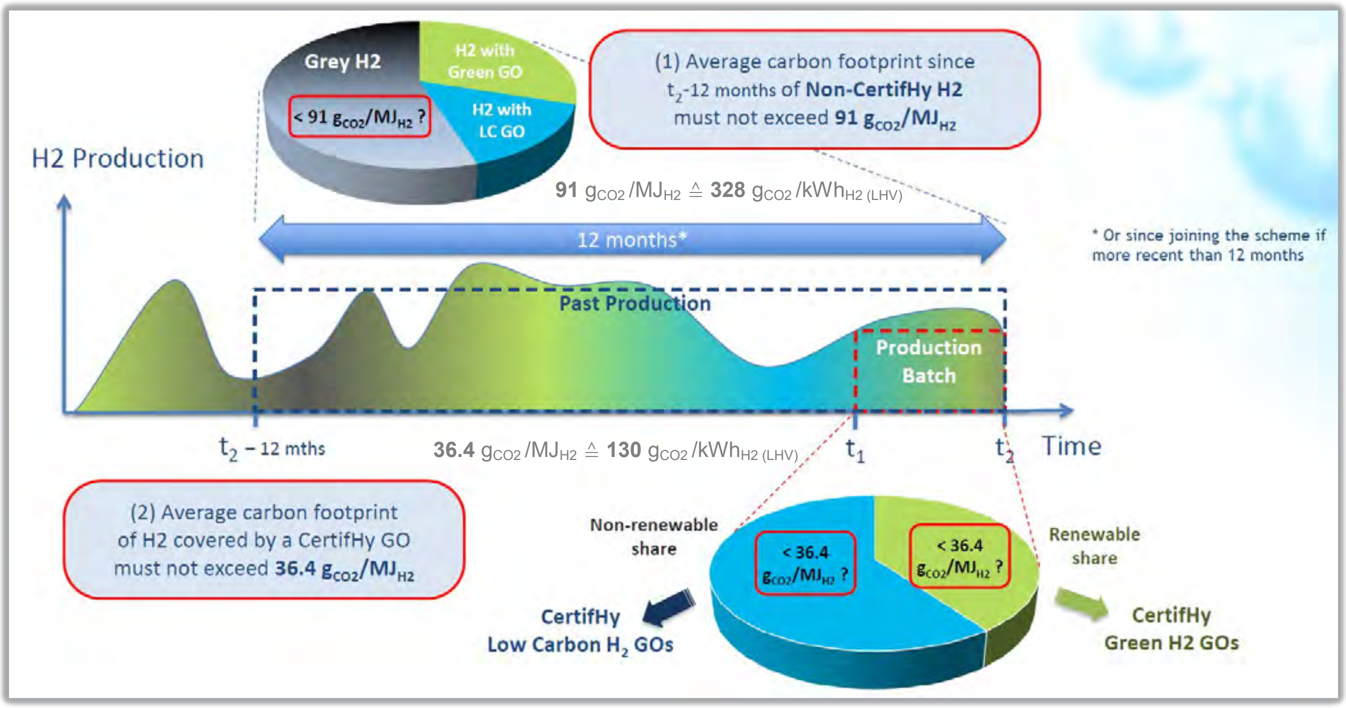
The first project phase (2014 to 2016) defined definitions for “green” and “low-carbon” hydrogen and determined how to design and implement a robust EU-wide GO scheme. The figure presents a decision tree for green and low-carbon hydrogen which can be used to check the compliance of a project with the CertifHy criteria. See HIPS-NET newsletter #10 and #13 for results of project phase 1. Afterwards, two further phases were initiated.

CertifHy 2

The second project phase (October 2017 to March 2019) prepared the implementation of an EU-wide GO scheme for green and low-carbon hydrogen. The partners tested the CertifHy-system in a pilot and identified open issues. Four hydrogen producers (Air Liquide, Nouryon/ Air Products, Colruyt Group, Uniper) with different production pathways lead to the issuance of GOs to the market. The pilot covered the complete certification life cycle of the GO scheme, including auditing hydrogen production plants, certification of respective hydrogen production batches and the issuance, trade and usage of certificates. The three important components of the second CertifHy project are:

1. Set up and run a pilot GO scheme in order to gain practical experience and lessons learned for a large-scale EU-wide scheme.
2. Establish a well-functioning Stakeholder platform, acting as a governance framework.
3. Ensure compatibility with EU legislation, in part. RED II.

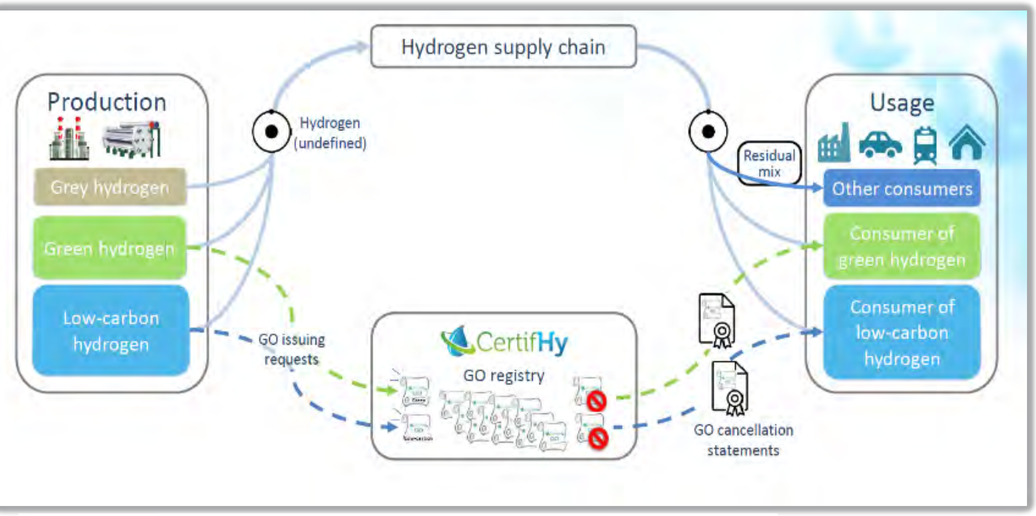
The results of the pilot were incorporated to the final system. Finally, more than 75.000 GOs for green and low-carbon hydrogen were included into the register. The first GOs were issued in December 2018. In March 2019 already ten organisations have been registered as account holders in the registry service. The first commercial transactions have been publicly announced by H2Mobility Germany.



Criteria for Grey, Green or Low-Carbon H_2 (Source: Hinico)

CertifHy - Certifying the Carbon Footprint of Hydrogen in Dual Certification System until 2021 | Europe (2/2)

The figure shows the process of certifying hydrogen. A central registry has the authority to issue, transfer and cancel the GOs. The GO is cancelled upon use, so that it may only be used once for claiming hydrogen consumed as green or low-carbon hydrogen. Hydrogen without a GO is classified as hydrogen from the “residual mix” in the figure. The provided electronic cancellation statement includes a link for online access to the full GO content.



CertifHy Process (Source: CertifHy)

CertifHy 3

The overarching ambition for the next CertifHy phase is to create an EU-wide CertifHy Certification System that covers both GOs and Certificates. Guarantees of Origin will be used for disclosure of the origin of hydrogen to end-users (voluntary market), whereas Certificates will be used to document the compliance of EU-wide and/or national requirements to state authorities and participants in the supply chain. Phase 3 further aims to provide a Central European issuing body and registry, which is capable of interfacing with

The partners foster continuation and will keep pilot plants and pilot schemes running as this is already working. The pilot plants should continue operating and keep issuing GOs during the third phase of CertifHy, at least initially, until the scheme is formally implemented. More importantly, the pilot scheme functionality should be expanded to operate as a voluntary scheme for demonstrating compliance with targets on the share of renewables in transport or heating and cooling, following the specific requirements that are applicable in that case.

It further needs a final agreement on the methods for the allocation of GHG to the hydrogen produced. At the moment, there is no consensus on the footprint calculation method for hydrogen with CO_2 capture, due to differing views on how to handle carbon capture and utilisation. This discussion will need to be extended to a wider group of stakeholders.

It was announced that the third project phase will run from 2019 to 2021. But phase 3 has not been allocated by the EU yet.

With the GO-system, green hydrogen and low-carbon hydrogen certification becomes available across the EU independently from the site of its production. With acquisition of CertifHy GOs and/or Certificates consumers can use renewable energies for their processes and improve their greenhouse gas balance.

Matthias Altmann at Matthias.Altmann@lbst.de https://bit.ly/2Vng1E1

Certification of ‘GreenHydrogen’ by TÜV SÜD | Germany

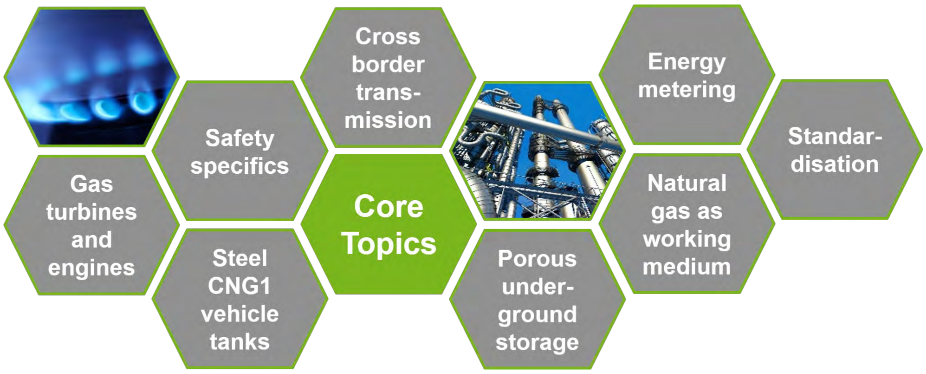
Besides auditing for the CertifHy-System, TÜV SÜD certifies additionally according to its own ’GreenHydrogen’ Standard. Certain findings from the CertifHy project have been incorporated into the revision of TÜV SÜDs standard. One megawatt certified ‘GreenHydrogen’ is comparable to one CertifHy Guarantee of Origin. TÜV SÜD only certifies green hydrogen (definition by CertifHy) – low carbon hydrogen cannot be certified according to TÜV SÜD standard. Regarding the permissible hydrogen generation technologies, TÜV SÜDs ‘GreenHydrogen’ corresponds to the CertifHy technologies for green hydrogen. According to the TÜV, there are only a few completed certifications, and a few are in process. But the demand in this sector is increasing.

Dr Thomas Oberst at thomas.oberst@tuev-sued.de https://bit.ly/3eAbQfQ

HIPS-NET CORE TOPICS

We gather and disseminate the latest available knowledge to improve the understanding of hydrogen/natural gas blends in pipeline systems with emphasis on the core topics:

We additionally keep a minor focus on the general development of power-to-gas, hydrogen networks, and further topics around the utilisation of (renewable) hydrogen.



EVENTS AND PARTNERS

Selection of Appointments

May 2020

19-20 Renpower H_2 Sub-Sahara Africa| online conference, *https://euroconventionglobal.com/event/renpower-h2-sub-saharan-africa/*

June 2020

09 DBI-Workshop Wasserstoff | Freiberg, Germany, *https://www.dbi-gti.de/termine/dbi-workshop-wasserstoff.html*

22-24 8th Workshop on Ion Exchange Membranes for Energy Applications - Fuel Cells + Electrolysers + Flow Batteries | Bad Zwischenahn, Germany, *https://emea-workshop.de/*

22-26 EU Sustainable Energy Week (EUSEW) | Brussels, Belgium, *https://www.eusew.eu/*

September 2020

09-10 f-cell+HFC - The Hydrogen and Fuel Cell Event | Vancouver, Canada, *https://hyfcell.com/*

15-16 DBI-Fachforum Energiespeicher 2020| Berlin, Germany, *https://www.dbi-gti.de/termine/dbi-fachforum-energiespeicher-2020.html*

22-23 World Hydrogen Congress| Paris, France, *www.worldhydrogencongress.com/*

29-30 f-cell 2020 | Stuttgart, Germany, *https://f-cell.de/*

October 2020

08-09 Hydrogen Online Conference | online conference, *https://hydrogen-online-conference.com/*

20-23 14th European SOFC & SOE Forum | Lucerne, Switzerland, *www.efcf.com/2020*

November 2020

03-04 6th HYPOS-Forum| Dresden, Germany, *http://www.hypos-eastgermany.de/*

04-06 European Hydrogen Energy Conference | Madrid, Spain, *http://ehec.info/*

Current Partners

Alliander AG, Areva H_2Gen,
Cadent, DGC, DNV GL, Enagás,
Enbridge, Energinet.dk, ENGIE,
EWE Netz, Gas Connect Austria GmbH,
Gasnetz Hamburg, Gasum OY,
Gasunie, GRTgaz, GRZI e.V. (FIGAWA),
Infraserv GmbH & Co. Höchst KG,
INERIS, innogy SE, ITM Power,
Joint Research Centre (JRC), EC,
KOGAS, NAFTA a.s,
Naturgy, ONTRAS, ÖVGW,
Open Grid Europe GmbH,
Polymer Consult Buchner GmbH,
RAG Rohöl-Aufsuchungs AG,
Shell, Solar Turbines Europe S.A.,
Storengy, SVGW,
Synergrid, Teréga, TNO,
Uniper Energy Storage GmbH,
Verband der Chemischen Industrie (VCI),
Volkswagen AG, Wintershall Dea AG.

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Certified DIN EN ISO 9001:2015

HIPS-NET

"Establishing a pan-European understanding of admissible hydrogen concentration in the natural gas grid"

NEWSLETTER #27 | **June, 2020**

Dear HIPS-NET Partners,

the volume of power-to-gas projects worldwide has **tripled in the last five months** (as of March 2020), Wood Mackenzie claims. The consultants identified power-to-gas projects with a total capacity of 8.2 GW_{el} worldwide. The 17 largest projects, each with at least 100 MW_{el}, are planned in Europe, Australia, Paraguay and the USA. Although, the rapid increase in the figures is also likely to include the visionary, albeit very long-term plans. source/

The studies around hydrogen are popping up faster than we can sometimes summarise them. The newsletter happens to be longer than intended because we did not want to withhold recent information. The 27th edition includes articles, which introduce

- 5 years' experience of hydrogen admixture with 10 vol% in a gas distribution network
- Laboratory results on the hydrogen tolerance of appliances
- Two studies pushing the market scale up of hydrogen
- National Hydrogen Strategy of Germany
- Information about the hydrogen tolerance and its integration in the Netherlands
- And last but not least a brief introduction of the recently started THyGA project

We hope you find interesting information and enjoy reading.

Your HIPS-NET Team

Gert, Anja, and Josephine

PS: We will look at the study "Infrastructure Outlook 2050" published in 2019 aiming to understand future designs of the integrated energy system for Germany and the Netherlands in the year 2050 and the follow-up study: Pathways to 2050 (Phase II) in the next newsletter. Just to let you know that they are published – in case you can't wait – have a look.

The study "Impact of the use of the biomethane and of the hydrogen potential on trans-European infrastructure" is now published after acceptance by DG Energy.

Not enough yet? The study "The role of Trans-European gas infrastructure in the light of the 2050 decarbonisation targets" is out now. Four interesting topics we will summarise keeping a special eye on the hydrogen tolerance of the gas network including future expectations.

CONTENT

CONTENT NEWSLETTER #27

ANNIVERSARY - 5 YEARS OF EXPERIENCE WITH 10 VOL% H_2 | GERMANY (1/2)

The municipal energy supplier in Mainz / Germany is supplying 972 houses with hydrogen enriched natural gas since 2015, for five years by now.

Three PEM electrolysers (with 1,3 MW_{el} capacity each) are directly connected to a local wind park and producing renewable hydrogen. The hydrogen supplies an existing local gas grid and trailer with gas cylinders on a regular basis. The gas in the cylinders requires an increased degree of pureness. Impurities stay below 0.0002 % oxygen and 0.0005 % water.

ENERGIE PARK MAINZ

Some technical details of the “Energiepark (energy park) Mainz”:

- 20 kV electricity voltage level
- 4 x 2 MW_{el} electric capacity wind park
- 3 x 1,3 MW_{el} electric capacity of the electrolyser
- 35 bar(g) output pressure of the electrolyser
- 780 kg (26 MWh) @ 80 bar(g) storage capacity
- 200 bar(g) operating pressure – trailer
- 300-600 kg @ 200 bar(g) storage capacity for trailer
- 3 hrs approximate filling time

hydrogen compatibility of the gas network section

The project examined all essential elements of the gas network for their hydrogen compatibility in distribution, measurement and control, as well as gas utilisation. The investigations did not reveal any need to adapt this section of the gas network. Steel pipelines are endangered by stress induced corrosion cracking. This occurs primarily at hydrogen concentrations > 50 vol%, high pressures and with steels of high hardness (HV > 400). The natural gas pipelines in the Mainz’ network consist of steel grades with lower degrees of hardness (e.g. L245NB HV = 250). Further, typical pipeline steels for high pressures (e.g. X42, X70) show only marginal changes in the crack growth rate at hydrogen concentrations of up to 50 vol%. The risk of stress induced corrosion cracking therefore remains low in the selected network for blends with up to 10 vol% hydrogen.

ENERGIEPARK MAINZ WITH COMPRESSOR, GAS CYLINDERS, FEED-IN STATION, ELECTROLYSER BUILDING (SOURCE: MAINZER STADTWERKE)

live experience for hydrogen blending

Mainz is the biggest pilot site for hydrogen injection with 972 households in Germany (and maybe even worldwide). With a constant share of almost 10 vol% hydrogen they feed-in quantities between 0 - 1130 m³ hydrogen per hour. The chosen gas grid section is an existing one with a wide variety of heating and cooking appliances. The colleagues in Mainz did not examine every single appliance but only tested a few of them, i.e. gas boilers and cogeneration units (CHP). They further informed the gas customers and established a customers office to handle complaints. The customers office did not receive any reports about malfunctions or irregularities and was eventually closed after 3 years.

BUILDING WITH THREE ELECTROLYSERS (SOURCE: MAINZER STADTWERKE)

feed-in / gas billing / calibration

The feed-in station receives hydrogen from the gas storage with inlet pressure of 24 – 80 bar(g). It is blended there with natural gas. A calorimeter determines the calorific value in the station. Further, the data of the gas volume is calculated as monthly mean value according to the DVGW standard G 685. The office of weights and measures approved the measuring approach. The gas leaves the feed-in station with an outlet pressure of 6 – 8 bar(g).

ionic compressor

The project includes an ionic compressor. These are primarily used for filling stations but found advantageous to work with a PEM electrolyser especially because of its wide load range and high efficiency in the partial load range. It can compress

Anniversary - 5 Years of Experience with 10 vol% H_2 | Germany (2/2)


Gas mixing Cabinet of the Gas Feed-In Station
(Source: Mainzer Stadtwerke)

Jonas Aichinger at jonas.achinger@mainzer-stadtwerke.de

https://www.energiepark-mainz.de/en/
https://bit.ly/3dUFv2F (report, in German only)

moist hydrogen and dries it in the process of compression so that the hydrogen is dry enough for gas grid feed-in without adsorptive drying. The compression of high-purity hydrogen to very high pressures was previously only possible with dry-running or diaphragm compressors, which have disadvantages in CAPEX, OPEX and dynamics/variability.

The compression with an integrated drying proves to be a viable concept, especially for stations that only supply the gas grid, because dryness is sufficient for this purpose and the adsorption dryer is not needed. However, ionic compressors require additional effort such as the process-related separation of the water at various points, the necessary thermal insulation and additional heating of the pipelines. For stations that supply partly or exclusively high-purity hydrogen (e.g. for trailer filling or filling stations), a conventional drying concept is recommended.

The project idea was born in 2012; the research started in 2015 for 2 years; afterwards the site entered commercial operation in 2017. In 2019, the project partners agreed to continue the production for a longer term despite the currently insufficient market design for renewable hydrogen. Greenpeace Energy supports selling the hydrogen with their product 'windgas'.

Partners: Stadtwerke Mainz, Linde, Siemens, Hochschule RheinMain

Effect of Hydrogen Admission to Emission Reduction for Gas Engine Plants | Germany (1/2)

The European Directive EU 2015/2193 requires national emission limits for combustion plants in particular for carbon monoxide (CO), ammonia (NH_3), nitrogen oxides (NO_x), sulphur oxides (SO_x), formaldehyde (CH_2O), and hydrocarbons (HC). The limits are stricter than the technical guidelines on air quality control (TA Luft 2002) that have been in place before in Germany (see table beside).

The tougher emission limits, especially for formaldehyde emissions, present considerable technical and economic challenges for electricity producers with existing combustion engines.

The **question** occurred: Can hydrogen admixture lower the emissions? And could this replace three-way catalytic converters for emission reduction? DBI tested two gas driven engines (see table beside).

The measurements of CHP 1 were taken first, after the combustion and before the catalytic converters and second, after the catalytic converters. The smaller CHP 2 was only tested after the catalysator. The CHP 2 was simply too small, the components too narrow to place measuring instruments between the

Emission Limits for Combustion Plants since 2019 | Germany

	thermal capacity [MW]	CO [mg/m³]	NH_3 [mg/m³]	NO_x [mg/m³]	SO_x [mg/m³]	CH_2O [mg/m³]	HC [mg/m³]
new emission limits (44. BImSchV)	**≥ 1 to < 50**	100	10	100	10	20	300
previous emission limits (TA Luft 2002)	**> 3**	300	-	500*	10	60	-

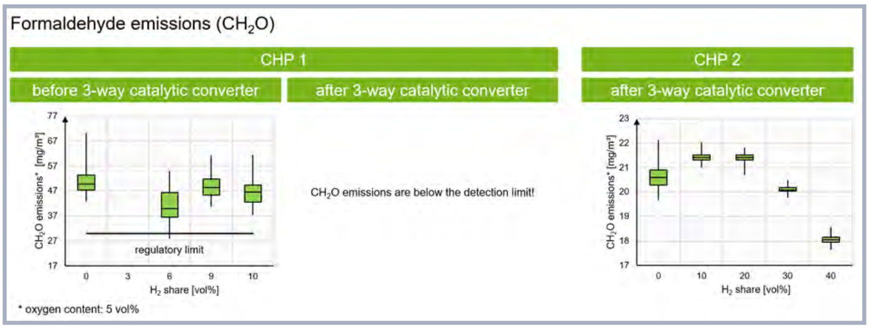
*Does not apply to engines with thermal capacity below 3 MW. Limit is 1,000 mg/m³ NOx.

	Combustion Engine (CHP 1)	**Combustion Engine (CHP 2)**
thermal capacity	689 kW_{LHV}	50 kW_{LHV}
electric capacity	224 kW_{el}	22 kW_{el}
type	straight (inline engine), 24 cylinders (lambda (λ) = 1)	straight (inline engine), 4 cylinders (lambda (λ) = 1)
measurement	field experiment	laboratory experiment
hydrogen admixture	0, 6, 9, 10 vol%	0, 10, 20, 30, 40 vol%

Effect of Hydrogen Admission to Emission Reduction for Gas Engine Plants | Germany (2/2)

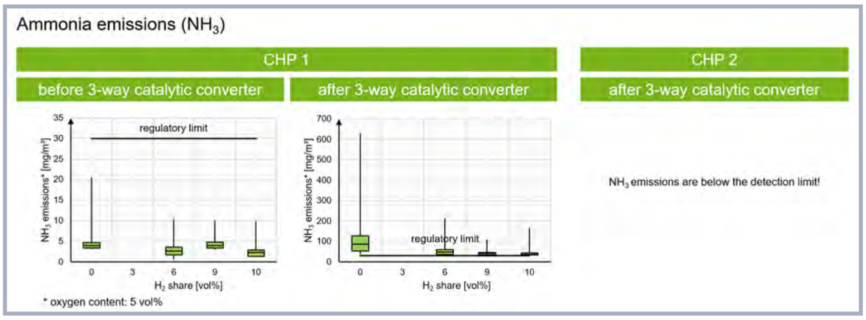
combustion unit and the catalysator. The emission limits apply to CHP 1 but not to CHP 2, since the latter is below the threshold of 1 MW.

Conclusion: Hydrogen admixture leads to emission reductions (CO, CH_4, NH_3, CH_2O) but does not replace the three-way catalytic converter. Please have a look at the following diagrams for further details.



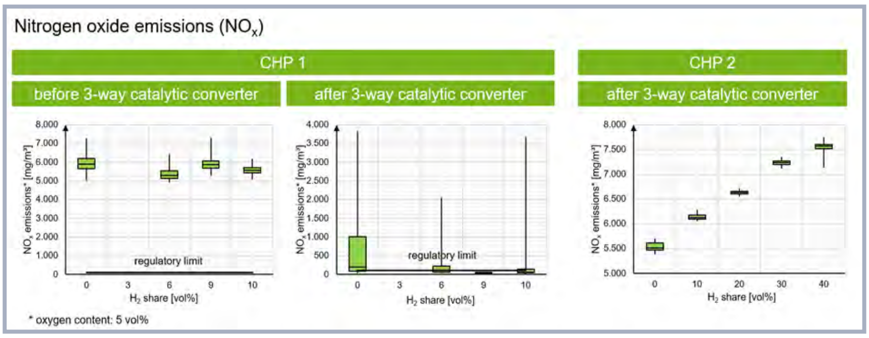
Formaldehyde emissions:

Hydrogen admixture lowers the formaldehyde emissions, but not under the required limits. Keeping the limits needs a catalytic converter.



Ammonia emissions:

Hydrogen admixture lowers the emissions. Especially with the catalytic converter, the emissions are higher than the regulatory threshold permits. Hydrogen lowers ammonia emissions in this case significantly.

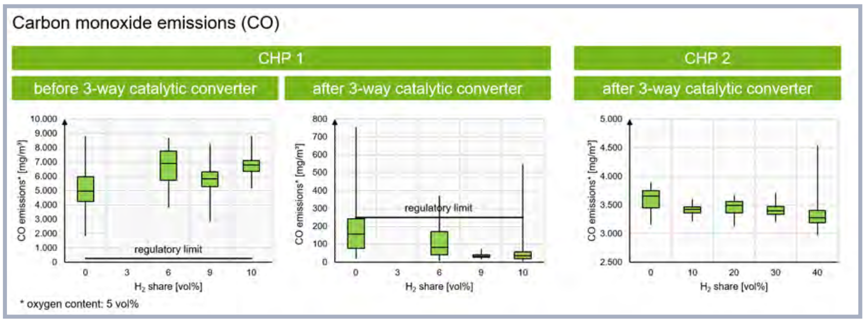


Nitrogen oxide emissions:

The influence of hydrogen admixture differs clearly. There is hardly any influence without the catalytic converter. With the catalytic converter of the large CHP, hydrogen supports dropping NO_x emissions. The opposite effect happens in the small CHP unit, where hydrogen increases the NO_x emissions. This is caused by thermal NO_x emissions.

Carbon monoxide emissions:

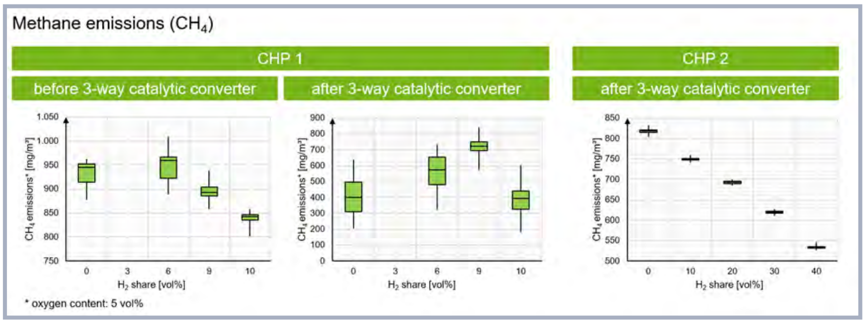
Hydrogen generally helps lowering CO emissions with the catalytic converter and in the small CHP.



Methane emissions:

The impact on CH_4 emissions varies – rising and dropping. A clear statement can only be given for the small CHP with dropping emissions.

The findings of the measurements show that hydrogen admixture influences combustion properties (including a shorter extinguishing distance, higher combustion temperature, higher combustion speed, diffusion-related higher mixing). Hydrogen further reduces emissions CO, CH_4, NH_3, and CH_2O but does not substitute secondary measures such as oxidation catalytic converter or 3‑way catalytic converter. It may, however support measures for emission reduction especially for NH_3.



Chris Schaaf at
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https://bit.ly/2Yo4Xaa (in German)

2x40 GW in 2030 - Green Hydrogen Initiative | Europe

Hydrogen Europe is calling for 2x40 GW electrolyser capacity in 2030 to realise a European green hydrogen market and push Europe to become a global industrial leader. Governmental support is crucial for the electrolyser market and needed as soon as possible. Time to act is now, to reach the goal in 2030.

Vision for a Hydrogen Infrastructure - Orange Lines (Source: report p. 15)

The paper postulates **40 GW** electrolyser capacity **in the EU** by 2030. This includes 6 GW in a captive market (hydrogen production at the demand location i.e. in steel plant) and 34 GW hydrogen market (hydrogen production close to electricity production). This 40 GW electrolyser capacity will produce 4.4 million ton or 173 TWh hydrogen in 2030, representing 25% of the total EU hydrogen market in 2030.

Further 40 GW electrolyser capacity are required **in North Africa and Ukraine** by 2030. This includes 7.5 GW hydrogen production for the domestic market and a 32.5 GW hydrogen production capacity for export. The domestic market is mainly for ammonia production, while the export market is mainly done via pipelines to the EU, about 3 million ton or 118 TWh hydrogen in 2030, representing 17 % of the total EU hydrogen market in 2030.

The storyline is clear and simple:

- Renewable **hydrogen and electricity are both carbon free** energy carriers. Both will be necessary and they are complementary to each other.
- **Hydrogen** can play a **crucial role** in achieving a **clean and prosperous economy**.
- Building 2x40 GW electrolyser capacity **reduces about 82 million tonnes CO_2 per year**, has a total **investment of 25-30 billion Euro**, and **creates 140,000-170,000 jobs** in the electrolyser manufacturing and maintenance sector.
- The industry needs the **European Union and its member states** to design, create and facilitate a hydrogen market, infrastructure, and economy.
- Crucial is the design and realisation of new, unique, and long-lasting mutual **cooperation mechanisms on political, societal, and economic levels** between the EU, North Africa, Ukraine, and other neighbouring countries.

With this initiative, renewable (green) hydrogen will become cost competitive with fossil (grey) hydrogen. GW-scale electrolysers at wind and solar hydrogen production sites will produce renewable hydrogen at costs competitive with low-carbon hydrogen for 1.5-2.0 €/kg_{H2} in 2025 and with grey hydrogen 1.0-1.5 €/kg_{H2} in 2030. The authors predict a rigorous drop in production costs (see table).

Partners: Ukrainian Hydrogen Council, Clean Energy Technology Network, African Hydrogen Partnership, Dii Desertenergy

https://bit.ly/2C01gQs

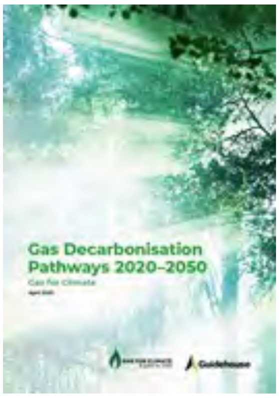
Hydrogen production by electrolysers*	Capex (€/kW)	OPEX %/yr Capex	System Efficiency (HHV**)	Electricity (4.000-5.000hr) (€/MWh)	Hydrogen (€/kg)
2020-2025	300-600	1.5%	75-80%	25-50	1.5-3.0
2025-2030	250-500	1%	80-82%	15-30	**1.0-2.0**
Up to 2050	<200	<1%	>82%	10-30	0.7-1.5

*Hydrogen production cost for hydrogen delivered at 30 bar pressure and 99,99% purity
**HHV = Higher Heating Value

Green Hydrogen Production Cost Development (Source: report p. 29)

Study 'Gas Decarbonisation Pathways 2020-2050' | Europe (1/2)

Scaling Up Biomethane, Green Hydrogen, Blue Hydrogen



The Paris Agreement goal to limit global temperature increase to well below 2 degrees requires deep decarbonisation. So far, the energy transition has mainly been an electricity transition. While there is increased awareness about the valuable role hydrogen and biomethane will play in the future, the potential of renewable and low carbon gases has yet to be unleashed. A noticeable amount of biogas (around 170 TWh/yr) is already being produced. However, blue and green hydrogen and biomethane are not available in large quantities today.

The Gas for Climate consortium has undertaken several large studies that analyse the future role and value of gas and gas infrastructure. In March 2019, the consortium published 'The optimal role for gas in a net zero emissions energy system' (see newsletter #24). The new study – on the pathways – targets the 'optimised gas 2050' energy system as described in the earlier study. It develops gas decarbonisation pathways from 2020 to 2050, and identifies what investments and actions are needed across the energy system along the way.

With the right climate and energy policies in place, the energy sector will be able to **massively scale-up the production of biomethane and green and blue hydrogen**, initially to 10 % of total gas demand by 2030 and to 100 % renewable and low carbon gas by 2050.

Blue hydrogen refers to conventional steam reforming (SMR) retrofitted with CCS or the recent autothermal reforming (ATR) technology combined with CCS. Further technologies as pyrolysis are mentioned but not subject of the roadmap.

The supply of green hydrogen could drive up to 50 TWh/yr with an installed capacity of 20-25 GW_{el} **by 2030**, while blue hydrogen would be scaled up more rapidly with up to 85 TWh/yr. In the early **2040s**, cheap green hydrogen would surpass the production of blue hydrogen, targeting at volumes around 1,590 TWh/yr (green) and 620 TWh/yr (blue) by 2050, including demand for aviation fuels and petrochemicals. Blue hydrogen production grows moderately from 2040 (555 TWh/yr) to 620 TWh/yr in 2050.

Substantial quantities of natural gas will remain to be transported through Europe's gas grids, but after 2030 the role for natural gas dwindles rapidly. Industrial consumers and the buildings sector will significantly reduce their natural gas consumption. This means that gas transmission capacity will become increasingly available for hydrogen transport while gas distribution grids will largely continue to carry gas to existing buildings, initially natural gas but increasingly biomethane to hybrid heating systems. Due to gas demand reduction, capacity will become available that can be used to convert pipeline segments to hydrogen transport.

Blending natural gas with a limited amount of injected hydrogen can be an effective temporary solution to boost hydrogen production and facilitate CO_2 emission reductions during the 2020s.

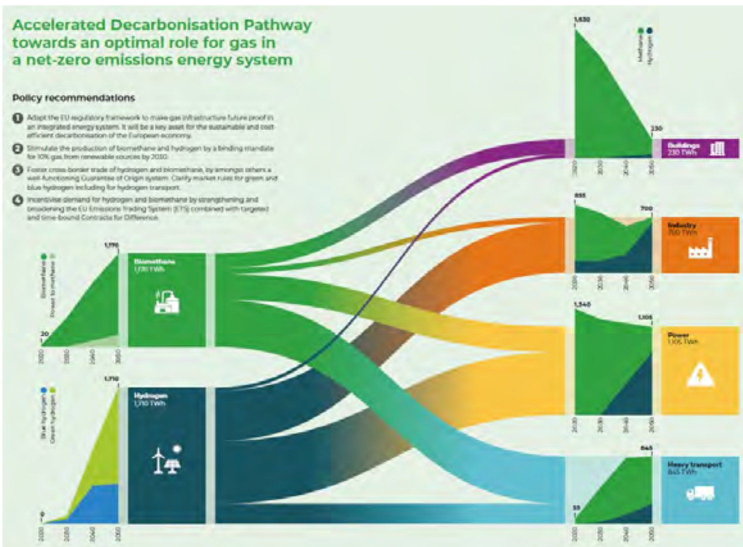
However, the volumes of hydrogen needed to reach a net-zero emission energy system in 2050 will require a separate regional and national pure hydrogen infrastructure around 2030, as well as trans-EU hydrogen flows around 2040. Such infrastructure can be largely based on existing gas infrastructure which can be retrofitted cost-effectively.

By 2050, just over 1,700 TWh would flow through the hydrogen grid. The transport of this quantity of hydrogen requires more pipeline capacity per unit of energy compared to natural gas because an energy unit of hydrogen has about 3 times more volume than methane. However, hydrogen flows much faster through gas grids. The net effect of both elements is that transport of hydrogen requires at least 20% more pipeline capacity per unit of energy compared to natural gas.

Accelerated Decarbonisation scenario in 2050	
Blue hydrogen	620 TWh/yr
Green hydrogen	1,590 TWh/yr
By-product hydrogen	60 TWh/yr
Total hydrogen	2,270 TWh/yr

Hydrogen blending

Blending hydrogen into natural gas grids requires upgrades to the current infrastructure above specific thresholds and could raise issues at the end user side as certain appliances, burners, and especially industrial consumers of feedstock have limitations in what share of hydrogen they can handle, and the (unpredicted) variations they can accept. Directing blended hydrogen to applications that can accept a blend will be highly complex for gas operators; separating the hydrogen and methane into finer grids closer to the demand centres using membranes is being considered.



(Source: Guidehouse, report p. 10)

Study 'Gas Decarbonisation Pathways 2020-2050' | Europe (2/2)

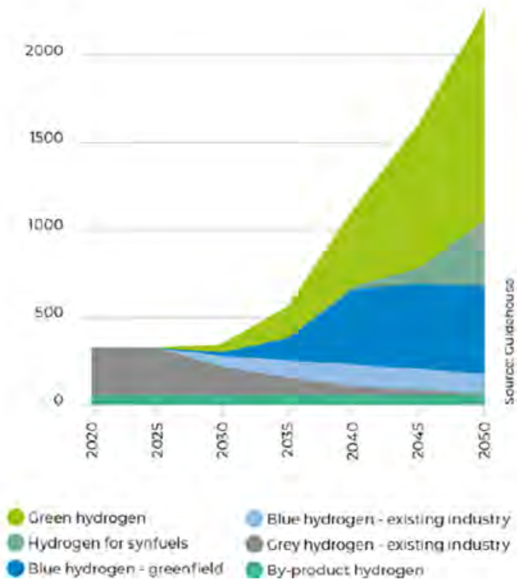
Scaling Up Biomethane, Green Hydrogen, Blue Hydrogen

Critical Timeline Hydrogen Supply
(Source: Guidehouse report p. 130)

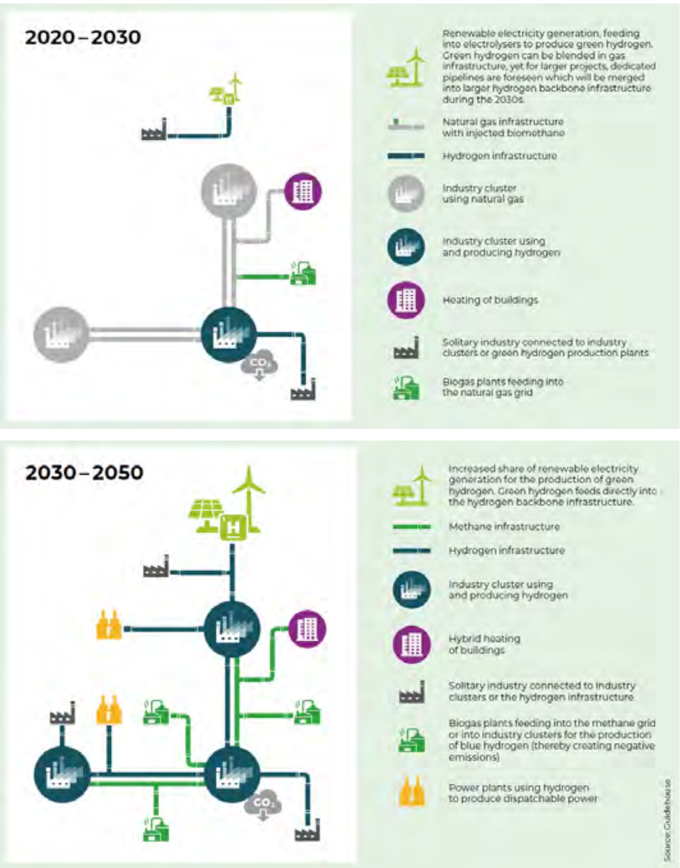
Blending hydrogen in the existing gas grid is often considered as a way to quickly scale-up hydrogen supply, while limiting the need for hydrogen pipeline and end-user investments. Studies report blending percentages of **between 5 and 20 vol%** to be technically feasible in current grids with minimal investments.

The report recommends the EU Green Deal needs to include various cross-sectoral policy measures. We selected a few focussing on the gas network:

- First, **adapting the EU regulatory framework to make gas infrastructure future proof** in an integrated energy system. It will be a **key asset for the sustainable and cost-efficient decarbonisation** of the European economy. Planning of energy infrastructure should be more integrated considering the **overall energy system** and the advantages offered by existing infrastructure. **TEN-E and CEF regulations** should facilitate and support the integration of renewable gas.
- A **binding mandate for 10% gas from renewable sources by 2030** will mainly stimulate sustainable biomethane production.



Accelerated Decarbonisation Pathway for Hydrogen Deployment towards 2050 (Source: Guidehouse, report app. p.26)



Development of Gas Infrastructure from 2020 to 2050 (illustrative) (Source: Guidehouse, report p. 65)

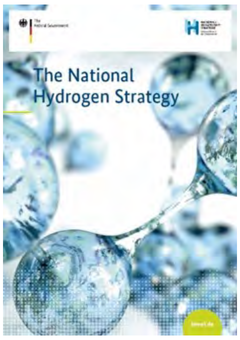
- Further, fostering **cross-border trade of hydrogen and biomethane**, by amongst others a well-functioning **Guarantee of Origin system**. **Clarify market rules for green and blue hydrogen** including for hydrogen transport. **Harmonise gas quality standards** and standards for biomethane injection in gas grids and set standards and definitions for hydrogen and blended gases to enable their transport through gas infrastructure and across borders. This should consider a current state **blend level and variability in blend levels** during the year or a ramp up towards the future.
- **Strengthening and broadening the EU Emissions Trading System (ETS)** combined with targeted and time-bound Contracts for Difference will mainly push blue hydrogen production in the medium term but further the production of green hydrogen in the early 2040s. An assumed EU ETS price of around €55/t_{CO2} in 2030, gradually increasing to €150/t_{CO2} by mid-century will allow deep decarbonisation in all industrial processes.

'Sustainable biomethane' includes the responsible use of biomass waste and residues plus biomass from sequential cropping and carbon farming, mainly in the southern half of the EU.

The authors see that imports of green hydrogen from North Africa by upgrading existing gas import pipelines may enter the picture, and possibly blue hydrogen imports from regions with large gas reserves like Russia may start playing a role as well.

Daan Peters at daan.peters@guidehouse.com https://bit.ly/2MPYAHd

National Hydrogen Strategy | Germany (1/2)



The German National Hydrogen Strategy was issued in June 2020 and sends clear intentions: The German Government expects a considerable increase in the demand for hydrogen in the medium to long term. In order to harness the full potential of hydrogen technology, the next steps need to be taken to speed up the rollout of this technology together with the private sector. Time to act is now, which the strategy markedly shows with 38 actions announced for 2020 and beyond.

The Government seeks to use green hydrogen, promote its rapid market rollout, and establish the necessary value chains. It believes that both a global and European hydrogen market will emerge in the coming ten years and that carbon-free (incl. blue) hydrogen will be traded.

The German Government expects that around 90 to 110 TWh/yr of hydrogen will be needed by 2030. Domestic hydrogen consumption currently amounts to roughly 55 TWh/yr. In order to cover part of the future demand, Germany plans to establish up to 5 GW hydrogen generation capacity including the offshore and onshore electricity generation facilities needed for this. This corresponds to 14 TWh/yr of green hydrogen production and will require 20 TWh/yr of renewables-based electricity.

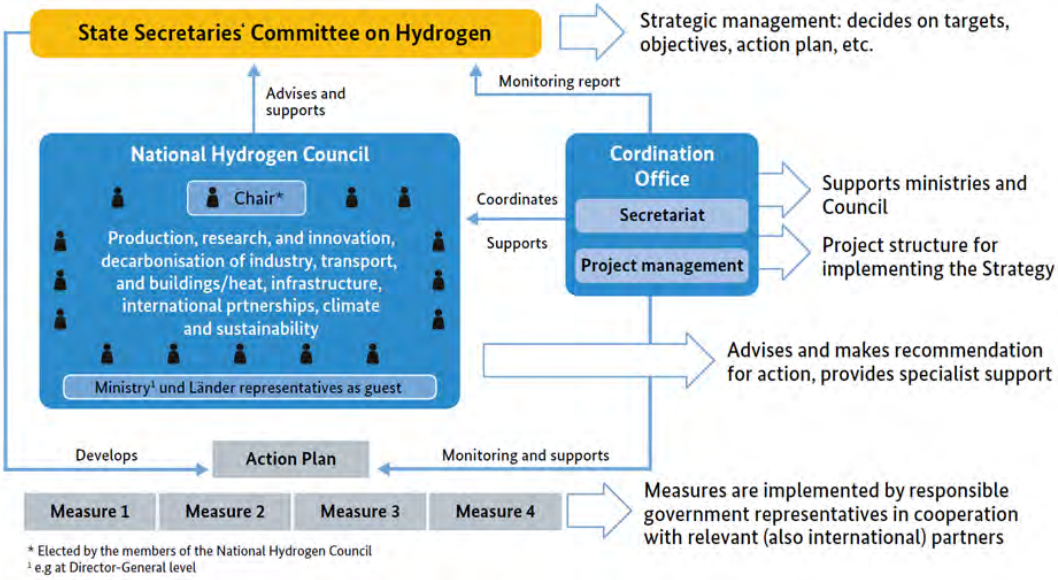
However, the domestic generation of green hydrogen will not be sufficient to cover all new demand, which is why most of the hydrogen will have to be imported. There are several places across the EU where large quantities of renewables-based electricity are being generated. These offer great potential for producing green hydrogen. The Government will work to ensure that this potential is tapped and that the generation capacities are further expanded. To this end, it will intensify its cooperation with other European Member States, particularly those bordering the North and Baltic Sea, but also with the countries of southern Europe. The use of offshore wind energy will play an important role. Further, countries currently producing and exporting fossil fuels also have attractive opportunities to convert their supply chains to the use of renewable energy and hydrogen, and thus to become potential suppliers of hydrogen. The Government aims to further diversify energy sources and transport routes and is looking also at new partners for international cooperation i.e. with developing countries.

In future, a part of the gas infrastructure will be reused for hydrogen as well. Further networks are to be created exclusively for the transport/distribution of hydrogen. Important options for transporting hydrogen include PtX downstream products or LOHCs (Liquid Organic Hydrogen Carriers).

Governance Structure

The Strategy explains the hydrogen governance structure (see figure below). A State Secretaries' Committee on hydrogen, composed of the relevant ministries, will provide continuous support for the activities under the National Hydrogen Strategy and ensure that the Strategy remains in line with market developments and delivers on its overall targets. The National Hydrogen Council is made up of 26 high-level experts from business, science, and civil society. The Hydrogen Council is to advise and support the State Secretaries' Committee through proposals and recommendations for action. The 'Green Hydrogen' Innovation Officer of the Federal Ministry of Education and Research (BMBF) supports both groups. The Hydrogen Coordination Office assists the implementation of the Strategy and the Council in coordinating and drafting recommendations for actions. It is also responsible to monitor the Strategy.

In order to drive forward technological progress and economies of scale and promptly obtain the critical mass of hydrogen needed for some initial sectors to switch to the new technology, the production and use of hydrogen need to be sped up globally.



Governance Structure of National Hydrogen Strategy (Source: strategy p. 14)

National Hydrogen Strategy | Germany (2/2)

Time Scale for German Hydrogen Strategy (Source: strategy p. 16)

A particular focus is being placed on areas that are already close to commercial viability and where major path dependencies can be avoided, or which cannot be decarbonised in other ways, as is the case for process-related emissions in the steel or chemicals industry, or in certain parts of the transport sector. Heat market: In the long run, hydrogen and its downstream products can help in various ways to decarbonise parts of the heat market. Efficiency and electrification potentials for process heat and the building sector have clear priority.

38 MEASURES

The measures cover a wide range of activities on national, EU level and beyond. The German EU Council Presidency offers a good opportunity in the second half of 2020 to proactively progress key hydrogen-related dossiers, e.g. in the context of the preparations for the legislative package on sector coupling and gas market design. These particularly include the Hydrogen Action Plan envisaged by the European Commission and the strategy on Smart Energy System Integration. On national level, reducing the EEG surcharge (levy), hydrogen quotas for transport, industrial products, and CO_2 pricing for fossil fuels used in transport and the heating sector are important elements and many more are described in the the Strategy in page 16ff. Have a read if you are curious.

https://www.bmbf.de/files/bmwi_Nationale%20Wasserstoffstrategie_Eng_s01.pdf

Adjusting the Dutch Gas Network to Hydrogen | Netherlands (1/2)

To what extent is the current gas distribution network resistant to renewable gases? What adjustments are needed to adapt the existing gas networks? What are the costs of the conversion? These questions are addressed in an older report from Kiwa, ordered by Netbeheer Nederlands, the national association for gas and electricity network operators.

“The gas network of the future can remain largely the same as the current natural gas network” for save and reliable hydrogen (and biomethane) supply.

The gas characteristics of hydrogen differ from natural gas’. In comparison with natural gas, hydrogen has a lower ignition temperature, wider explosion limits and a higher rate of ascent. When burning hydrogen, the flame is poorly or not visible and the combustion rate is higher. In addition, like natural gas, hydrogen cannot be smelled from itself. Existing appliances are not simply suitable for 100% hydrogen. Virtually none of the existing appliances at the end users are suitable for use with pure hydrogen. The combustion of hydrogen in existing boilers may result in flames and damage to the burner. Further, the protection principle (ionisation current) in the current appliances is not applicable for 100% hydrogen. This also applies to most gas boilers. An increased safety risk with cooking appliances is that combustion of hydrogen does not produce a visible flame. An important advantage of hydrogen is that carbon monoxide poisoning no longer occurs. In addition, the volatility of hydrogen reduces the risk of fire or explosion. On the other hand, the wider explosion limits, lower ignition temperature and lower ignition energy increase the risk. A practical study in the United Kingdom into the leakage of hydrogen in a test farm showed that it was not possible to create an explosive mixture under normal conditions. In short, there are arguments that lead to an increased risk and others that point to a lower risk compared to natural gas.

The question of what measures are needed to adequately control the risk of fire or explosion in the event of hydrogen leakage cannot yet be answered conclusively. Further, there are two other phenomena that are often associated with hydrogen. These are the permeation of hydrogen through plastic pipes and hydrogen embrittlement of steel. Both effects are negligible under the conditions prevailing in distribution networks and do not significantly degrade or increase the safety risk.

All studies published so far have shown no degradation of plastics and rubber gas distribution materials by hydrogen. For steel, stainless steel and cast iron, used in gas distribution, it can be concluded that the main failure mechanism (hydrogen embrittlement) will not occur in practice. Copper, brass and aluminum do not seem to be influenced by hydrogen. Therefore, it can be concluded that the existing gas distribution networks are suitable for the transport of hydrogen. The findings above suggest that the applied construction and design techniques can also be used for the construction of new gas pipelines.

*WEQ is not an officially determined parameter. The translation is “residential equivalent”, meaning one average Dutch flat/dwelling. Commercial buildings with 150 m2 floor space is set equal to one WEQ.

Adjusting the Dutch Gas Network to Hydrogen | Netherlands (2/2)

The current costs for maintaining the gas network are 100 -150 €/yr per WEQ*. Many of the adjustment measures under consideration require payments only once. Upon deprecation over a longer period, the costs are in the order of a few euros per WEQ/yr as far as gas distribution is concerned. The largest cost item is probably the replacement of the gas meter and the development and implementation of any other type of billing procedure. The costs of measuring variations in the calorific value at the level of a separate house are high and uncertain. It is therefore not expected that calorific value meters will be installed. The one-off costs associated with the (premature) replacement of gas appliances at the end user are much higher than any additional gas grid maintenance costs (calculated back tens of euros per WEQ/yr). Of the recurring costs, the items relating to any inspections are the highest. Additional inspection for excavation work is costly. A 100% inspection makes gas (hydrogen) supply 20 €/WEQ/yr more expensive. The alternative of sectioning the grid is not much cheaper and is a partly untried technique. Whether these measures are necessary in the long term is uncertain and depends on practical experience.

	Action	one-off costs, basis	one-off costs per WEQ	frequent costs	frequent costs per WEQ
		k€	€/WEQ	k€/jr	€/(jr WEQ)
1	Secure transport and distribution				
1.1	Educating of mechanics	++	+	0	0
1.2	Adjusting work procedures for construction and maintenance	0	0	0	10
1.3	Adapting standards and regulations	++	0	0	0
1.4	Supervising excavation work	0	0	0	+
1.5	Dynamic/automatic sectioning of the gas network	++	+	0	+
2	Security of supply and maintenance				
2.1	Adjustments measuring instruments	0	+	0	0
3	Injection of hydrogen or other sustainable gas				
3.1	Additional pollution control (S, CO, N2, O2, etc.)	0	0	0	+(++)
4	Safety of distribution and end-use				
4.1	Information campaign	++	+	0	0
4.2	Adjusting odoration	++	+	0	0
4.3	Additional odoration control	0	0	+	+
4.4	Adjusting standards for gas indoor installation (leak-tightness)	++	0	0	0
4.5	Adapting working procedures for construction and maintenance of gas indoor installation	0	0	0	+
4.6	Replacing open flame cookers	0	++	0	0
5	Adjusting installations of end-users				
5.1	Replacing gas meters (larger size)	0	+	0	0
5.2	Replacing gas meters (ultrasonic)	0	+	0	0
5.3	Additional monitoring of gas indoor installations (once a year)	0	0	0	++
5.4	Replacement or conversion of other appliances	0	++	0	0

An annual inspection of the indoor gas installation and/or gas sensors in the house is expensive (order of magnitude 100 €/WEQ/yr). This too is debatable. The overall conclusion is that the costs of maintaining the gas network will increase by less than 50%. Depending on the usefulness to be substantiated by practical experience and the need for inspections, **the best guess is that the additional conservation costs will ultimately amount to approximately 5% of the current costs (5 to 10 €/WEQ/yr)**.

The total costs of switching and adapting the distribution networks (0-8 bar(g)) in the Netherlands can amount to up to € 700 million. The network costs will increase roughly by 10 to 50 % per household per year. The largest cost item included in the switch to hydrogen is the replacement of the gas meter and the new approach to determine the energy content for gas billing due to differences in gas composition. A significant periodic cost item is associated with stricter supervision of excavation activities. Incidentally, these additional network operator costs are limited compared to the expected adjustment costs of appliances at end users.

The study raised further important steps; we quote some of them:

- Investigating measuring and offsetting approaches/methods
- Organizing and drawing of (international) standards through out the entire gas chain from production to use
- Setting up training courses and public awareness campaigns

The table indicates the magnitude of additional costs of the relevant measures when using the existing gas infrastructure for the transport of hydrogen.

++: higher additional cost,
+: limited additional cost,
0: no action and/or no additional cost

For further detail, please see page 54f of the report.

We will read and summarise the recent Dutch report ‘Phase II – Pathways to 2050”, a joint study by Gasunie and TenneT in the upcoming newsletter. Have a glance if you are curious here.

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https://bit.ly/2B5wAfW

THyGA: Clearing the Way for the Use of Hydrogen - Natural Gas Blends for European Consumers | Europe

Authors: Alexandra Kostereva, Robert Judd | both GERG, Patrick Milin | Engie

Blending hydrogen with natural gas can help to decarbonise the energy mix while taking advantage of existing infrastructure assets. Understanding and mitigating any end-user impacts are vital elements to realise the blending opportunity. The FCH 2 JU funded project THyGA, **Testing Hydrogen admixtures for Gas Appliances**, aims at supporting a wide adoption of hydrogen and natural gas (H2NG) blends by assessing their technical impact on a wide selection of residential and commercial gas appliances.

The project consortium brings together nine partners with complementary strengths. In addition, an extensive advisory panel including manufacturers, European and international associations, and DSOs will ensure a constant challenge of the processed results and a great opportunity for a wide communication of the findings.

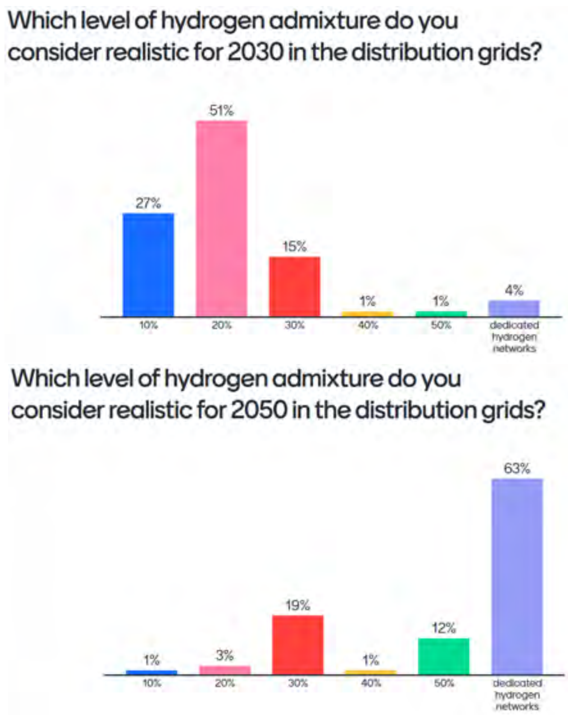
Project Goals & Main Working Steps

THyGA will investigate how the end-use appliances behave when fuelled with H2NG blends, evaluating safety, efficiency, lifetime, and environmental performance. The project consortium will then identify and recommend appropriate codes and standards that must be adapted in response, and finally develop a mitigation strategy for new and existing appliances. It will do this by:

- Screening and segmenting the portfolio of appliance technologies in the domestic and commercial sectors to select a representative sample of appliances for the testing.
- Developing a generic protocol that can be adapted to test the hydrogen tolerance of virtually any appliance.
- Testing up to 100 residential gas appliances through a generic protocol and assessing the impact of hydrogen admixtures (up to 60 vol% H_2).
- Evaluating the acceptable hydrogen tolerance of the natural gas system with the current stock of residential and commercial end use appliances.
- Evaluating the acceptable hydrogen tolerance of the natural gas system with new technologies.
- Theoretical specification of test gases, development of new testing procedures for certification purpose and validation on selected appliances.
- Evaluating mitigation solutions for installed appliances and new appliances, taking into account both technological and economic aspects for the best compromise between environmental / societal benefits and cost.
- Making recommendations for manufacturers and decision makers along the gas value chain for appliance design, manufacture, and certification.

First Results

Currently in month 5 of the project, the partners found more than 100 references on hydrogen tolerance in the literature for boilers, water heaters, fires, cookers and catering, decentralized heating, gas heating pumps (GHP) and cogeneration units (CHP). The partners defined four categories to summarise the knowledge on the impact of varying H_2 admixture: **safety** (H_2 leakages, CO, flashback, overheating), **appliance reliability** (lifetime and impact on materials), **efficiency**, and **emissions** (CO_2, NOx).



Impressions from the 1[st] THyGA Workshop - Poll with about 70 participating experts (Source: THyGA, Mentimeter)

Dissemination / Communication

THyGA also aims to increase the awareness of all stakeholders about H2NG blends and will work closely in alignment with other initiatives. To support this effort, a **series of webinars** is being organised to discuss specific topics such as state of the art of standards, leakages, materials science related to H2NG blends, combustion theory, and more. All deliverables of the project (except internal project documents) will be made public. The first public workshop gathered around 100 stakeholders; the diagrams give an impression of the views of the participating experts.

Project duration and budget: 36 months and FCH JU subsidy of 2.5 million €

Partners: BDR Thermea Group, CEA, DGC, DVGW-EBI, Electrolux, Engie, Gas.be, GERG and GWI

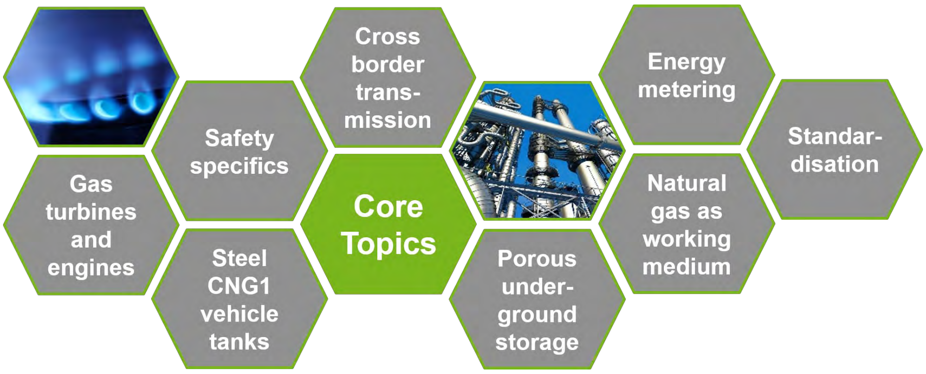
Patrick Milin at patrick.milin@engie.com Project website https://thyga-project.eu

Supported by the European Union's Horizon 2020 research and innovation programme, Hydrogen Europe and Hydrogen Europe research. FCH JU grant agreement No. 874983.

HIPS-NET CORE TOPICS

We gather and disseminate the latest available knowledge to improve the understanding of hydrogen/natural gas blends in pipeline systems with emphasis on the core topics:

We additionally keep a minor focus on the general development of power-to-gas, hydrogen networks, and further topics around the utilisation of (renewable) hydrogen.



EVENTS AND PARTNERS

Selection of Appointments

June/July 2020

23-24 7th Energy Symposium | online conference, *https://www.energy-symposium.eu/*

30-03 14th European SOFC & SOE Forum | Luzern, Switzerland, *https://www.efcf.com/2020*

08 July **"H2-NETZ": 4th** open day | Chemical Park Bitterfeld-Wolfen, Germany, *https://bit.ly/3e9Z33c*

September 2020

09-10 f-cell+HFC - The Hydrogen and Fuel Cell Event | Vancouver, Canada, *https://hyfcell.com/*

15-16 DBI-Fachforum Energiespeicher 2020| Berlin, Germany, *https://www.dbi-gti.de/termine/dbi-fachforum-energiespeicher-2020.html*

22-23 World Hydrogen Congress| Paris, France, *www.worldhydrogencongress.com/*

29-30 f-cell 2020 | Stuttgart, Germany, *https://f-cell.de/*

October 2020

08-09 Hydrogen Online Conference | online conference, *https://hydrogen-online-conference.com/*

20-23 14th European SOFC & SOE Forum | Lucerne, Switzerland, *www.efcf.com/2020*

November 2020

03-04 6th HYPOS-Forum| Dresden, Germany, *http://www.hypos-eastgermany.de/*

04-06 European Hydrogen Energy Conference | Madrid, Spain, *http://ehec.info/*

10-11 DBI-Fachforum Wasserstoff & Brennstoffzellen | Duisburg-Oberhausen, Germany, *https://bit.ly/30Il585*

24-25 Update: FCH JU Stakeholder Forum | Brussels, Belgium, *https://bit.ly/3hvMvoP*

Current Partners

Alliander AG, Areva H_2Gen,
Cadent, DGC, DNV GL, Enagás,
Enbridge, Energinet.dk, ENGIE,
EWE Netz, Gas Connect Austria GmbH,
Gasnetz Hamburg, Gasum OY,
Gasunie, GRTgaz, GRZI e.V. (figawa),
Infraserv GmbH & Co. Höchst KG,
INERIS, innogy SE, ITM Power,
Joint Research Centre (JRC), EC,
KOGAS, NAFTA a.s,
Naturgy, ONTRAS, ÖVGW,
Open Grid Europe GmbH,
Polymer Consult Buchner GmbH,
RAG Rohöl-Aufsuchungs AG,
Shell, Solar Turbines Europe S.A.,
Storengy, SVGW,
Synergrid, Teréga, TNO,
Uniper Energy Storage GmbH,
Verband der Chemischen Industrie (VCI),
Volkswagen AG, Wintershall Dea AG.

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Certified DIN EN ISO 9001:2015

HIPS-NET

“ESTABLISHING A PAN-EUROPEAN UNDERSTANDING OF ADMISSIBLE HYDROGEN CONCENTRATION IN THE NATURAL GAS GRID”

NEWSLETTER #28 | **SEPTEMBER, 2020**

Dear HIPS-NET Partners,

European Commission is **opting for an integrated energy system** for a climate-neutral Europe

“…. Electricity and gas networks are planned and managed independently from each other. Market rules are also largely specific to different sectors. This model of separate silos cannot deliver a climate neutral economy. It is technically and economically inefficient, and leads to substantial losses in the form of waste heat and low energy efficiency.” (source, p. 2)

The need for joint planning of electricity and gas networks is something we are hearing for years from gas network operators, but the planning authority denied joint planning due to a missing political mandate. (This applies to Germany, maybe to further countries as well?) Now there is a strong political signal from the EU. Is this the one the planning authorities were waiting for?

This 28th edition summarises articles around

- Long-term test with 15 mole% hydrogen in a Danish gas network
- Process of Increasing the European Emission Target 2030 from 40 % to maybe even 60 %
- EU Strategy for Energy System Integration (short)
- EU Hydrogen Strategy with more detail
- Dutch Hydrogen Strategy

And it includes a summary of the HIPS-NET workshop with brief information about the presentations of Néstor, Alfons, Eva, William. All four presentations raised a lot of interest during the HIPS-NET workshop. And Gert’s presentation

- HIPS-NET organisational matters – looking back and planning future activities

We hope you find interesting information and enjoy reading.

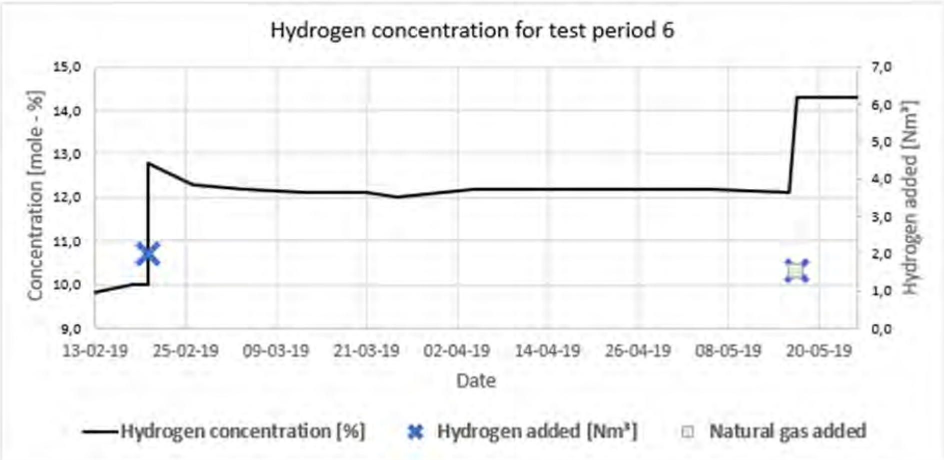
Your HIPS-NET Team
Gert, Anja, and Josephine

CONTENT

CONTENT NEWSLETTER #28

Long-Term Test with 15 mole% Hydrogen in Gas Network | Denmark (1/2)

15 mole% hydrogen admixture – Danish colleagues successfully demonstrated the operation of a natural gas network with components that have been taken out of operation from the Danish natural gas transmission and distribution systems. The components of the test network comprised measuring and regulation (M/R) stations for both the transmission and distribution grid with flow meters, regulators etc., and additionally a compressor and a hydrogen analyser. **The leakage of hydrogen from the system is comparable to natural gas. The tested components are capable of handling hydrogen in the tested concentrations without major modifications.** The project has also produced detailed knowledge on the effects on electrolysis systems from long-term standby periods.



Result for Hydrogen Concentration in Test Period 6 (Source: report, p. 35)

The test facility is geographically located in the western part of Denmark. The M/R stations were built in 1986. The facility was modified to a closed loop system in 2016. The test facility's M/R stations are designed for natural gas after the same specification as the rest of the Danish gas system. The system includes a low-pressure section with 4 bar(g) design pressure, a medium -pressure section with 40 bar(g) design pressure and a high-pressure section with 80 bar(g) design pressure.

The ability of the test facility to handle natural gas/hydrogen mixtures was analysed carefully before initiation of the tests and relevant authorities provided instructions for the test. The project has shown that **the test system is capable of handling hydrogen concentrations up to 15 mole% without modifications to the infrastructure**. **The existing routines and procedures for the operational staff at the M/R stations proved to a large extent to be sufficient for the operation and maintenance of the test facility with hydrogen injection. The process equipment of the M/R stations (regulator, flowmeter, safety systems, valves etc.) functioned well during the test phase.**

The hydrogen concentration was analysed in test periods between 1-3 months after injection of natural gas and hydrogen. These **long-term measurements of hydrogen concentration** were performed with concentrations up to 12 mole% hydrogen. **The hydrogen concentration did not decline in the test periods, indicating that hydrogen is not leaking from the test facility in a higher rate than natural gas.** A mass balance analysis indicates a total gas leakage of natural gas and hydrogen corresponding to only 0.0005 mass%, assuming an average volume flow of 1,000 Nm^3/h in real operation for the system. The test facility has been operated with hydrogen concentrations up to 15 mole% without any observations of operational issues, while the long-term test periods with concentration measurements without addition of hydrogen or natural gas has been performed with hydrogen concentrations up to 12 mole%. Hence, the conclusions regarding the tightness of the test system can be made only for concentration levels up to 12 mole%.

The goal for the sixth test period was to achieve a longer stable hydrogen concentration of 12 mole% than in the previous test period. The concentration of 12-12.1 mole% for hydrogen was kept stable for almost three months. As the result shows in the diagram above, a stable concentration of 12 mole% - the goal for test period 6 - was met.

In the project it was initially anticipated that gas detection systems in the gas infrastructure would have to be modified to operate with hydrogen/natural gas mixtures. The observation in this project is, however, that this is not the case for hydrogen concentrations up to 12 mole%, as tested in this project. **The gas detection systems typically used in the M/R stations in the Danish transmission grid would be fit for this purpose if the transmission system was operated with a hydrogen/natural gas mixture with a hydrogen content similar to the levels tested in this project.**

As hydrogen is introduced to natural gas in increasing concentrations, ATEX zones and explosion groups of the gas can change. This can potentially affect installed equipment in the gas infrastructure, if the explosion group of the gas mixture exceeds the applicable range of the equipment. It has been concluded that the conducted tests would not result in such critical changes of explosion groups, but if the hydrogen concentration exceeds 30 mole% in future tests, this aspect needs to be reconsidered.

It was originally planned that the hydrogen used in the tests should be produced **on-site with an electrolyser**. As a result of changes in the project partner consortium and scope, the hydrogen was, however, purchased and delivered from a supplier. The change in scope implied that the effect on electrolysers from **long-term standby** periods should be analysed.

Due to the change, the electrolyser system was in idle condition for more than 3 years, and due to that the performance of the system was assumed to be reduced compared to a new system.

Long-Term Test with 15 mole% Hydrogen in Gas Network | Denmark (2/2)

Consequently, the electrolyser system was analysed for performance, and key components were analysed for their conditions after the long idle time. The analysis included the following testing after more than 3 years of idle condition:

- The leak rate was very low, about 2 ml/min, and was fine.
- The performance was reduced, about 50 % of an equivalent new system.
- The most critical component in the electrolyser is the MEA (membrane assembly in the PEM stack). A MEA from a very poorly performing cell was tested in a single cell test set-up. It showed just a limited reduction in performance compared to an equivalent new MEA.
- The poor electrolyser performance cannot be explained by the function of the MEA. The explanation seems to be the contact resistances between layers in the cell assembly where different oxides might have increased the resistance on the contact surfaces.

The partners have decided to continue the operation of the test facility after the project and to increase the hydrogen concentration to 25 mole% in a new test programme.

Partners: Energinet, Evida, IRD Fuel Cells and DGC supported by EUDP

Jesper Bruun Munkegaard Hvid at jbr@energinet.dk https://bit.ly/35N6kVe

Increasing European Emission Reduction Target in 2030 from 40 % to at least 55 %, maybe 60 % - Work in Progress | EU

The European Green Deal - Striving to be the First Climate-Neutral Continent

The European **Commission officially proposed to raise the emission reduction targets in 2030 from 40 % to at least 55 %**. This is a significant increase from today's 40 % target and would set the EU on a credible trajectory towards climate neutrality. The European Commission's impact assessment showed the target is achievable and beneficial for Europe. This proposal now needs to be agreed by National Governments (Council) and the European Parliament in the next months. Members of the European Parliament's environment committee have voted for even more ambitious changes:

The **Parliament's Environment Committee** supports the EU climate law's overall aim for 2050 AND has adopted the **target** for **emissions to be reduced by 60 % in 2030** compared to 1990. It also wants an **interim target for 2040** to be proposed by the Commission following an impact assessment, to ensure the EU is on track to reach its 2050 target.

The Parliament's Environment Committee also requests that the Commission **assesses and proposes amendments to all relevant EU legislation that contributes to reducing greenhouse gas emissions**. It also wants the Commission to **issue a report every two years on the progress made by EU and member states** towards achieving the climate targets. An **independent scientific body should also be created to monitor the progress.**

Contrary to the Commission's proposal, the Parliament's Environment Committee also wants both the EU **and all member states individually to become climate neutral by 2050** and calls for sufficient EU and member state financing to do so. In addition, both the EU and member states should be climate negative after 2050, meaning that they must remove more greenhouse gases than they emit.

The European Green Deal (Source: https://bit.ly/3hLPwQG)

Work in progress: To agree and adopt European legislation, the topic is on track in the trilogue process. 'Trilogue' means the interinstitutional negotiations between the Parliament, the Council and the Commission. Their purpose is to reach a provisional agreement on a text acceptable to both the Council (Member States) and the European Parliament. #fast track legislation. The entire European Parliament will vote on the topic in October 2020. If the negotiations are final by the end of 2020, the results may be integrated in the Paris' negotiations process.

https://bit.ly/2ZQzMpz

EU Strategy for Energy System Integration | European Commission

The Commission communicated in July 2020 in two publications their view and necessary steps to reach climate targets. This and the following article are pointing out some central elements.

Energy system integration – the coordinated planning and operation of the energy system 'as a whole', **across multiple energy carriers, infrastructures, and consumption sectors** – is the pathway towards an effective, affordable and deep decarbonisation of the European economy. It is in line with the Paris Agreement and the UN's 2030 Agenda for Sustainable Development. An integrated energy system will minimise the costs of transition towards climate neutrality for consumers and open new opportunities for reducing their energy bills and active participation in the market.

Investments in energy infrastructure typically have an economic life of 20 to 60 years. The steps taken in the next five-to-ten years will be crucial for building an energy system that drives Europe towards climate neutrality in 2050. Thus, the **strategy proposes concrete policy and legislative measures at EU level** to gradually shape a new integrated energy system, while respecting the differing starting points of Member States. It contributes to the work of the Commission on a comprehensive plan to increase the EU 2030 climate target to at least 55 % in a responsible way and identifies follow-up proposals that will be prepared as part of the legislative reviews of June 2021, announced in the European Green Deal.

The parallel communication 'A hydrogen strategy for a climate-neutral Europe' complements this strategy to elaborate in more detail on the opportunities and necessary measures to scale up the uptake of hydrogen in the context of an integrated energy system. (see article below)

Energy system integration encompasses **three complementary and mutually reinforcing concepts**

1. A more 'circular' energy system, with energy efficiency at its core.
2. A greater direct electrification of end-use sectors.
3. The use of renewable and low-carbon fuels, including hydrogen, for end-use applications where direct heating or electrification are not feasible.

Overall, the transition to a more integrated energy system is projected to **reduce gross inland consumption by a third by 2050, whilst supporting an increase in GDP of two thirds**. Territories, regions and Member States facing the biggest transition challenges will be supported by the Just Transition Mechanism and, as part of it, the Just Transition Fund.

https://bit.ly/3c95a7q

EU Hydrogen Strategy | European Commission (1/3)

"Hydrogen rocks!" - Frans Timmermans, Executive Vice-President of the European Commission responsible for the European Green Deal and the European Climate Law

https://bit.ly/32H8hjV

The EU Hydrogen Strategy acknowledges: Hydrogen is enjoying renewed and rapidly growing attention in Europe and around the world. Hydrogen development is at a tipping point. And **hydrogen is essential** to support the EU's commitment to reach carbon neutrality by 2050 and for the global effort to implement the Paris Agreement while working **towards zero pollution**. It can offer **solutions for hard to abate parts** of the transport system and in some carbon-intensive industrial processes (such as steel and chemical industry). A progressive uptake of hydrogen solutions can also lead to **repurposing or re-using parts of the existing natural gas infrastructure**, helping to avoid stranded assets in pipelines. Hydrogen may further ensure back up for daily and seasonal variations and connecting production locations to more distant demand centres.

The hydrogen strategy presents measures to create the conditions for hydrogen to contribute to decarbonising the economy in a cost-effective way. The **priority** for the EU is to develop **hydrogen production from renewable electricity** which is the cleanest solution. In a **transitional phase** however, other forms of **low-carbon hydrogen** are needed to replace existing hydrogen and kick-start an economy of scale.

Investment

From now to 2030, investments in electrolysers could range between € 24 and € 42 billion. In addition, over the same period, € 220-340 billion would be required to scale up and directly connect 80-120 GW of solar and wind energy production capacity to the electrolysers to provide the necessary electricity. Investments in retrofitting half of the existing plants (mainly SMR) with carbon capture and storage are estimated at around € 11 billion. Moreover, investments of € 65 billion will be needed for hydrogen transport, distribution and storage, and hydrogen refuelling stations. From now to 2050, investments in production capacities would amount to € 180-470 billion in the EU.

EU Hydrogen Strategy | European Commission (2/3)

"Hydrogen rocks!" - Frans Timmermans, Executive Vice-President of the European Commission responsible for the European Green Deal and the European Climate Law

KEY ACTIONS (extract only!)

- **An investment agenda for the EU**
  - ⇒ … (to be developed)
- **Boosting demand for and scaling up production**
  - ⇒ Work to introduce a common low-carbon threshold/standard for the promotion of hydrogen production installations based on their full life cycle GHG performance (by June 2021).
  - ⇒ Work to introduce a comprehensive terminology and European-wide criteria for the certification of renewable and low-carbon hydrogen (by June 2021).
  - ⇒ …
- **Designing an enabling and supportive framework: support schemes, market rules and infrastructure**
  - ⇒ Start the planning of hydrogen infrastructure, including in the Trans-European Networks for Energy and Transport and the Ten-Year Network Development Plans (TYNDPs) (2021) taking into account also the planning of a network of fuelling stations.
  - ⇒ Design enabling market rules to the deployment of hydrogen, including removing barriers for efficient hydrogen infrastructure development (e.g. via repurposing) and ensure access to liquid markets for hydrogen producers and customers and the integrity of the internal gas market, through the upcoming legislative reviews (e.g. review of the gas legislation for competitive decarbonised gas markets (2021).
  - ⇒ …
- **Promoting research and innovation in hydrogen technologies**
  - ⇒ Launch a **100 MW electrolyser and a Green Airports and Ports call** for proposals as part of the European Green Deal call under Horizon 2020 (Q3 2020).
  - ⇒ Establish the proposed **Clean Hydrogen Partnership**, focusing on renewable hydrogen production, storage, transport, distribution and key components for priority end-uses of clean hydrogen at a competitive price (2021).
  - ⇒ Steer the development of **key pilot projects** that support hydrogen value chains, in coordination with the SET Plan (from 2020 onwards).
  - ⇒ Facilitate the demonstration of innovative hydrogen-based technologies through the launch of calls for proposals under the ETS Innovation Fund (first call launched in July 2020).
  - ⇒ Launch a call for pilot action on interregional innovation under cohesion policy on hydrogen technologies in carbon-intensive regions (2020).
- **The international dimension**
  - ⇒ … (strengthen EU leadership, cooperation with Energy Community, Southern and Eastern Neighbourhood partners, and African Union)

Structural Implementation

To support investment and the emergence of a whole hydrogen eco-system, the Commission kick-starts **the European Clean Hydrogen Alliance** – announced in the Commission's New Industrial Strategy. The Alliance will play a crucial role in facilitating and implementing the actions of this strategy and supporting investments to scale up production and demand for renewable and low-carbon hydrogen. It will bring together the industry, national, regional, local public authorities and the civil society. Through interlinked, sector-based CEO round tables and a policy-makers' platform, the Alliance will provide a broad forum to coordinate investment by all stakeholders and engage civil society.

A number of Member States have identified renewable and low-carbon hydrogen as a strategic element of their National Energy and Climate Plans. The Commission will exchange with Member States on their hydrogen plans through the **Hydrogen Energy Network (HyNet).**

Incentives on supply and demand

Increasing supply and demand for hydrogen requires reduced supply costs – through declining costs for clean production and distribution technologies and affordable costs of renewable energy input. Boosting demand and supply of hydrogen is likely to require various forms of support. **Two main lead markets are industrial applications and mobility.**

Demand side support policies will therefore be needed. The Commission will consider **various options** for incentives at EU level, **including** the possibility of minimum shares or **quotas of renewable hydrogen** or its derivatives in specific end-use sectors (for instance certain industries as the chemical sector, or transport applications), allowing demand to be driven in a targeted way. In this context, the **concept of virtual blending** could be explored. 'Virtual blending' refers to a share of hydrogen in the overall volume of gaseous energy carriers (i.e. methane) regardless as to whether these gases are blended physically in the same infrastructure or in separate, dedicated infrastructures.

The Commission will work to swiftly introduce, based on impact assessments, EU-wide instruments. This would include a **common low-carbon threshold/standard for the promotion of hydrogen production installations** based on their full life-cycle greenhouse gas performance. In addition, it would include a **comprehensive terminology and European-wide criteria for the certification of renewable and low-carbon hydrogen.**

Support schemes are likely to be required for some time. A possible policy instrument would be to create tendering systems for **carbon contracts for difference** ('CCfD'). Such a long term contract with a public counterpart would remunerate the investor by paying the difference between the CO_2 strike price and the actual CO_2 price in the ETS in an explicit way, bridging the cost gap compared to conventional hydrogen production. Finally, direct and transparent, **market-based support schemes** for renewable hydrogen, allocated through competitive tenders, could be envisaged e.g. flexibility services, augmenting renewable production levels, reducing burden from renewable incentives.

Development in three phases

In the first phase, from 2020 **up to 2024**, the strategic objective is to **install at least 6 GW** of renewable hydrogen **electrolysers** in the EU and the **production of up to 1 million tonnes** of renewable hydrogen. The short-term plans aim to install electrolysers next to (existing) demand centres, preferably powered directly from local renewable electricity sources. Infrastructure needs for transporting hydrogen will remain limited as demand will be met initially by production close or on site and in certain areas blending with natural gas might occur. Planning of medium range and backbone transmission infrastructure should begin.

EU Hydrogen Strategy | European Commission (3/3)

"Hydrogen rocks!" - Frans Timmermans, Executive Vice-President of the European Commission responsible for the European Green Deal and the European Climate Law

The policy focus will be on laying down the regulatory framework for a liquid and well-functioning hydrogen market and on incentivising both supply and demand in lead markets, including through bridging the cost gap between conventional solutions and renewable and low-carbon hydrogen and through appropriate State aid rules. Enabling framework conditions will push concrete plans for large wind and solar plants dedicated to gigawatt-scale renewable hydrogen production before 2030.

In a second phase, from 2025 to 2030, hydrogen needs to become an intrinsic part of an integrated energy system with a strategic objective to **install at least 40 GW of renewable hydrogen electrolysers by 2030** and the **production of up to 10 million tonnes** of renewable hydrogen in the EU.

In this phase, the need for an EU-wide logistical infrastructure will emerge, and steps will be taken to transport hydrogen from areas with large renewable potential to demand centres located possibly in other Member States. The backbone of a pan-European grid will need to be planned and a network of hydrogen refuelling stations to be established. The existing gas grid could be partially repurposed for the transport of renewable hydrogen over longer distances and the development of larger-scale hydrogen storage facilities would become necessary. International trade can also develop, in particular with the EU's neighbouring countries in Eastern Europe and in the Southern and Eastern Mediterranean countries.

By 2030 the EU will aim at completing an open and competitive EU hydrogen market, with unhindered cross-border trade and efficient allocation of hydrogen supply among sectors.

In a third phase, from 2030 onwards and towards 2050, renewable hydrogen technologies should reach maturity and be deployed at large scale to reach all hard-to-decarbonise sectors where other alternatives might not be feasible or have higher costs.

In this phase, renewable electricity production needs to massively increase as about a quarter of renewable electricity might be used for renewable hydrogen production by 2050. In particular, hydrogen and hydrogen-derived synthetic fuels, based on carbon neutral CO_2, could penetrate more largely across a wider range of sectors of the economy, from aviation and shipping to hard-to-decarbonise industrial and commercial buildings.

The role of infrastructure

Hydrogen may be transported via pipelines, but also via non-network-based transport options, e.g. trucks or ships docking at adapted LNG terminals, insofar as technically feasible. Transport can happen as pure gaseous or liquid hydrogen, or bound in bigger molecules that are easier to transport (e.g. ammonia or liquid organic hydrogen carriers).

The **blending of hydrogen** in the natural gas network at a limited percentage may enable decentralised renewable hydrogen production in local networks in a transitional phase. However, blending is less efficient and diminishes the value of hydrogen. Blending also changes the quality of the gas consumed in Europe and may affect the design of gas infrastructure, end-user applications, and cross-border system interoperability. Blending thus risks fragmenting the internal market if neighbouring Member States accept different levels of blending and cross-border flows are hindered. To mitigate such a situation, the technical feasibility of adjusting the quality and cost of handling the differences in gas quality need to be assessed. Current gas quality standards - national and CEN - would need to be updated. Moreover, reinforcement of instruments may be needed to secure cross-border coordination and system interoperability for an unhindered flow of gases across Member States. These options require careful consideration in terms of their contribution to the decarbonisation of the energy system as well as economic and technical implications.

To facilitate the deployment of hydrogen and develop a market where also new producers have access to customers, **hydrogen infrastructure should be accessible to all on a non-discriminatory basis**. In order not to distort the level playing field for market-based activities, network operators must remain neutral. Third-party access rules, clear rules on connecting electrolysers to the grid and streamlining of permitting and administrative hurdles will need to be developed to reduce undue burden to market access. Providing clarity now will avoid sunk investments and the costs of ex-post interventions later.

Further

The Commission's recovery plan from the COVID-19 crisis highlights clean hydrogen as one of the essential areas to address for the energy transition and mentions a number of possible avenues to support it.

The emergence of a hydrogen value chain serving a multitude of industrial sectors and other end uses could employ up to 1 million people, directly or indirectly. Analysts estimate that clean hydrogen could meet 24 % of energy world demand by 2050, with annual sales in the range of € 630 billion.

This strategy sets out a vision of how the EU can turn clean hydrogen into a viable solution to decarbonise different sectors over time. It identifies the challenges to overcome, lays out the levers that the EU can mobilise and presents a roadmap of actions for the coming years.

https://ec.europa.eu/energy/sites/ener/files/hydrogen_strategy.pdf

Government Strategy on Hydrogen | Netherlands (1/2)

Dutch Hydrogen Strategy - Original Document: "Kamerbrief over Kabinetsvisie Waterstof" 30-03-2020 (Link: https://bit.ly/3kNU3E2)

The Netherlands want to use their unique starting position in the gas value chain to become world leaders in the production and use of green hydrogen.

The Dutch government's hydrogen strategy was officially unveiled on 30th March 2020, with the letter "Hydrogen vision of the Netherlands" presented to the Dutch Parliament. This letter sets out the government's strategy on hydrogen as well as the corresponding policy agenda. This letter constitutes the prelude to the hydrogen programme that is to be jointly outlined and implemented with stakeholders. This programme will align with the ambitions of the Dutch National Climate Agreement on hydrogen.

Alongside green gas, zero-carbon hydrogen forms an inextricable part of a zero-carbon energy system. Zero-carbon gases are needed for some applications and for others constitute a potential cost-effective option alongside other technologies such as electrification. The use of gas is, for example, required to produce very high temperatures in **industry**. In addition, **heavy-duty transport** requires a source of fuel. In parts of the **building sector**, the transition to zero-carbon gas may constitute the most cost-effective method of achieving improved sustainability. It will also be required to supply the **peak load of heat grids and hybrid heat pumps**. Furthermore, gas can be stored effectively for long periods of time (vital with regard to **seasonal storage**) and is relatively easy to transport. Hydrogen specifically has the added benefit of contributing to better air quality.

Several energy scenarios indicate that, within a fully sustainable energy supply by 2050, gaseous energy carriers will provide at least 30 % of final energy consumption. A comparison of seven energy transition scenarios yielded a bandwidth of **337 to 775 PJ of gaseous energy carriers by 2050**. This corresponds to approximately **30 % to 50 % of final energy consumption**. The development of hydrogen supply chains is crucial to the Dutch economy for several reasons. The Dutch economy has a large percentage of energy-intensive industries. In order to retain these kind of industries in the Netherlands, it is crucial that companies should be able to purchase zero-carbon energy carriers at internationally competitive prices. Second, the development of hydrogen supply chains in the Netherlands will lead to opportunities for Dutch companies and knowledge institutions, which will also benefit employment. The Netherlands has a large number of companies in the manufacturing industry, which have the potential to grow into key players in the development of regional and international hydrogen supply chains based on their knowledge in fields, such as industrial gases, advanced materials and chemical processes. **Over 250 companies of Dutch manufacturing industry with operations in the hydrogen sector** have been identified. Furthermore, specifically with regard to ports and the Port of Rotterdam in particular, retaining the current hub function within international energy flows is crucial from a strategic perspective.

Hydrogen has the potential to become a globally traded commodity. Given the significant expected demand for sustainable hydrogen in industry in Northwest Europe, it would therefore be highly advantageous for the Netherlands to become the linchpin in that supply chain and to use existing infrastructure for that purpose.

Regions across the country are currently developing hydrogen clusters. As a result of the Fuel Cells and Hydrogen Joint Undertaking of the EU, the Northern Netherlands region is recognised as the first Hydrogen Valley in Europe. An integrated approach is also being developed in regions, such as Zeeland, Zuid-Holland and Noord-Holland (with the Port of Amsterdam). On a smaller scale, various groups of stakeholders – municipalities, small and medium enterprises, citizens, system network operators, agricultural establishments, among others, are working on innovative hydrogen applications.

The political agenda includes four main pillars:

1. legislation and regulations – including the use of the existing gas network, market organisation, guarantees of origin and certification, guidelines and standards for security, structural planning

2. cost reduction and scaling of green hydrogen – including research, temporary operating aid, support programme, coupling offshore wind and introducing a hydrogen quota of 2 vol% H_2 in the natural gas network, if possible, increase it to 10-20 vol%

3. making end consumption sustainable – over all sectors including transformation of ports and industrial clusters to CO_2 neutral hydrogen, hydrogen (including synthetic fuels) for transport), buildings, electricity production and the agricultural sector.

4. supporting policies – including international strategy, regional policy, R&D and the timeframe for the Dutch hydrogen programme

Government Strategy on Hydrogen | Netherlands (2/2)

Further Selected Details:

- Part of the existing gas grid can be used for the transport of hydrogen.
- Review conditions for transport and distribution in gas grid to enable the supply of hydrogen

Questions & Answers to the Dutch Hydrogen Strategy - Original Document: "Beantwoording Kamervragen over Kabinetsvisie Waterstof" 30-03-2020 (Link: https://bit.ly/307pH7w)

- Development of the North-Western European hydrogen market, which is relevant with a view to the potential hub function played by the Netherlands for provision to neighbouring countries. The connections with and in Germany are of particular interest as well as potential import supply (from overseas territories).
- The future hydrogen market could include both public and private networks.
- Four-year Hydrogen Safety Innovation Programme underway
- Joint planning for gas- and electricity network is crucial that the development of the electricity grid and the hydrogen grid should be effectively coordinated.
- Recognised: The National Climate Agreement includes an ambition to scale up electrolysis to approximately 500 MW of installed capacity by 2025 and 3-4 GW of installed capacity by 2030. This will need support schemes due to the substantial operating cost gap. In addition, the government is considering the options available to realise scaling up and cost reduction by linking the development of offshore wind energy and hydrogen through a **blending obligation.**
- Support scheme: In case of favourable conditions and/or in conjunction with other subsidies, companies will be able to qualify for the SDE++ (national incentive scheme for production of renewables) up to the maximum subsidy amount of € 300 per tonne. For the production of blue hydrogen (where the CO2 is captured during the production of hydrogen from natural gas), CCS will be able to compete in the SDE++ through the CCS category.

Blending Obligation

Mandatory blending of hydrogen in the natural gas grid (either physically or through certificates) is one option to increase hydrogen demand. The blending obligation is an ongoing European discussion in the context of increasing the sustainability of the European gas system. The Renewable Energy Directive also offers room for this option because it is a cost-effective and flexible way to support the scaling up of green hydrogen. Physical **blending up to 2 vol% is already achievable** with minor adjustments, and with further adjustments, the percentage could **gradually be increased to approximately 10-20 vol%**.

Final Hydrogen Consumption

For **various forms of final consumption**, zero-carbon hydrogen is one of the options that can lead to sustainability improvements. A key process in this context is the implementation of the Renewable Energy Directive. The national government is committed to ensuring that the forthcoming effects of the Directive are useful and stimulating for hydrogen. This is particularly important with regard to the applications in industry (including in refineries) and in mobility. Special focus is paid to **ports and industry clusters, hydrogen (including synthetic fuels) and zero emissions policies for transport, building (heating), electricity sector (flexibility), and agricultural sector.**

The Netherlands is firmly committed to a European blending obligation for aviation. In the event that this should not be feasible, the government will pursue a national obligation as of 2023.

National Hydrogen Programme

The National Climate Agreement includes an agreement to formulate a **National Hydrogen Programme.** This programme will be adaptive in nature and in principle be based on the hydrogen phasing plan **leading up to 2030** that is included in the National Climate Agreement.

The text of the Dutch Hydrogen Strategy often refers to the National Climate Agreement. The impression occurs that many measures / goals are already settled in the Climate Agreement. The letter (20 pages) in combination with a 55 pages document with questions and answers are the binding and leading documents for future activities in the Netherlands.

Strategy (English translation), Q&A (in Dutch; easy to translate with deepl.com)

HIPS-NET Organisational Matters | Gert Müller-Syring (DBI, Germany)

The first online HIPS-NET workshop took place in June 2020. Gert presented the working plan for the running year, the year ahead of us and shared central organisational matters with us. The **working plan for the running year**, year 7, is well under-way. The HIPS-NET team @DBI is covering the mandatory scope. The annual meeting took place via zoom due to Covid19 restrictions.

Special action this year is the updated power to gas map. We are proud to have it online. Many hours of research and layout resulted in an interactive map. Gert distributed it August 8th as e-mail, Josephine is tak-ing care of adjustments where needed. You may find the inter-active map on our HIPS-NET homepage and is accessible to everyone in the public area.

The working plan for next year (October 2020 until September 2021) is set as usual with newsletters, the HIPS-NET meeting and further activities. We are hoping to meet you in Brussels in the GERG office but it is too early to guess about future developments. Additional scope – if budget will be available: Your feedback to ideas are visible in the figure (on the right side). 14 members gave their opinion and they are rather re-luctant in terms of website update/relauch. Clear support is visible for a list of studies and the suggestion to add another core topic: pure hydrogen networks.

We transparently share the annual income and expenses in the HIPS-NET status report. Gert gave a short overview and outlook. You may find it in Gert's presentation, on the website (partners area) and received it via e-mail on March 3rd 2020 for the previous year.

HIPS-NET continuously increases the number of partners – we are 40 organisations at the moment. TNO joined the group in 2020 and Néstor González Díez from TNO supported the workshop with an interesting presentation (see summary be-low).

Many thanks for your continuous support throughout the past 7 years and are looking forward to accompanying future de-velopments around hydrogen in gas systems with you.

Hydrogen Embrittlement | Alfons Krom (Gasunie, Netherlands)

Alfons explained us to very detail the process of hydrogen embrittlement and decisive fac-tors. The presentation is worth reading if this topic is of interest to you and so are the links to short videos. It is full of test results and details physical explanations. Alfons conclud-ed: "Where hydrogen gas is being transported in pipelines at ambient temperatures and moderate pressures, the relevant hydrogen degradation mechanism is hydrogen-enhanced fatigue crack growth. When taking this degradation mechanism into account, 100% hydrogen gas up to the design pressure can be transported in existing natural gas pipelines without affecting the integrity of the pipeline during its lifetime." But there are questions re-maining for safe transport i.e. tightness of valves, and flanges, lower ignition energy, welding on live pipeline (hot tapping).

A.H.M.Krom@gasunie.nl

Importance of Blending - How to Convince Sceptics?
Eva Hennig (Thüga Group, Germany)

Eva encourages us to emphasise the advantage of hydrogen admixture, as this is not sufficiently known on European level. The European green deal recognises the role of hydrogen to a large extend but refers to blending it "deserves careful consideration". The chances of blending are not known; awareness of the scientific information of Marcogaz, GERG and many others are missing, it seems.

She further stresses the need to coordinate activities on EU level, on national level and between TSO and DSO level to convert pipelines to hydrogen. The need for gas DSO smart grid eligibility is important as well to track the changing gas qualities. So far, this is only open to electricity DSO in the TEN-E revision process; and should be extend to gas. One additional important point is the restriction on financing new tranches of the gas grid for H_2; this is currently not foreseen and needs to be included as well.

There is an urgent need to raise activities to promote hydrogen, to share existing knowledge, in order to ensure the gas energy transition will take place with gas networks. Eva is an expert, very active on many venues and is startled how little is known about hydrogen. A very short, very dense and very informative presentation. Have a read if you can support lobbying activities to raise awareness.

eva.hennig@thuega.de

Hydrogen Offshore & Inline Gas Sensor
Néstor González Díez (TNO, Netherlands)

The exiting plans to reuse former oil & gas production infrastructure to produce hydrogen offshore may be known to some of us. We learned, the North Sea is crowed with many interests and functions that need to be balanced in the energy transition. More than 30 partners gathered its activities in the North Sea Energy Program to integrate offshore wind and gas. A specific project in which electrolysis will be placed offshore is called POSHYDON. Néstor gave with his presentation further insights.

He caught a lot of attention when he told us about a cost-effective, inline gas composition monitoring device. This is under development as suitable sensors are currently missing. The gas composition sensor will collect data about the gas composition with the help of 8-10 chips, containing capacitive electrodes and responsive coating. The sensor reads a variety of gas components. The integrated H_2 sensor is aimed to operate between 0.1—90 vol%. Get in touch if this is of interest for you.

nestor.gonzalezdiez@tno.nl (offshore topics) | huib.blokland@tno.nl (sensor)

Hydrogen Admixture in French Gas Network
William Rahain (Teréga, France)

William gave us insights to the view of French gas operators to the future integration of hydrogen in the gas network. In the **short term**, blending of **6 vol% hydrogen** is feasible. By **2030**, they recommend the targets: **10 vol%** and then **20 vol% beyond**. The French gas operators need to mobilise solutions for blending, methanation and deployment of 100 % hydrogen clusters on certain meshes by conversion of structures or creation of new networks.

The vision is to integrate a significant volume of hydrogen into the 2050 gas mix with limited infrastructure adaptation costs. The targets rely on a report (link) and supplement the Hydrogen Plan of France (link), and many projects in France. See for more detail the presentation of William and the Q&A of him distributed by Gert on July 9th.

william.rahain@terega.fr

Outlook 29th HIPS-NET Newsletter

… IEA Energy Technology Perspectives 2020, issued in September 2020

… Infrastructure Outlook and Pathways to 2050 – two publications to integrate the future electricity and gas planning in the region Netherlands and Germany

… Canadian Hydrogen Strategy

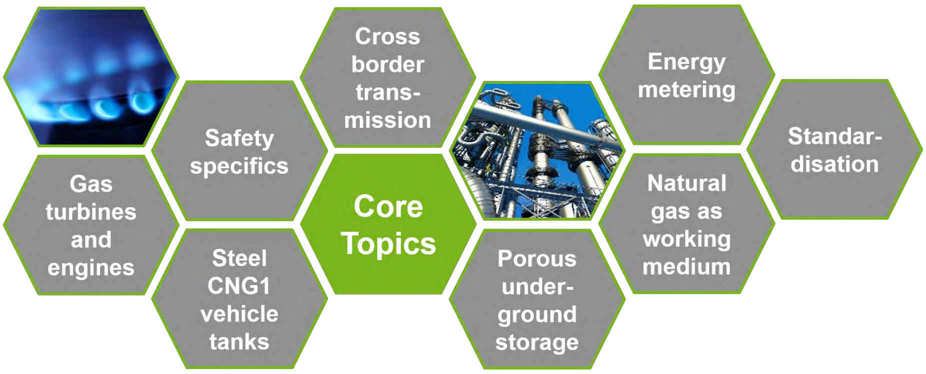
… Australian Hydrogen Strategy

… and many more

HIPS-NET CORE TOPICS

We gather and disseminate the latest available knowledge to improve the understanding of hydrogen/natural gas blends in pipeline systems with emphasis on the core topics:

We additionally keep a minor focus on the general development of power-to-gas, hydrogen networks, and further topics around the utilisation of (renewable) hydrogen.



EVENTS AND PARTNERS

Selection of Appointments

October 2020

08 Compressor Day 2020 | Übach-Palenberg, Germany, *https://eneargy.com/compressor-day-2020/*

8-09 Hydrogen Online Conference | online conference, *https://hydrogen-online-conference.com/*

20-22 Center for Hydrogen Safety Europe Conference 2020 | online conference, *https://bit.ly/2GcE2bJ*

20-23 14th European SOFC & SOE Forum | Lucerne, Switzerland, *www.efcf.com/2020*

24-25 Update: FCH JU Stakeholder Forum | Brussels, Belgium, *https://bit.ly/3hvMvoP*

25-26 European Conference Hydrogen & P2X | Copenhagen, Denmark, *https://fortesmedia.com/hydrogen-p2x-2020,4,en,2,1,4.html*

November 2020

03-04 6th HYPOS-Forum| Dresden, Germany, *http://www.hypos-eastgermany.de/*

10-11 DBI-Fachforum Wasserstoff & Brennstoffzellen | Duisburg-Oberhausen, Germany, *https://bit.ly/30Il585*

February 2021

10-11 HyVolution | Paris, France, *www.hyvolution-event.com*

10-11 Hypothesis XV | Muscat, Oman, *www.hypothesis.ws*

March 2021

3-4 Hydrogen Summit 2021 | Munich, Germany, *https://gasworldconferences.com/conference/hydrogen-summit-2020/*

16-18 Energy Storage Europe | Düsseldorf, Germany, *https://www.eseexpo.de/*

Current Partners

Alliander AG, Areva H2Gen,
Cadent, DGC, DNV GL, Enagás,
Enbridge, Energinet.dk, ENGIE,
EWE Netz, Gas Connect Austria GmbH,
Gasnetz Hamburg, Gasum OY,
Gasunie, GRTgaz, GRZI e.V. (figawa),
Infraserv GmbH & Co. Höchst KG,
INERIS, innogy SE, ITM Power,
Joint Research Centre (JRC), EC,
KOGAS, NAFTA a.s,
Naturgy, ONTRAS, ÖVGW,
Open Grid Europe GmbH,
Polymer Consult Buchner GmbH,
RAG Austria AG,
Shell, Solar Turbines Europe S.A.,
Storengy, SVGW,
Synergrid, Teréga, TNO,
Uniper Energy Storage GmbH,
Verband der Chemischen Industrie (VCI),
Volkswagen AG, Wintershall Dea AG.

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Certified DIN EN ISO 9001:2015

HIPS-NET

"ESTABLISHING A PAN-EUROPEAN UNDERSTANDING OF ADMISSIBLE HYDROGEN CONCENTRATION IN THE NATURAL GAS GRID"

NEWSLETTER #29 **OCTOBER, 2020**

*"These are **historical times** in the energy sector, where the future is not something that we contemplate from a far, but something we must strive to enable and create now and with a sense of urgency. **Hydrogen will only be the future, if we commit to it now, in the present.** Not this or that company, not this or that set of companies, and surely not this or that country individually, but **collectively, collaboratively. In sense: together**."*

João Galamba, Deputy Minister and State Secretary for Energy of Portugal
World Hydrogen Fuel Cells Summit, Amsterdam 11th March 2020

Dear HIPS-NET Partners,

Design news first — please have a glance at our new logos on page 13 to 15 ☺.

And as usual – the informative part: Our 29th edition summarises articles about

- IEA Energy Technology Perspectives 2050 | worldwide
- European Hydrogen Backbone —TSO Vision of a Hydrogen Network | Europe
- Hydrogen Strategy of Portugal
- Study: Infrastructure Outlook 2050 & Pathways to 2050 | Netherlands & Germany
- HIGGS Project First Steps

The **HIPS-NET workshop 2021** is scheduled for **16th/17th of June**. Robert Judd once again invites us to Brussels. We are kindly asking to save these dates in your calendar. We hope for a live meeting next year … time will show what will be realistic.

SAVE THE DATE!

2021

16th/17th

June

NEXT HIPS-NET Workshop in Brussels

Stay healthy! We send you warm greetings.

Your HIPS-NET Team
Gert, Anja, and Josephine

CONTENT

CONTENT NEWSLETTER #29

IEA Energy Technology Perspectives 2020 | worldwide (1/4)

The World's Guidebook on Clean Energy Technologies - International Energy Agency (IEA)

"In 2019, CO_2 emissions from fossil fuel combustion reached more than 33 gigatons (Gt) - a record high." p. 31

With **global carbon emissions at unacceptably high levels**, structural changes to the energy system are required to achieve the rapid and lasting decline in emissions called for by the world's shared climate targets. The IEA's Energy Technology Perspectives **analyses more than 800 different technology** options to assess what would need to happen **to reach net-zero emissions by 2070** while ensuring a resilient and secure energy system.

The report finds that **transitioning just the power sector** to clean energy would get the world **only one-third of the way** to net-zero emissions. Completing the journey will require devoting far more attention to the transport, industry and buildings sectors, which today account for about 55 % of CO_2 emissions from the energy system.

First issued in 2006, the report 'Energy Technology Perspectives' has for more than a decade contributed to global energy and environmental policy-making. To further strengthen its relevance to decision-makers in governments and industry, the IEA has revamped the publication in 2020 with a focus on technology opportunities for reaching international climate and sustainable energy goals. The flagship report - Energy Technology Perspectives 2020 (ETP 2020) - offers vital analysis and advice on the clean energy technologies the world needs to meet net-zero emissions objectives.

2 + 1 Scenarios in line with Paris Agreement and WEO 2019

The ETP 2020 report employs two scenarios to describe possible energy technology pathways over the next half century. The *Sustainable Development Scenario* – the focus in this report – sets out the **major changes** that would be **required to reach** the key energy-related goals of the **United Nations Sustainable Development Agenda**, **including** an early peak and rapid subsequent reductions in emissions in line with the **Paris Agreement**. The Sustainable Development Scenario aims to reach global net-zero CO2 emissions by around 2070. The *Stated Policies Scenario* takes into account energy- and climate-related policy commitments already made or announced by countries, including the Nationally Determined Contributions under the Paris Agreement. The Stated Policies Scenario provides a baseline from which we assess the **additional policy actions and measures needed** to achieve the key energy and environmental objectives incorporated in the Sustainable Development Scenario. The **scenarios** are broadly **consistent with** those presented in the 2019 edition of the IEA's flagship publication, **World Energy Outlook (WEO 2019)**, however the time horizon is extended to 2070 to underpin a more technology focussed view of the energy system. An additional *Faster Innovation Case* explores the technology needs for reaching net-zero emissions by 2050.

Technology needs and energy transformations for net-zero emissions

An energy sector transition to net-zero CO2 emissions by 2070 of the kind depicted in the Sustainable Development Scenario **requires a radical** technological **transformation** of the energy sector. **Energy efficiency and renewables are central pillars**, but **additional technologies are needed** to achieve net-zero emissions. Four technology value chains contribute about half of the cumulative CO_2 savings:

- technologies to widely electrify end-use sectors (such as advanced batteries);
- carbon capture, utilisation and storage (CCUS);
- hydrogen and hydrogen-related fuels;
- and bioenergy.

Success depends upon a wide range of fuels and technologies, tailored to individual parts of the energy sector and to country-specific circumstances. The share of electricity in final energy demand grows from one-fifth today to nearly 50 % in 2070 in the Sustainable Development Scenario. **Electricity** demand **expands** by 30,000 TWh, which means that **each year** to 2070 sees electricity demand equivalent to the current annual demand of Mexico and the United Kingdom combined **be added** to the world power system, pushing far more use of solar, wind and other renewables, as well as nuclear power. About 70 % of the growth is to satisfy rising electricity demand in end-use sectors, and 30 % is to produce low-carbon fuels, in particular hydrogen.

Global **hydrogen production grows by a factor of seven** to 520 Mt in 2070. Hydrogen use expands to all sectors and reaches a share of **13 % in final energy demand** in 2070. Around 300 Mt of hydrogen are produced from electrolysers in 2070 in the Sustainable Development Scenario. This requires 13,750 TWh of electricity, equivalent to half of global electricity generation today. **Electrolyser capacity rises from 170 MW today to more than 3,000 GW by 2070**. Hydrogen production with CCS also plays an important role in regions with low cost gas resources and available CO_2 storage. The development of technologies at the demonstration and prototype stage today leads to **hydrogen and hydrogen-based fuels becoming important** for the decarbonisation of **heavy trucks, aviation and shipping** as well as for the **production of chemicals and steel**.

Technology needs for heavy industries

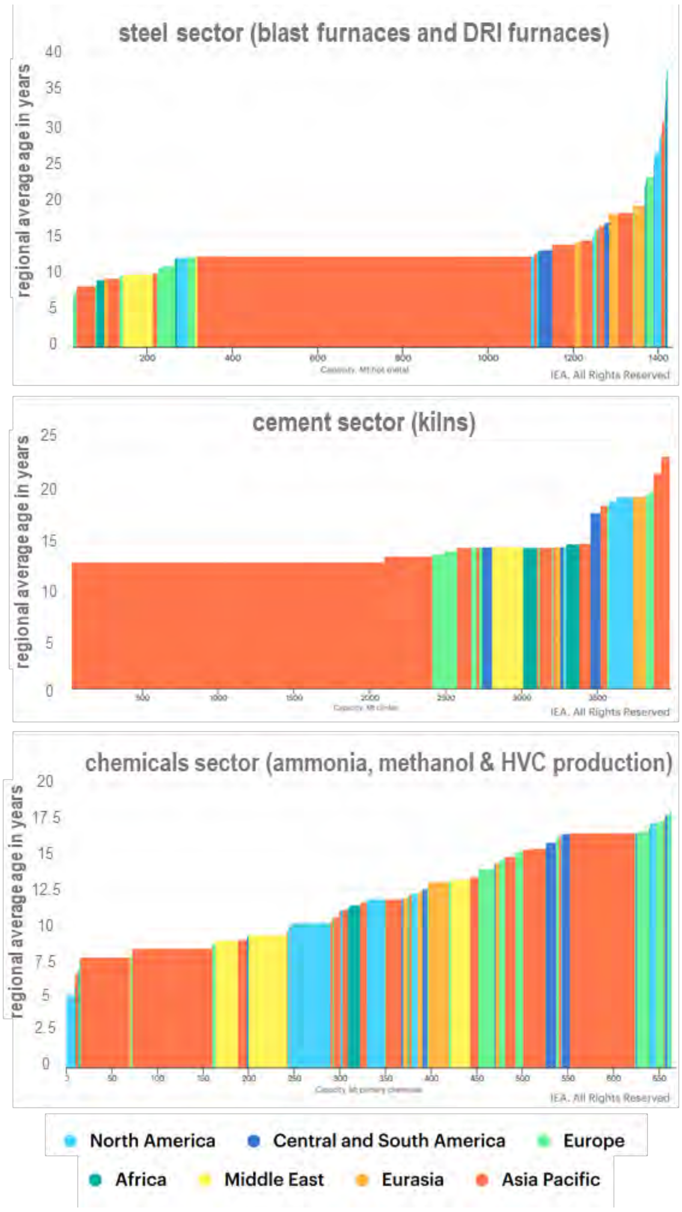
Three heavy industries – chemicals, steel and cement – account for **over half of industrial energy use and around 70 % of direct CO_2 emissions** from industry.

Emissions from existing assets are a **pivotal challenge**. Many existing energy assets are still young, particularly in Asia, and could operate for decades to come.

IEA Energy Technology Perspectives 2020 | worldwide (2/4)

The World's Guidebook on Clean Energy Technologies - International Energy Agency (IEA)

The global average age is 10-15 years, compared with a typical lifetime of 30 years for chemical plants and 40 years for steel and cement plants (see diagrams below). The situation underscores the need for hydrogen and CCUS technologies. Ensuring that new clean energy technologies are available in time for key investment decisions will be critical. In heavy industries, for example, strategically timed investments could help avoid around 40 % of cumulative emissions from existing infrastructure. The report emphasises: Governments will need to play the decisive role in supporting transitions towards net-zero emissions.



Age Profile of Global Production Capacity for Three Sectors (Source: https://bit.ly/3LFWMzV)

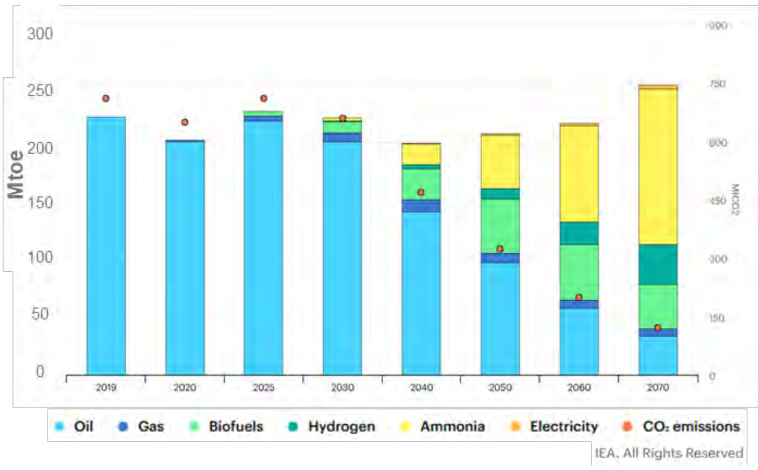
Carbon capture utilisation and storage (CCUS) and electrolytic hydrogen play leading roles, with an average of about 75 plants incorporating CCUS and 20 plants incorporating low-carbon hydrogen **being added each year from 2030**.

Technology needs in long-distance transport

In 2019, **transport** accounted for nearly 30 % of global final energy use and **23 % of total** energy sector **direct CO_2 emissions**. Reducing oil use and CO_2 emissions in long-distance transport modes – heavy-duty trucking, maritime shipping and aviation – is particularly difficult because of their energy and power density requirements.

In trucking, electricity and hydrogen dominate the fuel mix in 2070, powering vehicles that no longer rely on internal combustion engines. This depends on rapid developments in batteries and fuel cells, as well as massive investment in new infrastructure, including hydrogen refuelling stations, fast chargers for electric trucks and electric road systems (which power vehicles as they drive).

In maritime shipping, biofuels, ammonia and hydrogen meet more than 80 % of fuel needs in 2070, using around 13 % of the world's hydrogen production (see diagram below).



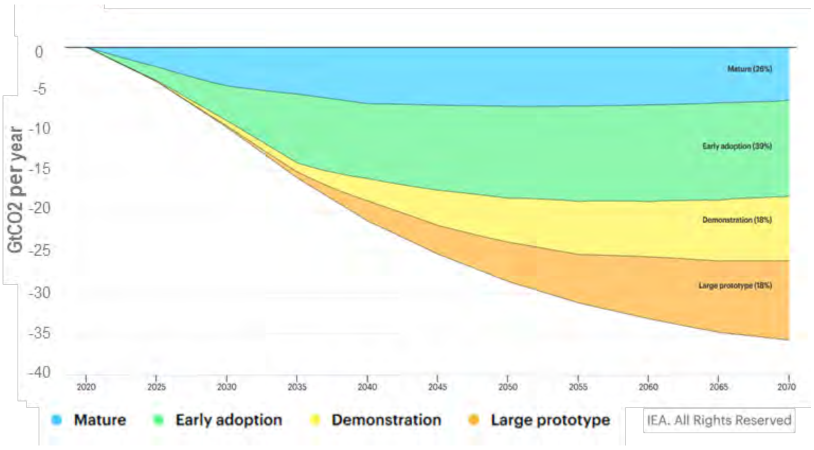
Global Energy Consumption and CO_2 Emissions in International Shipping in the Sustainable Development Scenario, 2019-2070 (Source: https://bit.ly/3dpOrxe)

Clean energy innovation

Innovation is an uncertain and competitive process in which technologies eventually pass through four stages: prototype, demonstration, early adoption and maturity. Governments have a particularly central and wide-ranging role to play in this process that goes far beyond the provision of funds for R&D. In the Sustainable Development Scenario, almost 35 % of the cumulative CO_2 emissions reductions by 2070 compared with the Stated Policies Scenario come from technologies that are currently at the prototype or demonstration phase which will not become available at scale without further R&D. About 40 % of the cumulative emission reductions rely on technologies that have not yet been commercially deployed in mass-market applications (see diagram on the next page).

IEA Energy Technology Perspectives 2020 | worldwide (3/4)

The World's Guidebook on Clean Energy Technologies - International Energy Agency (IEA)



Global Energy Sector CO_2 Emissions Reductions by Current Technology Maturity Category in the Sustainable Development Scenario Relative to the Stated Policies Scenario, 2019-2070 (Source: https://bit.ly/3LHZTBE)

Making the transition to clean energy

Making a path to net-zero emissions requires governments to establish a long-term vision for their energy sector to guide future expectations and build investor confidence, and to support the strategy by tracking progress, re-prioritising as necessary, and communicating expectations and progress effectively. Effective policy toolkits must be built around five core areas:

1. **Tackle emissions from existing assets**. Much of the existing capital stock will remain in operation decades into the future, but there is scope to retire some assets early or re-purpose them, taking advantage of investment cycle timetables.
2. **Strengthen markets for technologies at an early stage of adoption**. It is for governments to set the framework for markets; they can maximise the contribution from private capital with appropriate instruments and incentives.
3. **Develop and upgrade infrastructure** that enables technology deployment. Careful strategic planning is necessary to avoid bottlenecks in the deployment of clean energy technologies.
4. **Boost support for research, development and demonstration**. Achieving net-zero emissions requires rapid progress in developing new early stage technologies. Options range from increased public R&D funding to support for large-scale demonstrators.
5. **Expand international technology collaboration**. The scale and urgency of the challenges mean that there is a strong case for international co-operation which can make use of existing multilateral forums.

Economic stimulus measures and recovery plans in response to the Covid-19 pandemic offer an opportunity to take action that would boost the economy while supporting clean energy and climate goals, including action in these five areas.

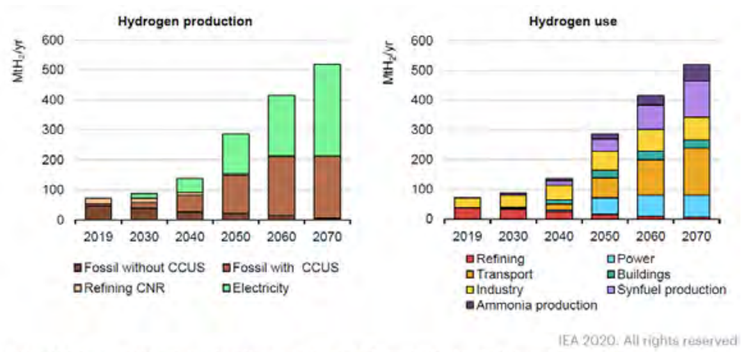
2070? 2050!

The blistering pace of technological transformation that would be necessary for the world to reach net-zero emissions by 2050 is explored in the report's **Faster Innovation Case**. It finds that to meet the huge increase in demand for electricity, additions of renewable power capacity would need to average around four times the current annual record, which was reached in 2019.

The power sector would need to decarbonise sooner while generating additional electricity of nearly 20,000 TWh in 2050 relative to the Sustainable Development Scenario (a 35 % increase) to support higher electricity demand, including higher need for hydrogen and synthetic fuels. Average annual renewable capacity additions to 2050 would be 770 GW, almost 50 % above the Sustainable Development Scenario. Additional demand for alternative fuels would be almost 20 % higher: hydrogen demand would rise by more than 50 %, requiring nearly 50 GW of additional electrolyser capacity each year.

Hydrogen deployment in the final picture 2019 - 2070

Industry accounts for 15 % of hydrogen use in 2070, mostly for chemicals and iron and steel; the power sector accounts for almost 15 %, which supports flexible electricity generation; and the **buildings sector accounts for 5 %**, which is used for space and water heating, **5 %** in the form **of hydrogen blended** together with natural gas and biomethane in the gas grid, and 95 % in the form of pure hydrogen transported in new pipelines or in converted natural gas pipelines. See diagrams below for more detail.



Notes: CCUS = carbon capture, utilisation and storage. *Refining CNR* refers to the production of hydrogen as a by-product of catalytic naphtha reforming in refineries. *Ammonia production* refers to the fuel production for the shipping sector. Hydrogen use for industrial ammonia production is included within the industry use.

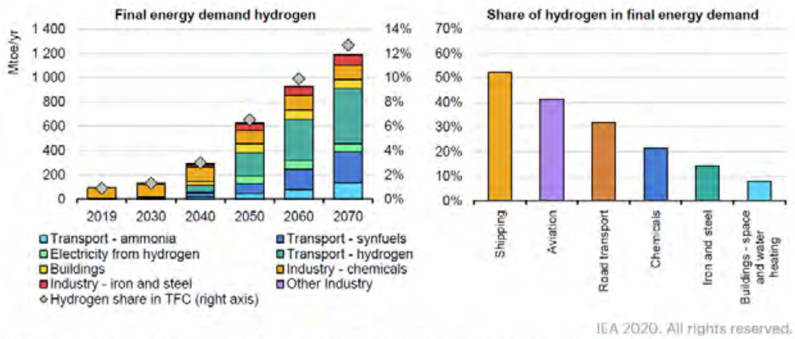
Global Hydrogen Production by Fuel and Hydrogen Demand by Sector in the Sustainable Development Scenario, 2019-70 (Source: report, p. 110)

In the Sustainable Development Scenario, **hydrogen and hydrogen-based fuels** account in 2070 for **13 % of all final energy needs**, compared to around 1 % in 2019 with most of these fuels being used in transport and industry. **Transport** accounts for 70 % of the use of these fuels in 2070, which meet significant shares of the final energy demand for different transport modes: 52 % for shipping, 40 % for aviation and a third for road transport.

IEA Energy Technology Perspectives 2020 | worldwide (4/4)

The World's Guidebook on Clean Energy Technologies - International Energy Agency (IEA)

Industry accounts for approaching 20 % of the use of these fuels in 2070, with the introduction of hydrogen as a reducing agent in steel production being the main driver for growth in industrial hydrogen demand. See diagrams for further detail.



Notes: TFC = total final consumption. *Synfuels* refer to synthetic hydrocarbon fuels produced from hydrogen and CO_2. Shares of hydrogen in the final energy demand include for transport modes ammonia and synthetic hydrocarbon fuels.

Global Final Energy Demand for Hydrogen by Sector and Share of Hydrogen in Selected Sectors in the Sustainable Development Scenario (Source: report, p. 111)

Hydrogen blending in gas networks

Hydrogen blended into natural gas networks or supplied to buildings through dedicated networks **accounts for only about 1.5 % of the total reduction** in cumulative emissions related to heat in buildings in the period to 2070 in the Sustainable Development Scenario relative to the Stated Policies Scenario. This small contribution is explained by a phase-out of natural gas boilers as **blending rates do not exceed 6-7 % in energy content (and 20 % in volume)**, and that supply limitations of biomethane make it challenging to decarbonise the remaining emissions from heat in buildings. Since the direct use of hydrogen in fuel cells or hydrogen boilers is typically much more energy intensive than low-carbon heating alternatives, their use is limited to regions with existing gas infrastructure and/or in very cold climates (e.g. Russia, Canada) and poorly insulated buildings in the case of hydrogen boilers.

Global average **blending** shares for **biomethane** into natural gas networks reach 8 % in 2040 and 16 % in 2070.

ETP report issued in September 2020 https://bit.ly/35xuv8h

An ETP special report on Accelerating Clean Energy Technology Innovation was issued in July 2020. The ETP special report does not focus blending but it recommends building enabling infrastructure. One proposed action is: Policy to modify gas networks to be ready to accept hydrogen. Even though, we will not summarise the report, we want to give a brief reference here for interested colleagues.

European Hydrogen Backbone - TSO vision | Europe (1/4)

How a dedicated hydrogen infrastructure can be created ...

A group of eleven European gas transmission system operators from ten European countries presented in July 2020 a plan to create a dedicated hydrogen pipeline network of almost 23,000 km by 2040, to be used in parallel to the natural gas grid. They call their vision the "European hydrogen backbone" – a vision for a truly European undertaking, connecting hydrogen supply and demand from north to south and west to east.

Hydrogen Backbone Vision

The companies foresee a network gradually emerging from the mid-2020s onwards to an initial **6,800 km pipeline network by 2030**, connecting 'hydrogen valleys'. **By 2040, a hydrogen network of 23,000 km** is foreseen, **75 %** of which will consist of **converted natural gas pipelines**, connected by **new pipeline stretches (25 %)**. Likely additional routes through countries not (yet) covered by the hydrogen backbone initiative are included as dotted lines (see figure 2040). Further network development is expected up to 2050. Ultimately, two parallel gas transport networks will emerge: a dedicated hydrogen and a dedicated (bio)methane network. The hydrogen network can be used for large-scale hydrogen transport over longer distances in an energy efficient way, also taking into consideration hydrogen imports.

2040' Vision of the Hydrogen Backbone (Source: report, p. 8)

Creating this network has an estimated cost of €27 to €64 billion, which is relatively limited in the overall context of the European energy transition. The **levelised cost** is estimated to be between **€0.09-0.17 per kg of hydrogen per 1,000 km**, allowing hydrogen to be transported cost-efficiently over long distances across Europe.

European Hydrogen Backbone - TSO vision | Europe (2/4)

How a dedicated hydrogen infrastructure can be created ...

The relatively wide range in the estimate is mainly due to uncertainties in (location dependent) compressor costs.

Pipeline transport of hydrogen can either take the form of **blending** shares of hydrogen with methane or can be dedicated hydrogen transport. Blending makes sense when hydrogen volumes are small, especially during the 2020s. When hydrogen volumes increase while transported volumes of natural gas decrease, dedicated hydrogen transport will emerge, initially connecting industrial clusters and later connecting regional and national hydrogen infrastructures.

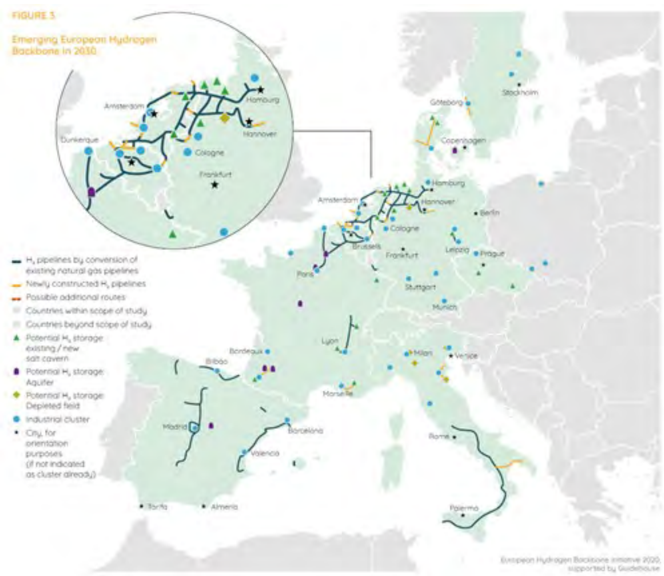
European Hydrogen Strategy

The European Commission has a clear ambition to stimulate the scale-up of hydrogen already before 2030, as highlighted in its Hydrogen Strategy and Energy Integration Strategy (see newsletter #28). There is a great potential for renewable and low-carbon hydrogen to be produced in large volumes domestically within the European Union. By 2030, electrolyser capacity may reach 40 GW and produce around 100 TWh of renewable hydrogen within Europe. In addition, 80 TWh blue hydrogen may be produced by 2030, including retrofitted grey hydrogen production plants as well as newly built blue hydrogen facilities.

Emerging European Hydrogen Backbone in 2030

The backbone vision in 2030 includes the proposed Dutch and German national hydrogen backbones, with additional branches extending into Belgium and France. Furthermore, unconnected regional networks are likely to emerge in Italy, Spain, Denmark, Sweden, France, and Germany (see figure 2030 below).

The emerging backbone in 2030 is mainly based on retrofitted natural gas infrastructure. Retrofitting is often achieved through conversion of existing pipelines where parallel (“looped”) routes are available. This is the case in areas in the Netherlands, Germany, France, Spain, and Italy, where pipeline availability is not constrained by long-term natural gas commitments and capacity contracts. Pipeline costs are limited given that most of the network will be retrofitted.

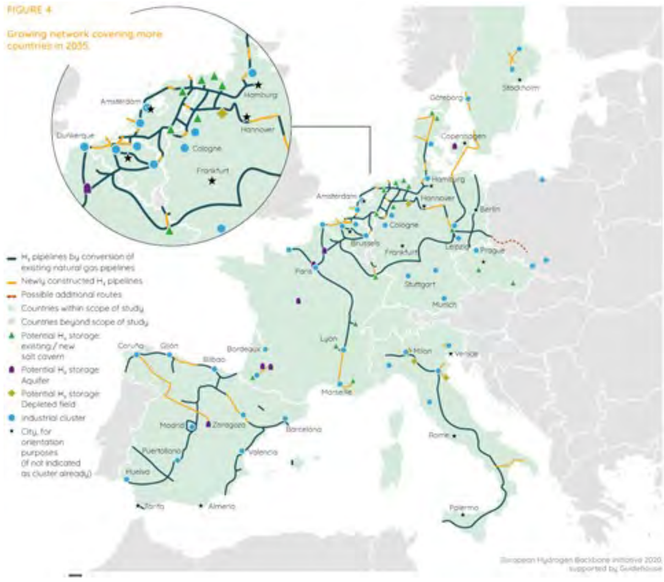


2030’ Vision of the Hydrogen Backbone (Source: report, p. 5)

Regional backbones are expected to form in and around first-mover hydrogen supply and demand hubs, or “hydrogen valleys”. These include industrial clusters, ports, cities, and other regions that are already embracing pilot projects and commercial hydrogen developments today.

European Hydrogen Backbone in 2035

Between 2030 and 2035, the European Hydrogen Backbone will continue to grow, covering more regions and developing new interconnections across Member States (figure 2035).



2035’ Vision of the Hydrogen Backbone (Source: report, p. 7)

Core Hydrogen Backbone in 2040

A ‘core European Hydrogen Backbone’ means a pan-EU hydrogen infrastructure with large corridors connecting the majority of West-European countries as well as valuable extensions into Central and Eastern Europe by 2040 (figure 2040 previous page). The 22,900 km pipeline system with a fit for purpose and technically robust compression system, should be able to adequately meet the 1,130 TWh of annual hydrogen demand in Europe by 2040.

Network optimisation – Compression is a Major Factor

Hydrogen can be transported through pipelines that were built for natural gas. The pipelines themselves need little modification, and new stretches of dedicated hydrogen pipeline do not differ a lot from natural gas pipelines. However, depending on the capacity at which the pipeline is operated, major modifications on the compressor stations may be needed.

Hydrogen has a lower energy density than natural gas: at the same pressure, a cubic meter of hydrogen only contains 1/3 of the energy of a cubic meter of natural gas. However, this

European Hydrogen Backbone - TSO vision | Europe (3/4)

How a dedicated hydrogen infrastructure can be created ...

does not mean that three times as many pipelines are required to transport the same amount of energy. The **volume flow of hydrogen** can be **higher** than for natural gas, bringing the **maximum energy capacity of a hydrogen pipeline to a value of up to 80 % of the energy capacity it has when transporting natural gas**. That way, a 48-inch pipeline, one of the widest pipeline types in the intra-EU gas network, can transport around 17 GW_{LHV} in hydrogen, and a 36-inch pipeline can transport around 9 GW_{LHV}.

The greater compression efforts impact the suitability of existing compressor types. The views vary amongst TSOs and compressor OEMs. Whereas some see a potential to retrofit existing stations, other studies suggest that existing stations may not be fit for hydrogen's higher gas volumes.

The network design can be further optimised. Exploratory analysis by gas TSOs shows that operating hydrogen pipelines at less than their maximum capacity, e.g. 13 GW_{LHV} for a 48-inch pipeline and 7 GW_{LHV} for a 36-inch pipeline gives much more attractive transport costs per MWh transported as additional expensive high capacity compressor stations and corresponding electricity consumption can be avoided. The fixed pipeline-related costs per MWh obviously increase, yet compressor costs and the corresponding cost of the energy fall sharply.

For new stretches, the picture is similar, meaning that when more than 13 GW_{LHV} of transport capacity is required on a route with one 48-inch hydrogen pipeline, it can be more attractive to partly build a second one with the same or even larger capacity rather than investing in expensive compressors to ramp up the capacity of the first pipeline. The **concept of compression versus pipeline dimension**, while considering the characteristics and availability of the existing gas network, is **one of the main levers for cost optimisation**.

		Low	Medium	High
Pipeline cost	€ billion	17	23	28
Compression cost	€ billion	10	17	36
Total investment cost	**€ billion**	**27**	**40**	**64**
OPEX (excluding electricity)	€ billion/year	0.7	0.9	1.1
Electricity costs	€ billion/year	0.9	1.2	2.4
Total OPEX	**€ billion/year**	**1.6**	**2.1**	**3.5**

Estimated Investment and Operating Costs of the 22,900 km European Hydrogen Backbone (2040) (Source: report, p. 12)

		Low	Medium	High
Levelised cost, 100% new infrastructure	€/kg/1000km	0.16	0.20	0.23
Levelised cost, 100% retrofitted infrastructure	€/kg/1000km	0.07	0.11	0.15
Levelised cost, European Hydrogen Backbone (75% retrofitted)	**€/kg/1000km**	**0.09**	**0.13**	**0.17**

Estimated Levelised Cost of Hydrogen Transport Through Pipeline Infrastructure (Source: report, p. 12)

Further options for network optimisation

One example: **inner coating of an existing natural gas pipeline** – though not technically required – might allow for higher pressures when switching to hydrogen. The optimisation between the additional cost of coating and the higher relative pressures that it enables is expected to be route-specific.

It can further be explored whether **electrolysers can inject hydrogen** into the pipeline **with a high pressure**. At reduced capacity, hydrogen can then already travel over quite large distances without any additional compression needed.

Adapting the network design: **relatively small compression stations placed at 100 km intervals** and larger stations providing a range of 600 km each. Preliminary calculations suggest that both approaches lead to the same order of magnitude of costs per 100 km transported.

Hydrogen embrittlement

In terms of impact on structural integrity, due to differences in chemical properties, hydrogen can accelerate pipe degradation through a process known as hydrogen embrittlement, whereby hydrogen induces cracks in the steel. A range of **solutions** exists to combat this, including: (a) applying inner coating to chemically protect the steel layer; (b) pigging (monitoring) of pipes to regularly check crack widths; (c) operational strategies such as keeping pressures steady to prevent initial crack formation; (d) using lower-grade, more ductile steel. For example, whilst initial hydrogen conversion projects in Germany and the Netherlands have shown that existing pipelines in those regions do not require internal coating, studies in France show that re-coating can be a viable part of the optimisation solution by enabling pipes to be operated at pressures closer to the pressure of natural gas.

Compressor capacity

One of the preliminary findings is that **compression capacity of 190-330 MW_{el} per 1,000 km is sufficient** to operate the network between 40 and 80 bar(g) in a 36-inch pipeline or between 30 and 67 bar(g) in a 48-inch pipeline. This represents a significant reduction in the compression capacity required compared to previous studies, including the 2019 "Gas for Climate" study (see newsletter #24) which had estimated levelised transport costs of 0.23 €/kg/1000km, in part due to higher volume flow leading to higher compression costs.

Conversion process

Current estimations and empirical evidence from TSOs indicate that the capital cost of a **newly built** dedicated **hydrogen pipeline** will be **10-50 % more expensive than** its **natural gas** counterpart. Initial discussions with manufacturing

European Hydrogen Backbone - TSO vision | Europe (4/4)

How a dedicated hydrogen infrastructure can be created …

companies suggest that the capital cost of **repurposing existing pipelines** represents **10-25 % of that of building new dedicated hydrogen pipelines**.

The main elements of the conversion process include nitrogen purging to remove undesirable parts, pipeline monitoring to identify cracks, and replacements of valves in cases where the latter have been operational for extended periods of time. Furthermore, natural gas pipelines converted to hydrogen have to be operated at a lower pressure, although this may be avoided by adding a layer of internal coating. The **relative ease of conversion from a technical standpoint** and the **modest repurposing costs** are two key enablers of the hydrogen backbone vision.

Valves and seals: Transmission pipelines include many valves along their length. These valve placements depend on location, but spacings typically range from 8-30 km. Depending on **regional variations** in existing network properties, **partial replacement** of valves and seals will be enough in some regions, whereas other regions will need **full equipment replacement** to prevent leakages.

Metering stations: Given the different chemical composition of hydrogen compared to methane gas, metering equipment will likely **need to be adapted**. However, such equipment typically represents a small portion of total infrastructure costs.

Cost parameter	Unit	Estimate / range
Pipeline capex, new	% of natural gas pipeline with similar diameter	110-150%[37]
Pipeline capex, retrofit	% of new hydrogen pipeline with similar diameter	10-35%
Compression capex, new	% of similar natural gas compressor	140-180%
Compression capex, retrofit	% of new built H_2 compression capex (line above) compressor	100%
Gas metering station, new	% of similar natural gas metering station	110-120%
Gas metering station, retrofit	% of similar natural gas pipeline	20-40%
Valve and seal replacements[38]	k€/km	~40
Internal coating	k€/km	~40

Basic Cost Assumptions for Construction and Retrofitting of Hydrogen Pipeline Infrastructure (Source: report, p. 19)

City gate stations: The basic function of these stations is to meter the gas and reduce its pressure from that of the transmission system to that of the distribution system, which operates at a lower pressure. As part of the pressure reduction process, these stations must accommodate for the so-called 'Joule-Thompson' effect in gases, whereby a change in pressure leads to a change in temperature.

Whereas the temperature of natural gas decreases by approximately 0.5 °C/bar when pressure is reduced, hydrogen has an "inverse Joule-Thompson" coefficient of 0.035 °C/bar. This means that a pressure reduction from 80 to 20 bar leads to a 2.1 °C increase in temperature for hydrogen, compared to a 30 °C temperature reduction in the case of natural gas. Like metering stations, city gate stations represent a small portion of total infrastructure costs, and hydrogen-specific conversion requirements are minimal.

Pipeline transmission costs (€0.009-0.17 per kilo of hydrogen per 1,000 km) only represent a small portion of total hydrogen costs when considering the full value chain from production through to end consumption. Even assuming future production costs of 1-2 €/kg for green and blue hydrogen, transport through the hydrogen backbone will add less than 10 % on top of production costs for 1,000 km transported.

Partners: developed by transmission system operators from Germany, France, Italy, Spain, the Netherlands, Belgium, Czech Republic, Denmark, Sweden, Switzerland, and consultancy company Guidehouse.

Kees van der Leun (Guidehouse) kees.van.der.leun@guidehouse.com

Report: https://bit.ly/3nLd78q
Webinar (~ 30 minutes): https://bit.ly/3jYpBqM

Hydrogen Strategy | Portugal (1/2)

João Galamba, Deputy Minister and State Secretary for Energy of Portugal, speech at the World Hydrogen Fuel Cells Summit in March 2020

„Designing public policies that guaranty a successful energy transition has become a core concern of every responsible government. The challenge we face is unprecedented, but so are the opportunities involved. […] I admit, the most efficient way to ensure a fully renewable power system is not to pursue full electrification of our energy system, but to combine electrons and molecules, both increasingly green."

Portugal is committed to achieve carbon neutrality in 2050 and has set an ambitious national target of attaining 47 % of its final energy consumption from renewable sources in 2030. To reach the goals, the government has developed an ambitious, but realistic National Energy and Climate Plan for the 2021 - 2030 horizon (PNEC 2030). The PNEC 2030 is the main instrument for energy and climate policy in Portugal and defines the policies and measures for the next decade to achieve carbon neutrality in 2050. Hydrogen will be a fundamental vector for the decarbonisation of various sectors of the national economy towards carbon neutrality.

Portugal has very favourable conditions for developing a hydrogen economy and hydrogen projects. There are abundant renewable energy sources (PV, wind, etc), existing industry (steel, refining, chemical), a relatively young gas network, a deep water port for exporting residual hydrogen via ship, strategic geographical location for exports, and a favourable policy framework with support mechanisms (see for more detail the figure next page).

Hydrogen Strategy | Portugal (2/2)

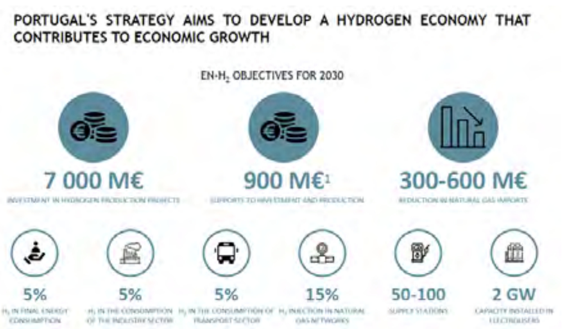
1. Off-take	• Proximity to off-take • Existence of industries (steel, refining, chemistry)	+++
2. Water	• Access to water sources, namely sea water or wastewater, which are technically possible today and without incurring significant cost increases.	+++
3. Renewable resources	• High availability of renewable resources	+++
4. Land	• Land availability (600 m2 for every 100 MW of electrolysers)	++
5. Policy	• Favorable policy framework • Existence of support mechanisms	+++
6. Curva de preço / % Renováveis	• Market with significant number of hours with electricity at low cost • High availability of renewable electricity or access to PPAs	++
7. Infrastructure	• Access to transport infrastructure (gas pipelines and ports)	+++

Favourable Conditions for Hydrogen Economy in Portugal (Source: presentation, p. 8)

The Portuguese Hydrogen Strategy was released in August 2020 with about 100 (!) pages and has the main objectives to:

- introduce an element of incentive and stability for the energy sector, **promoting** the **gradual introduction of hydrogen** as a sustainable pillar and integrated in a more comprehensive strategy of transition to a decarbonised economy.
- **frame the current and future role of hydrogen** in the energy system and **propose a set of measures and targets** for incorporating hydrogen in the various sectors of the economy.
- give a **solid framework to all companies and promoters** with hydrogen projects enabling the consolidation of these projects into a broader and more coherent strategy.
- **promote an industrial policy around hydrogen**, based on the definition of a set of public policies that **guide, coordinate and mobilise public and private investment** in projects of production, storage, transportation and consumption of renewable gases in Portugal.

Hydrogen will facilitate and accelerate the energy transition in various sectors, with a **particular focus on transport and industry**.



Objectives of the Portuguese Hydrogen Strategy (Source: presentation, p. 11)

Short term actions of the Hydrogen Strategy – ongoing (under legislation or providing financial support):

- Enabling the **injection of hydrogen**, and other renewable gases, **into the natural gas transport and distribution networks** has the advantage of reducing costs and barriers to the entry of hydrogen into the system, prevents gas assets from becoming idle in the future, takes advantage of a system in operation that allows the immediate integration of hydrogen in the national energy system. *#regulating hydrogen injection*

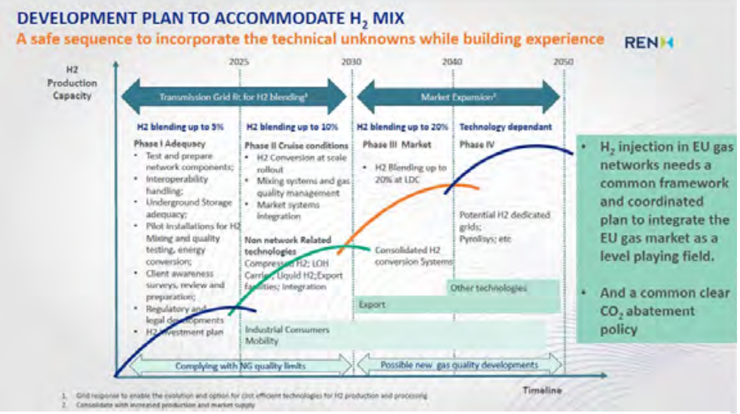
Phases of the Portuguese Hydrogen Strategy (Source: presentation, p. 12)

- Ensure the demand side, in addition to boosting the production side, which creates the necessary conditions for a true hydrogen economy in Portugal. Therefore, ambitious but realistic **targets for incorporating hydrogen in the various sectors** of the economy will be set, compatible with the ambition of the various sectors in the energy transition, with the current and future investment capacity and with the availability of technological solutions. *#setting hydrogen targets*
- Prepare and launch a **call to support projects** for the production and distribution of energy from renewable sources, which will include hydrogen, with a budget of around EUR 40 million. *#support investment in hydrogen projects*
- Introduce clear and transparent **support mechanism** to produce green hydrogen during the period 2020-2030 by providing support to **cover the difference between the production cost of green hydrogen and the price of natural gas** in the national market, which will have no translation in the tariffs paid by consumers. *#implement mechanism to support hydrogen production*

The new legal framework will initiate the decarbonisation of the natural gas grid by

- setting **technical and regulatory conditions for the injection of hydrogen** (and methane) into the natural gas transport and distribution grids and
- extending (and adapting) the system of **guarantees of origin/certification** for renewable gases.

Portugal is planning to set a target of 10 vol% of hydrogen in gas grids by 2030, gradually rising (see also figure with REN development plan below). The focus is on hydrogen produced via electrolysis from renewable electricity sources.



Development Plan for Hydrogen (Source: REN presentation, p. 8 - REN is a national electricity and gas network operator in Portugal)

João Galamba at the Clean Energy Ministerial (CEM) - a high-level global forum to promote policies and programs that advance the deployment clean energy technology. CEM11: webinar minute 26:26 bis 33:40
Portuguese Hydrogen Strategy: https://bit.ly/37fxuVk (see executive summary on p. 9-14 and for further detail translate i.e. with deepl.com)

Infrastructure Outlook 2050 | Netherlands, Germany (1/2)

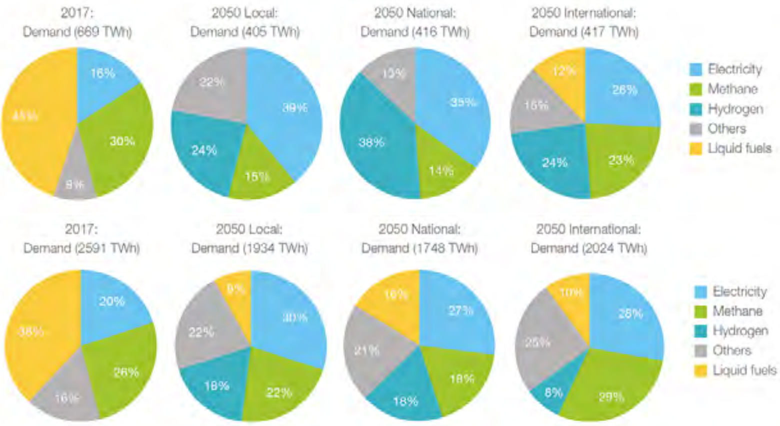
TenneT and Gasunie, **electricity and gas transmission system operators** (TSOs) in Germany and the Netherlands, have **joined forces to answer questions regarding the future energy system**. The study "Infrastructure Outlook 2050" (IO2050) published in 2019 is aiming to understand future designs of the integrated energy system for Germany and the Netherlands in the year 2050 (see following article).

The IO2050 report addresses the requirements and limitations of a future energy system largely based on solar and wind power. Meeting demand with these highly fluctuating energy sources will require both a strong electricity and gas infrastructure, in which gas storage plays a crucial factor in securing supply at every moment in time.

This study applied an innovative modelling approach focused on coupling the gas and electricity infrastructure, which enabled it to consider the (future) infrastructures for electricity, methane and hydrogen as well as their mutual dependence for the Netherlands and Germany.

The analysis shows that coupling electricity and gas will give the energy system the flexibility it needs. **The existing gas transmission grid has enough capacity to fulfil its fundamentally changed role in the future energy system**, although some technical adaptations are needed due to the different characteristics of hydrogen.

Coupling the electricity and gas transport infrastructure with P2G installations gives the overall energy system additional flexibility. However, under scenarios with a high penetration of wind and solar power, the use of P2G causes a massive increase in electrical peak load, as a result of which it can worsen the infrastructural bottlenecks if the capacities and locations of these P2G installations are not properly aligned with the grids. Therefore, **appropriate incentives for the operation of P2G units must be put in place to ensure efficient grid operation**. In critical situations of high demand and high infeed of renewables in the Netherlands for example, siting P2G installations near renewable supply will decrease the total transport demand for electricity and will reduce the number of bottlenecks.



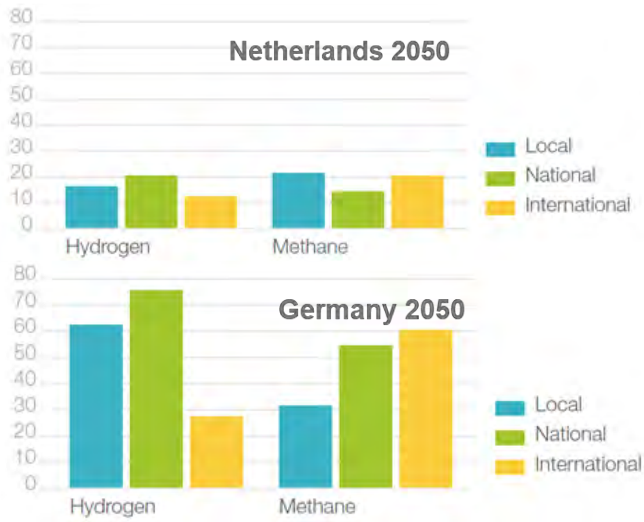
Final Annual Demand in Netherlands (above) and Germany (below) in 2017 and in 2050 for the Three Scenarios (Source: report, p. 30f)

The analysis has three different scenarios (main characteristics see report p. 21ff):

1. Local – focus on decentralised renewables
2. National – focus on centralised renewable production
3. International – focus on energy import

For the Netherlands, the scenarios with a high share of domestic renewable electricity production ('Local' and 'National') show an increase of 30 % in the total amount of electricity that will need to be transported. For the international scenario, the total amount of electricity that will need to be transported is comparable to today's transport volumes. The total amount of electricity that will be transported through the German electricity system in 2050, will remain within a range of +10 % of the present levels (see figures left).

For all German and Dutch scenarios, the report finds that the **total annual volume of gas** that will need to be transported (biomethane, synthetic methane and hydrogen) **will be either comparable to, or even higher than today's volume**. The final total energy demand will decrease in both countries. This is mainly because of a decline in liquid fuel consumption. The primary production of electricity will be much higher in both countries due to the intermediate conversion of power into gas. For most German scenarios, the demand for hydrogen will also be higher, due to the subsequent conversion of hydrogen into methane and liquid fuels.



Required Hydrogen and Methane Gas Storage Volumes in 2050 in TWh for the Three Scenarios

The results show that there are currently **enough pore and aquifer storages** (depleted gas fields) **available for both countries to store methane in all of the considered scenarios**. The available **storage volumes of salt caverns in the Netherlands need to be expanded for all scenarios** considered. **For Germany** the results show that the available **cavern storage capacity is sufficient to meet the demand**

Infrastructure Outlook 2050 | Netherlands, Germany (2/2)

for the international scenario. For the other two scenarios a certain expansion is foreseen. Due to the lower calorific value of hydrogen, converting caverns from methane to hydrogen storage will reduce the energy content of the facility by a factor three. In Germany, some 140 TWh of cavern storage is available for methane. Converting all caverns from methane to hydrogen storage would reduce the energy content of cavern storage to 45 TWh. In the Netherlands, around 3 TWh of cavern storage for natural gas would be reduced to 1 TWh for hydrogen. The modelling results for the Netherlands show that, depending on the scenario, a cavern storage volume up to 20 times higher than currently available will be needed to secure future hydrogen supply.

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Report: https://www.gasunie.nl/en/expertise/system-integration/infrastructure-outlook-2050

Provided that proper guidance can be given to P2G locations, coupling electricity and gas infrastructures may significantly alleviate the long-term expansion needs of the electricity transmission networks. However, further expansion of the electricity grid after 2030 will be required due to the expected growth in demand from end users and the fundamentally changed energy supply structure based on renewable energy sources.

The follow-up study "Pathways to 2050" (Phase II) is focusing on different possible transition pathways for the integrated energy infrastructure in the timeframe 2030-2050 (see following article). Additionally, in the Netherlands the topic of integrated energy infrastructure is further elaborated in the study "Integrale Infrastructuurverkenning 2030-2050", which is currently work-in-progress.

Study Phase II - Pathways to 2050 | Netherlands, Germany (1/2)

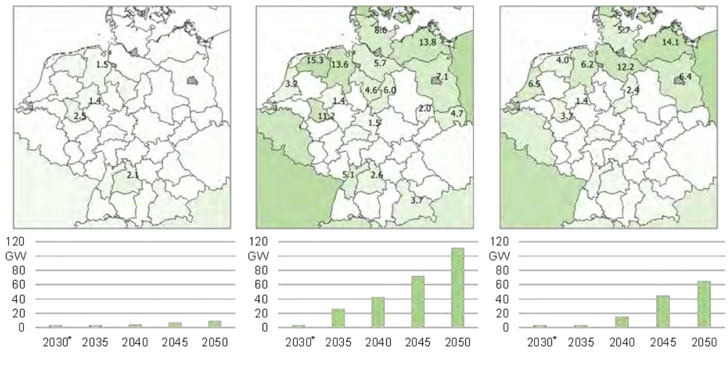
TenneT and Gasunie have conducted the study "Infrastructure Outlook 2050" (IO2050) in 2019 to understand future designs of the integrated energy system for Germany and the Netherlands in the year 2050. Based on findings and open questions of IO 2050, the follow-up study Phase II: Pathways to 2050 (Phase II) focuses on transition pathways of the energy infrastructures towards an integrated European energy system. Central questions are:

- How does the expansion of RES capacities as well as the development of demand for electricity, renewable hydrogen and renewable methane influence the European energy system transition between 2030 and 2050?
- When, where and how many conversion and storage assets should be installed?
- How do the transmission infrastructures for electricity, renewable hydrogen and renewable methane need to evolve to link future supply and demand?

The study determines transition pathways of the European energy infrastructure by minimising the total investment and operational costs of various technological options (i.e. energy transmission infrastructures, power-to-gas (PtG) units, power plants and storages). Based on this, the study puts a special focus on the Netherlands and Germany (focus area) and covers the timeframe from 2030 to 2050 in 5-year steps. All scenarios assume a 95 % decarbonisation target within the energy system. The three scenarios (EL & RES), (EL & RES+), and (Gas & RES+) vary type and amount of installed RES as well as energy demand (focus on electrification (EL) vs. focus on gas (GAS)).

In all scenarios, a high share of the final energy demand is assumed to be covered by hydrogen as energy carrier. To enable this, an EU-wide hydrogen grid needs to be developed. This can be done efficiently by refitting of existing methane transmission infrastructure. Expansion of electricity transmission capacity as well as refitting of methane to hydrogen transmission infrastructure is necessary in all considered scenarios.

Development of power-to-gas units, especially electrolyser units, largely depends on the available RES generation and electricity demand. With higher installed RES capacities, electrolyser units become more advantageous to the overall system towards 2050. They are mostly installed close to offshore wind connection points. In addition, some capacities are also located near to hydrogen demand centres. In total, around 110 GW of electrolyser capacity is installed in the (Gas & RES+) scenario inside the focus region, followed by the (EL & RES+) scenario with around 63 GW capacity. The lowest amount is installed in the (EL & RES) scenario, with around 8 GW in 2050.



Installed Electrolyser Capacity in GW in 2050 (Source: study, p. 45)

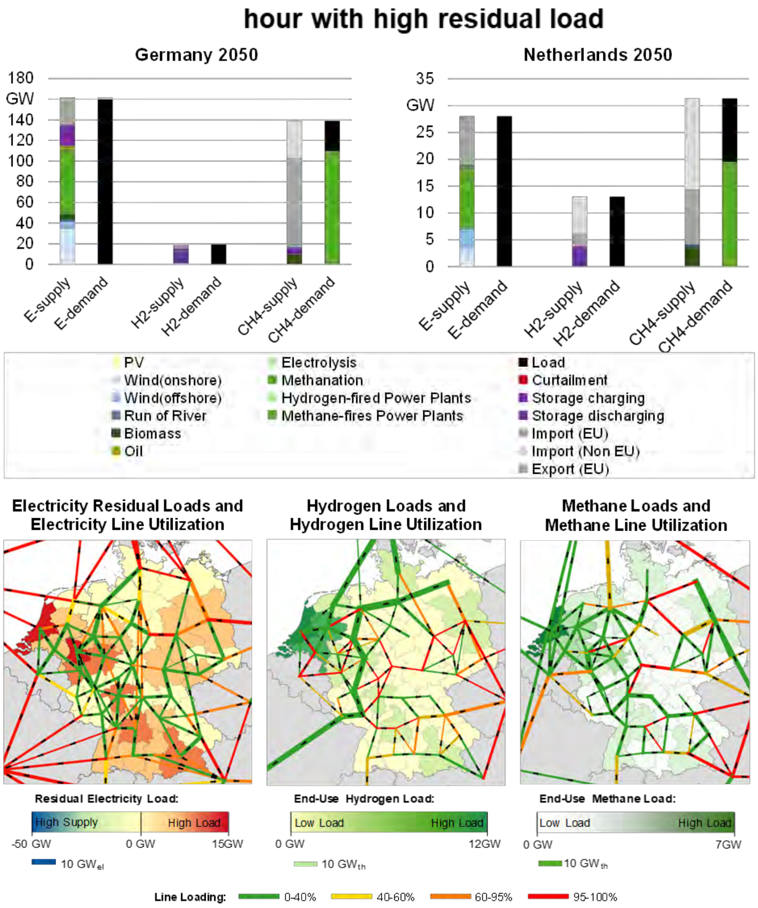
Study Phase II - Pathways to 2050 | Netherlands, Germany (2/2)

Dispatchable power plants are necessary in all scenarios but have very few load hours. In the investigated scenarios, significant capacities of methane-fired power plants are not decommissioned in order to provide secured capacity in high load situations. In two scenarios, the initial capacities of these power plants suffice for the most part and are not expanded. Here, 75 GW in the (EL & RES+) scenario and 31 GW in the (Gas & RES+) scenario of installed capacity are required by the system in the focus area in 2050. Based on the used meteorological year, these units only reach very low full load hours of less than 100 h in both 'Higher RES' scenarios in 2050.

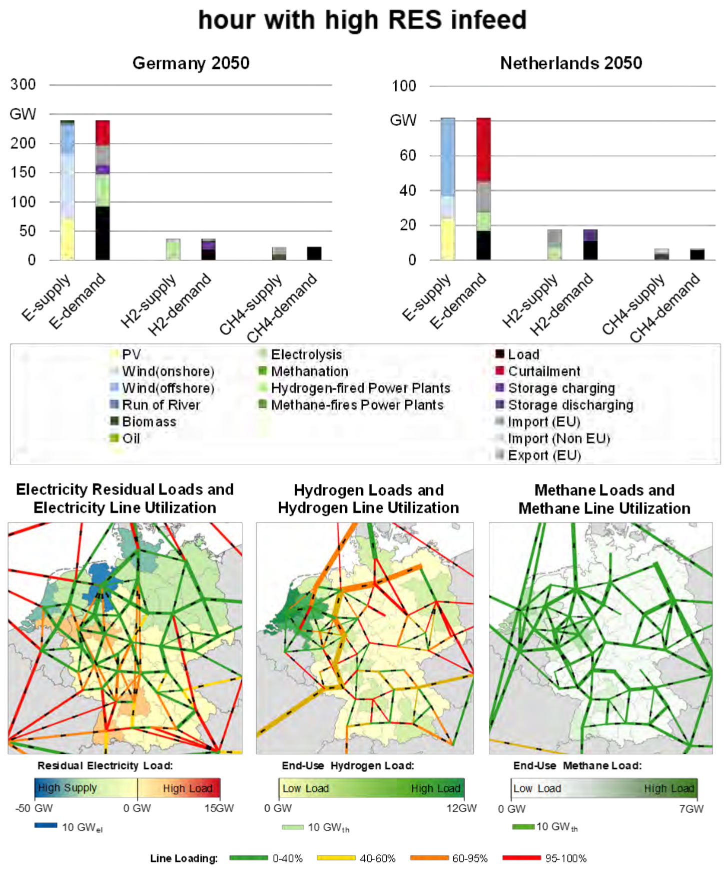
In the investigated scenarios, demand side management (DSM) is not considered. Therefore, the applied model invests only in other sources for flexibility such as transmission, conversion and storage. The authors recommend to include DSM in further analysis which could consequently lower the investments in the aforementioned options if increasing overall societal welfare.

The results underline that the system is able to cover high residual electricity loads as shown. In order to do so, the system relies on methane-fired power plants that cover roughly 50 % of the electricity demand in this hour, complementing the comparatively low RES infeed. Storages and imports cover the remaining electricity demand.

An example of how the system integrates RES infeed a situation with high RES infeed in the EU-oriented scenario is illustrated in the figure below. In this situation, RES supply is significantly higher than the electricity demand in Germany and the Netherlands (as well as in other neighbouring countries). The RES surplus is used to charge electricity storages, cover electricity demand in other regions (i.e. is exported, if residual demand exists in other regions), or to operate electrolysis units. However, in this hour, RES generation is also curtailed to a significant extent, being the measure of last resort, when all other flexibility options are fully utilised.



Dispatch in Hour With High Residual Load in DE and NL in 2050 in EL&RES+ Scenario (Source: study, p. 52f)



Dispatch in Hour With High RES Infeed in DE and NL in 2050 (Source: study, p. 54f)

An example of how the system covers a high residual load situation in the (EL & RES+) scenario is illustrated in the figures above. For Germany and the Netherlands, supply and demand in this hour for every simulated energy carrier is displayed, as well as the composition of each of these positions. Additionally, the effects of this demand and supply situation on the respective infrastructures are illustrated for electricity, hydrogen and methane transmission capacities.

Global imports of CO_2 neutral gases to Europe, i.e. green hydrogen, synthetic methane and others, will become an essential part of the energy supply in all our scenarios. Regardless of the total installed RES capacities within Europe, a complete European energy independency is not achievable in any of the scenarios.

Tobias Frohmajer at Tobias.Frohmajer@tennet.eu, Ksenia Berezina at Ksenia.Berezina@gasunie.de, Levin Skiba at l.skiba@iaew.rwth-aachen.de

Report: https://www.tennet.eu/company/publications/infrastructure-outlook-2050/

HIGGS Project Underway | Europe

Validation of various hydrogen admixture levels in high pressure gas grids

Author: Felix Künkel, DVGW

The main objective of the HIGGS project is to show that the safe injection of hydrogen into the EU high pressure transmission natural gas grid is a sustainable, long-term solution to decarbonise the energy system.

To achieve this goal, the HIGGS project team will tackle various key aspects during this three-year project (duration: 2020-2023). First, the HIGGS team is going to take up on legal, regulatory and technical aspects by mapping the present equipment, as well as regulations, standards and certification (RSC) of the natural gas grids. The identification of the most critical RSC bottlenecks will not only enable end users and operators to work the entire gas grid safely but also help to prevent the replacement of fully operable equipment and appliances due to rising hydrogen concentrations in the gas grid.

On a more practical side the HIGGS project will examine the impact of transporting high amounts of hydrogen through the gas grid by designing and building an experimental R&D platform. The testing loop will include the usual components and materials of gas pipelines and is designed to work at 80 bar(g) with various hydrogen admixture levels up to 100 %. The project will be able to recreate the injection of different flows of electrolytic H_2 into a natural gas grid as well as to test its components. A hydrogen purification prototype based on membrane technology is also included in the design to separate H_2/CH_4 for end-use applications.

Felix Künkel at kuenkel@erig.eu

The biggest concern for safety when admixing hydrogen into the natural gas grid is related to steel degradation and embrittlement, especially when hydrogen is present for long periods and at high concentrations and pressures. The HIGGS project is going to target this issue by mapping the existing steel types used in the gas networks, defining a laboratory test protocol to study them and finally provide recommendations for those materials to be used in high pressure hydrogen mixtures.

The impact of higher H_2 levels on the economics of the gas transport value chain will be assessed in the project, considering gas producers, transport companies up to delivery to the gas distribution networks. A techno-economic model will be built for representative cases in Europe simulating the grid behaviour. The model will allow analysis of how different technological choices in adapting the grid to higher H_2 levels as well as how operational strategies for the future grid with hydrogen injection impact the value chain economics. Sector coupling shall also be considered in the model.

All the work done within the project will contribute to the description of a pathway towards integrating hydrogen in the EU gas networks. It will not only summarise recommendations for admixture and injection facilities as well as for RSC aspects but also point out potential issues, barriers and facilitators for cross-border and interoperability in the gas grids.

Partners: DVGW, HSR, Redexis, Tecnalia, ERIG, FHa

FUEL CELLS AND HYDROGEN

This project has received funding from the Fuel Cells and Hydrogen 2 Under-taking (FCH JU) under Grant Agreement no. 875091. This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme.

HIPS-NET - Update Logo and Core topics

Last but not least, we proudly present ;-) the updated design of the

- HIPS-NET logo and
- HIPS-NET core topics.

You can see the HIPS-NET logo here on this page on the right side. With the HIPS-NET core topic design it is a bit more complicated — we like two designs. You can see the designs on the following two pages on the top of the page.

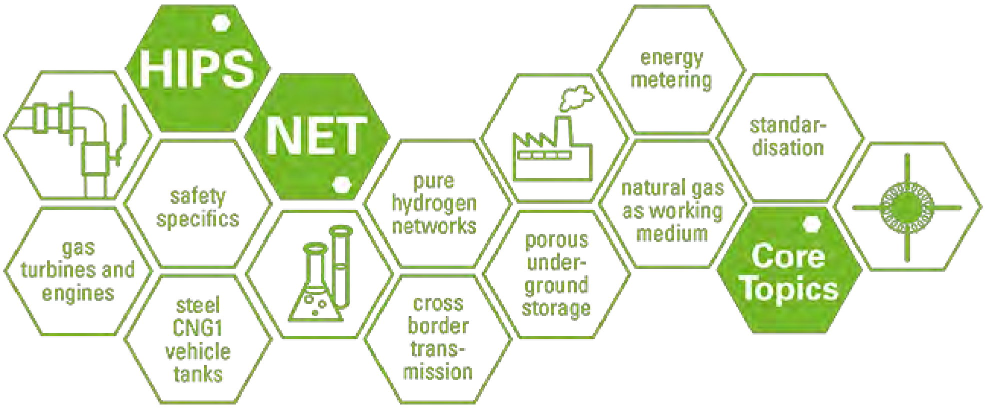
How do you like the designs? Do you see need for adaptions? Do you fancy one of the core topic designs more? Or should we keep both designs?

Please share your view and get in touch with Josephine.
josephine.glandien@dbi-gruppe.de

HIPS-NET CORE TOPICS

Pure hydrogen networks?
The survey during the previous HIPS-NET meeting showed that pure **hydrogen networks** are prone to become an additional core topic. We included this in the suggested design and we are curious to hear more voices about this idea.

DESIGN OPTION 1 of the HIPS-NET Core Topics
See next page for option 2.



EVENTS AND PARTNERS

Selection of Appointments

November 2020

03-04 6th HYPOS-Forum | Dresden, Germany, *http://www.hypos-eastgermany.de/*

04 Panel Discussion with Gasunie and Stedin: Developing Efficient Hydrogen Infrastructure - What Will it Take? | Webinar 16:00 - 17:00, *https://bit.ly/3j8v0uk*

10 From Production to Application: Actual Studies P2X | Webinar 14:00 - 15:30, *https://bit.ly/3jhhkgB*

11-12 DBI-Fachforum Wasserstoff & Brennstoffzellen | Online & Leipzig, Germany, *https://bit.ly/30Il585*

12 H2.0-Conference 2020 | Online, *https://www.wattzweipunktnull.de/h20-konferenz/*

24 From Production to Application: Different Electrolysis Types (AEL, PEM, HTEL) | Webinar 14:00 - 15:30, *https://bit.ly/3jhhkgB*

24-25 Update: FCH JU Stakeholder Forum | Brussels, Belgium, *https://bit.ly/3hvMvoP*

December 2020

08 From Production to Application: Pyrolysis and Steam Reforming | Webinar 14:00 - 15:30, *https://bit.ly/3jhhkgB*

08-09 Next Generation Electrolysers | Webinar 14:00 - 15:30, *https://bit.ly/37oEnDO*

January 2021

13-14 Hydrogen Business for Climate | Belfort, France, *https://bit.ly/2TnThCl*

February 2021

09-10 Hydrogen & P2X: Fuel Cells, Road Transport and Energy Production | Copenhagen, Denmark, *https://bit.ly/37neAvL*

10-11 HyVolution | Paris, France, *www.hyvolution-event.com*

10-11 Hypothesis XV | Muscat, Oman, *www.hypothesis.ws*

Current Partners

Alliander AG, Areva H2Gen,
Cadent, DGC, DNV GL, Enagás,
Enbridge, Energinet.dk, ENGIE,
EWE Netz, Gas Connect Austria GmbH,
Gasnetz Hamburg, Gasum OY,
Gasunie, GRTgaz, GRZI e.V. (FIGAWA),
Infraserv GmbH & Co. Höchst KG,
INERIS, innogy SE, ITM Power,
Joint Research Centre (JRC), EC,
KOGAS, NAFTA a.s,
Naturgy, ONTRAS, ÖVGW,
Open Grid Europe GmbH,
Polymer Consult Buchner GmbH,
RAG Austria AG,
Shell, Solar Turbines Europe S.A.,
Storengy, SVGW,
Synergrid, Teréga, TNO,
Uniper Energy Storage GmbH,
Verband der Chemischen Industrie (VCI),
Volkswagen AG, Wintershall Dea AG.

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DBI GUT Gas- und Umwelttechnik GmbH

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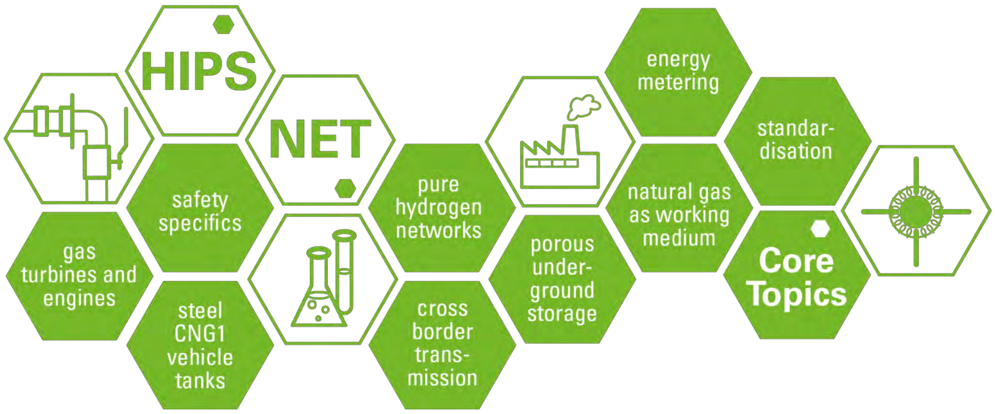
CEO: Dr.-Ing. Jörg Nitzsche, Dipl.-Ing. (FH) Gert Müller-Syring, Dipl.-Kfm. Olaf Walther

Certified DIN EN ISO 9001:2015

HIPS-NET CORE TOPICS



DESIGN OPTION 2 of the HIPS-NET Core Topics

See previous page for option 1.

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Gasnetz Hamburg, Gasum OY,
Gasunie, GRTgaz, GRZI e.V. (FIGAWA),
Infraserv GmbH & Co. Höchst KG,
INERIS, innogy SE, ITM Power,
Joint Research Centre (JRC), EC,
KOGAS, NAFTA a.s,
Naturgy, ONTRAS, ÖVGW,
Open Grid Europe GmbH,
Polymer Consult Buchner GmbH,
RAG Austria AG,
Shell, Solar Turbines Europe S.A.,
Storengy, SVGW,
Synergrid, Teréga, TNO,
Uniper Energy Storage GmbH,
Verband der Chemischen Industrie (VCI),
Volkswagen AG, Wintershall Dea AG.

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Certified DIN EN ISO 9001:2015

HIPS-NET 30th Edition

"ESTABLISHING A PAN-EUROPEAN UNDERSTANDING OF ADMISSIBLE HYDROGEN CONCENTRATION IN THE NATURAL GAS GRID"

NEWSLETTER #30 ANNIVERSARY EDITION — DECEMBER, 2020

Dear HIPS-NET Partners,

We hope you and your families are well – finding a way to deal with the current situation. Covid19 turned many things upside down. With lock down, home office, closed child care / schools, closed theatres and cinemas, many online meetings, almost no traveling, the list is long. CHANGES—easy ones and difficult ones. We need to redevelop interactions in this changing world and see the advantages and disadvantages. The HIPS-NET online workshop is just one example. We (Gert, Anja, Josephine) miss meeting you in Brussels with the exchange and hope to meet you in 2021 in save and well-off.

This is the last newsletter before the x-mas break. Even though it might be different this year, we hope you enjoy the time with family and friends and find time to rest & relax.

HIPS-NET goes overseas with this 30th edition. It summarises articles around

- Integrity of steel pipes under hydrogen exposure – lifetime assessment
- European overview for hydrogen energy technology focussing on opportunities
- IEA report on renewables (short) with focus worldwide
- IEA report on hydrogen with focus worldwide
- Hydrogen roadmap of South Korea
- Hydrogen strategy of Australia

Merry x-mas!
Your HIPS-NET Team Gert, Anja, and Josephine

SAVE THE DATE!

2021

16th/17th June

NEXT HIPS-NET Workshop in Brussels

CONTENT

CONTENT NEWSLETTER #30

Integrity of Steel Pipes under Hydrogen | Germany (1/2)

Authors: Florian Adämmer, Dennis Hoeveler (both Nowega)

The use of hydrogen as a climate-friendly energy carrier is currently in the focus of discussion. The demand is large. The German Government sees a demand of about 90 to 110 TWh H_2. For this purpose, 5 GW electrolysis capacity is required in Germany by 2030. In order to efficiently supply hydrogen to potential customers, the focus is on pipeline-based transport. By using existing gas infrastructure, the expenses and environmental impact are kept within limits. However, it is important to examine whether the integrity of a previously used steel natural gas pipeline is negatively affected by the conversion to hydrogen transport. A particular focus is on frequent and high-pressure changes with the simultaneous presence of defects in the pipeline material, such as cracks. If the geometry of a crack in the pipeline is known, the crack growth until failure of a pipeline can be predicted by means of fracture-mechanical methods.

How such a lifetime assessment can be carried out will be described more detailed in this article, based on an example using a software-based analysis (without laboratory tests).

In this example, we are dealing with a natural gas transport pipeline DN 250 made of steel grade L360 NB. The design pressure DP is 70 bar and the yield strength is 440 N/mm². Yield strength means the maximum tensile load $Rt_{0.5}$, at which plastic deformation of the material does not yet occur. The pipeline under consideration is a line pipe with an average radius r = 132.95 mm and a wall thickness t = 7.1 mm, which undergoes a daily pressure change of 20 bar over a period of 100 years. In addition, an initial crack in the pipeline is assumed with a crack length in the axial direction of the pipe of 30 mm and a crack depth a0 in the radial direction of 3.5 mm. The maximum stress distribution at the crack tip (fracture toughness KIH) of the material under hydrogen atmosphere is assumed to be 85.55 MPa √m.

If a radial crack in the pipe wall is assumed, the pipeline will fail if the crack has reached a depth at which the remaining wall thickness of the pipeline is not sufficient to compensate for the forces present in the pipeline. Consequence: the material fails; this is called critical crack depth. This critical crack depth ac can be calculated via the design pressure DP of the pipeline, the yield strength of the material Rt0.5 and the pipeline geometry.

From the values mentioned above, a critical crack depth ac is 4.99 mm for this example.

This crack depth must be avoided in any case. It is important to mention that in this example no safety factor S against stress exceedance was considered in the calculation of the critical crack depth. The safety factor S is usually assumed to be 1.6 and is taken into account when calculating the minimum wall thickness of a pipe. However, this value is not suitable for fracture mechanics considerations when the actual service life of the pipe is calculated.

To assess whether an existing crack in the pipe reaches this critical crack depth, the crack growth per pressure change is calculated over a defined period of time. In this example the pressure change corresponds to a daily pressure fluctuation in the pipeline of 20 bar. In this case, the observation period shall be 100 years.

Altogether, this equates to a total of 36,500 pressure change events.

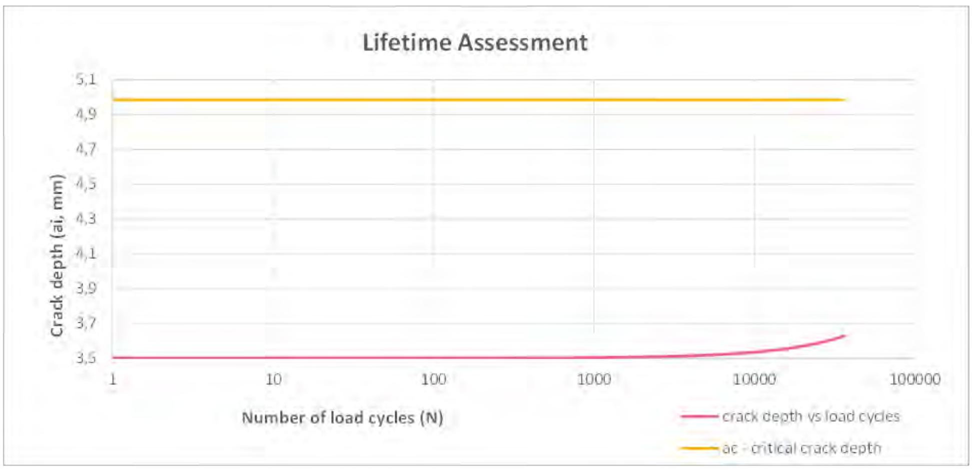
To calculate the crack growth per pressure change, the height of the maximum stress distribution at the crack tip is required. This material-specific characteristic value, also known as fracture toughness KIH, results from material tests and must be given for the respective pipe material under hydrogen atmosphere. In simple terms, this value indicates the resistance to crack growth. In this example the value is 85.55 MPa √m.

If the actual stress distribution at the crack tip (this value is called stress intensity factor KI and is calculated using fracture mechanics models), which depends on the actual pressure in the pipe, exceeds the fracture toughness KIH determined on the test rig, the crack grows uncontrolled without the influence of pressure fluctuations, i.e. quasi-statically, up to the critical crack depth ac. The pipe material suddenly fails.

In this example, the cyclic stress intensity factor of 17.1 MPa √m is significantly lower than the fracture toughness KIH of 85.55 MPa √m, so that uncontrolled crack growth cannot occur.

Under pressure changes, however, a crack in a pipeline can grow in a controlled manner well below the fracture toughness KIH. In this case the material does not fail suddenly, but only after reaching the critical crack depth over a certain period of time. The crack growth is calculated for each of the 36,500 cycles at a daily pressure change of 20 bar. For this purpose, fracture mechanical functions and crack growth relationships are used, which have been derived using conservative methods. More details can be found in the American standard ASME B31.12-2019.

If the calculated crack growth is plotted over the number of 36,500 pressure change cycles, the following figure results:



Lifetime Assessment over 100 Years, N = 36,500 Cycles

Integrity of Steel Pipes under Hydrogen | Germany (2/2)

Authors: Florian Adämmer, Dennis Hoeveler (both Nowega)

The assessment shows that under the given parameters the initial stress intensity factor KI is 19.65 MPa √m. This value clearly remains significantly below the material-specific fracture toughness KIH. Uncontrolled, static crack growth and thus a sudden failure of the pipeline does not occur.

In addition, the crack growth under cyclic pressure changes is so low that the initial crack does not reach the critical crack depth ac during the 36,500 cycles (see figure).

The steel material investigated here was frequently used for the construction of gas transmission pipelines. The result of a lifetime assessment, however, depends primarily on future operating conditions of the pipeline in a hydrogen atmosphere and the geometry of cracks in the material, so that a lifetime assessment always represents a case-by-case consideration. Nevertheless, first calculations as these, as well as of higher-strength materials under moderate operating conditions, allow a thoroughly positive conclusion.

Florian Adämmer at f.adeammer@nowega.de

The assumptions used in this example are based on a pipeline made of steel > 16 bar in DN 250 according to DIN EN ISO 3183. The operating pressure corresponds to the usual operating pressures in the pipeline network today. The initial crack geometry is a crack that could be detected in a pipeline by suitable test methods. Usual pressure changes in the transmission system are limited to less than 10 bar. 20 bar represents an extreme value.

Assumptions for this example assessment are:

- Material: L360 NB
- DP = 70 bar = 7 MPa
- r = 132,95 mm
- t = 7.1 mm
- Rt0,5 = 440 MPa
- KIH = 85.55 MPa √m (conservative value, as measured under electrolytic load)
- Initial crack depth a0 = 3.5 mm
- Crack length 2c = 30 mm
- Pressure difference pmax-pmin = 20 bar = 2 MPa
- one pressure change per day

Opportunities for Hydrogen Energy Technologies Considering the National Energy & Climate Plans | Europe (1/5)

Authors' remark: We summarised the study "Opportunities for Hydrogen Technologies …" and it turned to be a long article. The attempts to shorten the article failed since we feel all information here is worth reading and so much more interesting information is missing and may be discovered in the report.

Hydrogen in the **National Energy and Climate Plans** (NECPs) – this study identifies and **highlights opportunities for renewable and low carbon hydrogen technologies** to achieve the 2030 climate and energy targets of the EU and its Member States effectively and efficiently. It covers all EU Member States (plus the UK) and focuses on the period up to 2030 (i.e. the period of time covered by the NECPs). The Fuel Cells and Hydrogen Joint Undertaking (FCH 2 JU), in consultation with the European Commission - DG Energy, has commissioned the study. It was conducted by the consultancies Trinomics and Ludwig-Bölkow-Systemtechnik (LBST).

The authors developed two scenarios of renewable hydrogen demand (high and low) in 2030 (42 and 183 TWh/a respectively for EU28), based on different levels of ambition in each Member State. To cover this renewable hydrogen demand estimated in the **2 scenarios**, **13 and 56 GW** respectively of **electrolyser capacity** will have to be installed, assuming an average annual utilisation rate of 4.800 full load hours. To this end, **68 and 291 TWh/a** respectively of **renewable power** will be needed, based on an electrolysis efficiency of 69 %. "Surplus" electricity from the markets in times of low electricity wholesale prices can be used for this purpose as well. However, the main share will have to be covered by dedicated renewable electricity sources. For three countries with a high readiness for CO_2 storage, namely Germany, the Netherlands and the UK, low-carbon hydrogen produced via steam methane reforming (SMR) in combination with CCS is considered as an alternative.

The **annual costs to produce renewable hydrogen** (including the cost of dedicated renewable electricity generation), to develop the transport infrastructure (or adapt the existing one) and end-user applications would in the considered scenarios reach **10 and 33 billion EUR**, respectively. The **cumulative investments** needed **up to 2030** would reach **70 and 249 billion EUR**, respectively. These activities will generate value added in the domestic economy, amongst others, by **creating jobs** in manufacturing, construction and operation of hydrogen technologies **estimated at 104,000 and 357,000 jobs** respectively (see table per country on the next page).

Opportunities for Hydrogen Energy Technologies Considering the National Energy & Climate Plans | Europe (2/5)

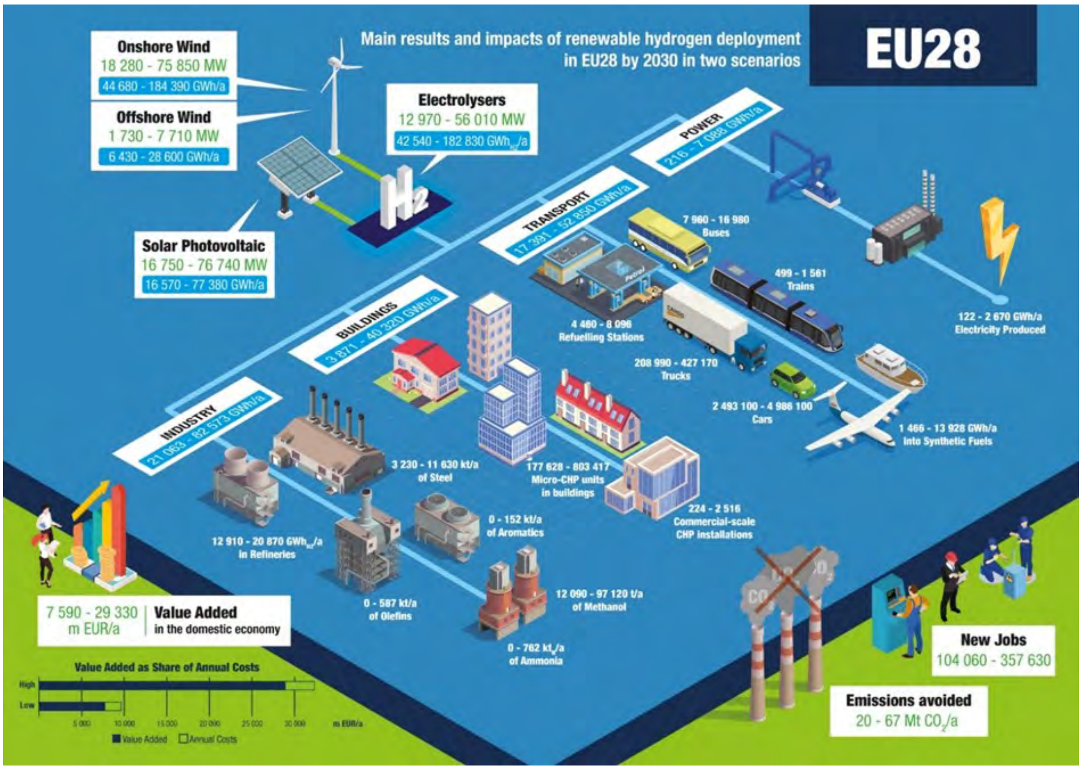
Member State	Hydrogen Demand (TWh_{H2}/a)	Electrolysis Capacity in GW_{el} (SMR+CCS Capacity in GW_{H2})*	Avoided Fossil Fuel Imports (TWh/a)	Value Added (million EUR)	Jobs (FTEs)
Austria	2 - 6	0.6 - 2.0	4 - 11	303 - 980	3324 - 10509
Belgium	1 - 7	0.4 - 2.3	2 - 8	224 - 1140	2525 - 10735
Bulgaria	0.8 - 1.4	0.3 - 0.5	1 - 2	109 - 190	3354 - 6001
Croatia	0.1 – 0.4	0.03 - 0.2	0.1 - 1	13 - 70	177 - 591
Cyprus	0.02 - 0.1	0.01 - 0.1	0.03 - 0.1	5 - 30	97 - 599
Czech	0.4 - 2	0.1 - 0.6	1 - 3	77 - 290	535 - 1330
Denmark	0.4 - 2	0.1 - 0.6	1 - 2	66 - 290	558 - 1442
Estonia	0.01 - 0.1	0.005 - 0.05	0.03 - 0.2	2 - 20	70 - 483
Finland	1 - 5	0.3 - 1.1	3 - 11	273 - 900	2728 - 8854
France	4 - 20	1.2 - 5.3	8 - 27	669 - 2680	10379 - 33648
Germany	9 - 41	3.0 - 13.7 (1.1 - 5.0)	19 - 67	1918 - 7620	23192 - 82799
Greece	1 - 3	0.4 - 1.0	2 - 4	229 - 540	4450 - 10432
Hungary	1 - 2	0.3 - 0.9	1 - 3	134 - 360	721 - 1548
Ireland	0.1 - 1	0.0 - 0.3	0.2 - 1	15 - 130	246 - 1797
Italy	4 - 20	1.3 - 6.7	7 - 26	779 - 3510	11509 - 41760
Latvia	0.05 - 0.2	0.02 - 0.1	0.1 - 0.3	8 - 30	316 - 1222
Lithuania	0.1 - 0.7	0.04 - 0.3	0.1 - 1	18 - 120	569 - 3742
Luxembourg	0.1 - 0.4	0.1 - 0.3	0.2 - 1	44 - 160	420 - 1531
Malta	0.01 - 0.05	0.003 - 0.03	0.01 - 0.04	1 - 10	33 - 224
the Netherlands	3 - 12	0.8 - 3.6 (0.3 - 1.5)	4 - 14	460 - 1930	5112 - 18204
Poland	2 - 6	0.7 - 1.7	3 - 8	343 - 870	3597 - 8608
Portugal	1 - 7	0.3 - 2.7	1 - 8	92 - 740	2500 - 18450
Romania	1 - 2	0.3 - 0.8	2 - 3	156 - 350	1925 - 4440
Slovakia	0.4 - 1.1	0.1 - 0.4	1 - 2	59 - 160	1285 - 3609
Slovenia	0.1 - 0.2	0.02 - 0.1	0.1 - 0.3	12 - 30	270 - 686
Spain	4 - 17	1.0 - 4.1	7 - 20	604 - 2360	10527 - 35827
Sweden	2 - 5	0.4 - 1.2	4 - 11	312 - 880	1106 - 2593
UK	4 - 21	1.1 - 5.6 (0.5 - 2.5)	7 - 27	664 - 2940	12532 - 45975
EU28	**42 - 183**	**13 – 56 (1.9 - 8.9)**	**80 - 259**	**7 590 – 29 330**	**104 060 – 357 630**

** Low-carbon hydrogen production via SMR+CCS is considered as an alternative for renewable hydrogen production via electrolysis in countries with high readiness for CO_2 storage, i.e. Germany, the Netherlands and the UK.*

Main Results of Hydrogen Deployment by 2030 in the Two Scenarios per Country (Study, p. 10)

Opportunities for Hydrogen Energy Technologies Considering the National Energy & Climate Plans | Europe (3/5)

According to the European emission reduction scenario, there is a remaining gap of 1.5 Gt_{CO2}/a in emission reduction plans that needs to be closed in order to achieve the 2030 goals. In the scenarios considered, the deployment of hydrogen could contribute 20 and 67 Mt_{CO2}/a respectively to this goal, which is equivalent to 1.4 % and 4.6 % respectively of the required emission reduction.

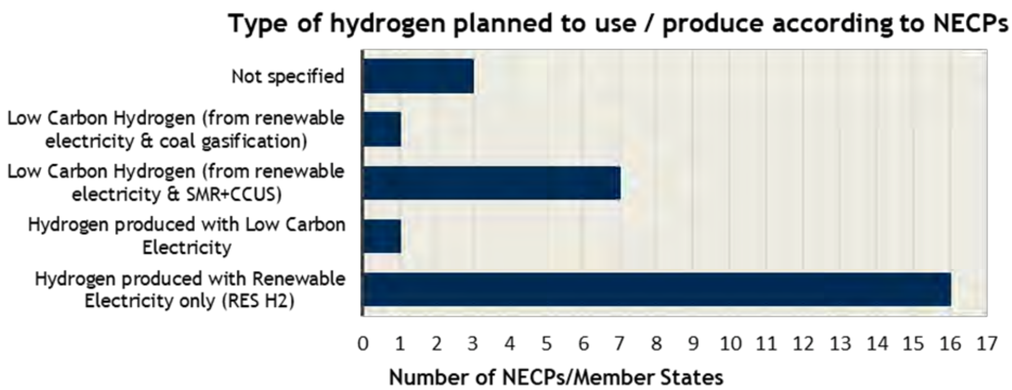


Main Results of Hydrogen Deployment for the EU28 by 2030 in the Two Scenarios (Study, p. 11)

For most EU Member States, a significant development of renewable hydrogen demand is assumed in **transport** (especially for passenger cars, buses, trucks and trains) and **industry** (especially in refineries, chemical industry, the iron and steel sector). Switching **high temperature heat processes** fuels to renewable hydrogen represents another important potential use considered in the scenarios. The **building sector** is expected to have in the low scenario a limited demand of hydrogen by 2030 but would have a stronger demand in the high scenario. The scenarios assume only a marginal share of electricity generation from hydrogen by 2030, coming from combined heat and power installations. The picture above summarises the hydrogen deployment for Europe in the different sectors and applications. Please zoom in the picture for detailed information.

Renewable hydrogen is in several NECPs considered as link between various energy carriers - electricity, heat, cold, gas - with each other and with end-use sectors, such as buildings, transport and industry, and to support the integration of higher volumes of variable renewable electricity into the system by providing system flexibility (**system integration**). Given their limited potential to domestically produce green or low carbon hydrogen, some Member States seem to consider **importing** low-carbon or renewable **hydrogen**. Other Member States with a large technical potential for variable renewable electricity production, consider becoming renewable **hydrogen exporting** countries, like Portugal and Spain. Many countries focus on **green hydrogen only** (produced with renewable electricity by electrolysis), while others follow a mixed path adding low carbon hydrogen technologies in the NECPs. One country only relies on low carbon hydrogen and three countries did not specify the question green vs. low carbon hydrogen (see diagram below).

Several gas TSOs (e.g. in France, Germany, Hungary, the Netherlands) have plans to use their methane infrastructure for hydrogen transport or to set up a specific hydrogen backbone infrastructure, using existing methane pipelines for 100 % hydrogen transport.



Type of Hydrogen Production (Study, p. 32)

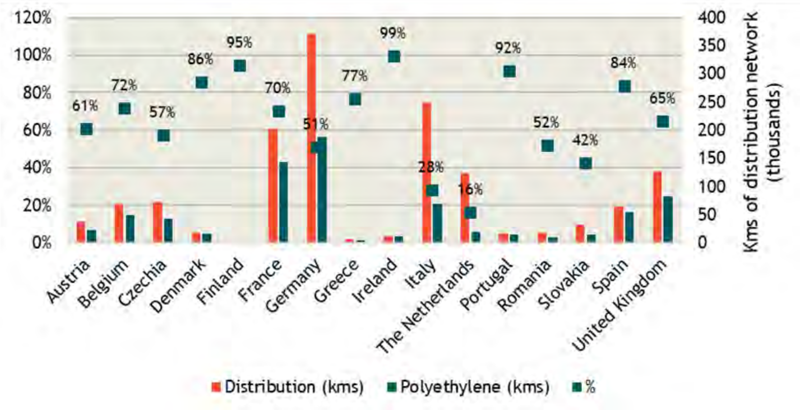
Salt caverns and underground layers are distributed across Europe and could provide a basis for a well-distributed hydrogen storage network for seasonal energy storage. Storage should also be considered when deploying transport and distribution infrastructure to link production and end-use.

Opportunities for Hydrogen Energy Technologies Considering the National Energy & Climate Plans | Europe (4/5)

Hydrogen / natural gas blends

Next to refurbishing existing methane transport infrastructure in view of its use for 100 % hydrogen, blending hydrogen with natural gas in existing methane infrastructure is also considered in several Member States. The study refers to the work of the expert group guided by DBI and the materials published by Marcogaz in 2019: "Overview of available test results and regulatory limits for hydrogen admission into existing natural gas infrastructure and end-use appliances" (see also newsletter #23).

At least half of the Member States (AT, BE, CZ, DK, FR, DE, EL, HU, IE, PT, RO, SK, ES, UK) can consider using their existing methane infrastructure for hydrogen transport and distribution, by blending hydrogen in the public grid in the short and medium term and potentially converting (part of) their network to hydrogen in the long term. As the share of polyethylene in their distribution network is in general relatively high (see diagram below), it could be converted to a dedicated hydrogen network at relatively low cost. However, conversion of the natural gas networks to a dedicated hydrogen transport system would be for most EU Member States a longer-term consideration, as the hydrogen production volumes are expected to remain relatively low until 2030 (except in a few pilot projects such as Leeds in the UK). In the short and medium term, hydrogen could hence be blended with methane in the existing grid, without the need for physical adjustments to the transport and end-use infrastructure.



Share of Polyethylene Pipelines in Distribution Systems (Report, p. 51 based on Marcogaz 2013)

According to their NECPs, several Member States like Belgium, Estonia, France, Italy, Latvia and Slovenia plan to further analyse the impact of blending hydrogen into the natural gas infrastructure on the network as well as the different types of end-users, in view of establishing appropriate technical and regulatory specifications to facilitate the injection of hydrogen.

Several Member States (FR, DE, PT, RO, SK, UK) are effectively considering using their existing methane infrastructure for an admixture of hydrogen with natural gas (and biomethane). In Germany, blending hydrogen into the natural gas network is – according to the report – under debate. (*Remark HIPS-NET team: Hydrogen is blended with up to 10 vol% in selected networks today already operating regularly.*)

For several Member States (BG, HR, HU, LV, LT, LU, PL, SL), there is no publicly available information regarding the share of polyethylene in their distribution network, and hence no indication regarding the technical and economic feasibility of converting the network to a dedicated system for hydrogen. These Member States could also start injecting limited hydrogen volumes into their natural gas transport and distribution infrastructure, and assess whether in the medium or long term, conversion of (part of) their methane network or construction of new dedicated pipelines for hydrogen transport and distribution would be feasible. Among the above-mentioned Member States, Hungary and Slovenia have an extensive natural gas network; they plan to carry out an assessment of their natural gas infrastructure in view of its possible use for hydrogen.

Cyprus and Malta have no potential for using existing methane infrastructure to transport or distribute hydrogen, as there is no natural gas network.

In Estonia, the methane grid has limited coverage and use intensity; the opportunity for Estonia to use this infrastructure to facilitate hydrogen deployment is therefore low. In Sweden and Finland, natural gas consumption (and related infrastructure) is also limited, but as their distribution networks are mostly made of polyethylene, they could be converted to accommodate hydrogen at a relatively low cost.

Main barriers for hydrogen injection or infrastructure conversion at EU level

The main barriers which hinder the injection of hydrogen into existing methane infrastructure and/or the conversion of existing infrastructure for dedicated hydrogen use, are:

- The **lack of harmonised standards regarding the threshold content and the technical specifications** to inject hydrogen within natural gas infrastructure;
- The lack of clarity regarding the options on whether hydrogen should be blended with natural gas (at least in a transitory period) or should be transported in dedicated infrastructure. This is in particular an issue if end-users require hydrogen rather than methane;
- The **lack of an enabling regulation to stimulate the deployment of hydrogen** applications and the use of existing methane infrastructure (e.g. certification, guarantees of origin);
- The **lack of clarity regarding possible EU and national pathways** that may give rise to the development of a dedicated hydrogen network and market within the EU as a basis for deploying production, transport and storage infrastructure;
- The **absence of adequate EU and national frameworks for dedicated hydrogen infrastructure and markets**.

Opportunities for Hydrogen Energy Technologies Considering the National Energy & Climate Plans | Europe (5/5)

We (HIPS-NET Team) recommend reading the report upon interest. The findings come along with many diagrams, which help to comprehend the detailed information.

The analysis of the NECPs shows that EU Member States are increasingly considering hydrogen deployment as part of their strategy to decarbonise energy supply. The NECPs for 2021-2030 show that hydrogen is gaining momentum in the debate on decarbonising the EU economy. However, only some NECPs comprise concrete dedicated measures to facilitate hydrogen deployment and its integration into energy systems.

Several Member States mention their intention to improve the regulatory framework for renewable gases, including hydrogen, and refer to financial or fiscal measures that would facilitate their development.

The majority of NECPs do not address how the national regulatory frameworks will actually be improved and provide limited information regarding measures to effectively address the barriers to hydrogen deployment. In short words: There are many opportunities for hydrogen deployment and much work to be done ahead for all stakeholders including the European and national legislators and regulators to enable realising the opportunities.

https://bit.ly/36X7E8d

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IEA Renewables 2020 | worldwide (1/2)

The International Energy Agency (IEA) published "Renewables 2020" with a detailed analysis and forecasts through 2025 of the impact of Covid-19 on renewables in the electricity, heat and transport sectors.

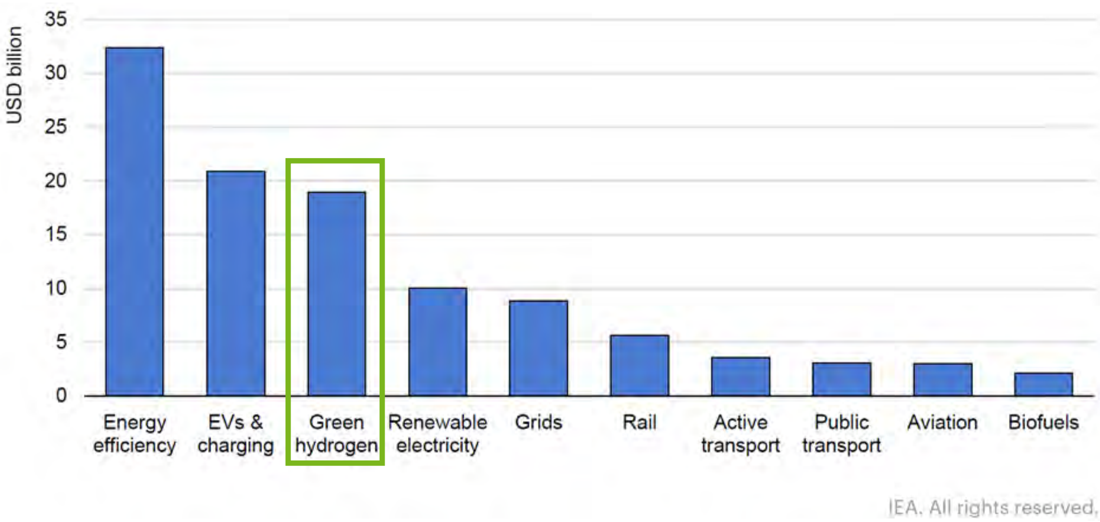
Authors' remark: The term 'renewable energy / capacity' is used in this report mainly for renewable electricity and biofuels (mobility). We did not change the wording, please be aware of the meaning while reading this article. The term 'hydrogen' is used 22 times in the 172 pages of the report. This reflects the minor role of hydrogen. 'Gas infrastructure' and natural gas / hydrogen blends are not mentioned in the report. Somewhat surprising, since the IEA also publishes around hydrogen. Renewable energy and hydrogen seem to be separate topics for the IEA analysis and forecast. See the following article "Hydrogen Tracking Report" for specific information on hydrogen.

Driven by **China and the United States**, net installed renewable capacity will grow by nearly 4 % globally **in 2020**, reaching almost 200 GW. Higher additions of wind- and hydropower are taking global renewable capacity additions to a new record this year, accounting for almost 90 % of the increase in total power capacity worldwide. Solar PV growth is expected to remain stable.

Europe and India will lead a renewables surge in **2021**. Renewable capacity additions are on track for a record expansion of nearly 10 % in 2021.

Renewables will overtake coal to become the largest source of electricity generation worldwide in 2025. By that time, they are expected to supply one-third of the world's electricity. Hydropower will continue to supply almost half of global renewable electricity. It is by far the largest source of renewable electricity worldwide, followed by wind and solar PV.

The **biofuels** industry has been strongly impacted by the Covid crisis. Global transport biofuel production in 2020 is anticipated to decline by 12 % from 2019's record. This is the first reduction in annual production in two decades, driven by both lower transport fuel demand and lower fossil fuel prices.



Announced Clean Energy Stimulus Packages by Sector Worldwide - Forecast 2025 (Report, p. 143)

IEA Renewables 2020 | worldwide (2/2)

Renewable heat uptake - The share of **renewable heat** is expected to remain broadly constant over the next five years. Global renewable heat consumption is projected to be 20 % higher in 2025 than it was in 2019, with a stronger increase in the buildings sector than in industry.

Green and low-carbon Hydrogen

Recent policy momentum has the potential to give renewable energy use an extra boost. The planned measures can support renewables by providing additional financial support either directly – **or indirectly through** areas such as buildings, grids, electric vehicles and **low-carbon hydrogen**.

Green hydrogen programmes (see figure) are also expected to raise renewable (electric) capacity, although investors could also use existing wind, solar PV and hydropower plants for hydrogen production.

In the long term, other measures could pave the way to further renewable heat uptake in hard-to-abate industrial subsectors. This is the case for support given to renewable or "green" hydrogen projects in countries such as Australia, France, Germany and Korea. It also applies to material efficiency measures, such as steel recycling in the United Kingdom, which can engender heat savings and encourage greater shares of (renewable) electricity in the steelmaking process. (See the following article for more information around hydrogen.)

https://bit.ly/37Lje5l, download free of charge but registration required

IEA Hydrogen Tracking Report | worldwide (1/3)

The International Energy Agency (IEA) issued a landmark report "The Future of Hydrogen" in June 2019. One year later, in June 2020, the IEA published a hydrogen – tracking report. The report's résumé:

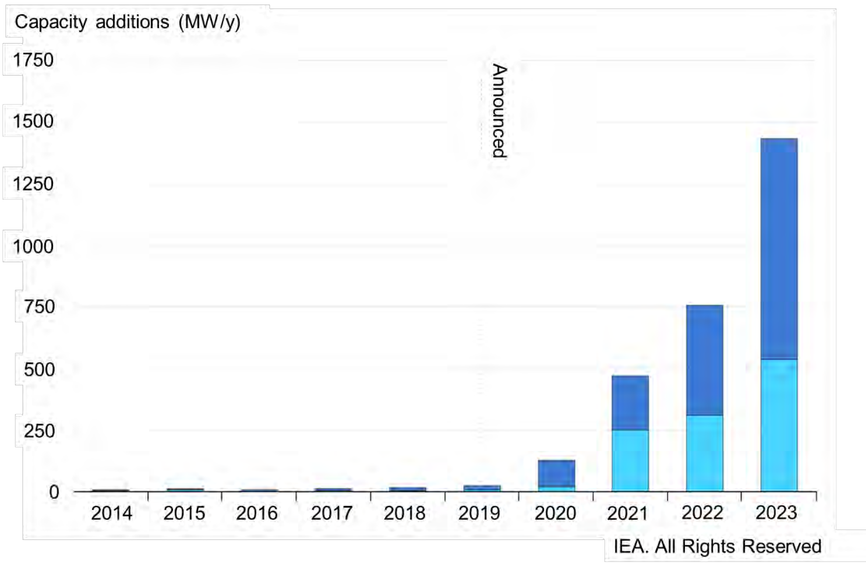
Hydrogen technologies maintained strong momentum in 2019, awakening keen interest among policy makers. It was a record year for electrolysis capacity becoming operational and several significant announcements were made for upcoming years. The **fuel cell electric vehicle market almost doubled,** owing to outstanding expansion in China, Japan and Korea. **However, low-carbon production capacity remained relatively constant and is still off track** with the 'Sustainable Development Scenario'. More efforts are needed in the following areas: scale up to reduce costs, replace high-carbon with low-carbon hydrogen in current applications, and expand hydrogen use to new applications.

Coupling conventional technologies with CCUS is still the main route for **low-carbon hydrogen** production. It will likely remain so in the short to medium term because production costs are lower than for other low-carbon technologies such as electrolysis.

Interest in projects that combine conventional technologies with CCUS is growing. Six projects, with a total annual production of 350,000 tonnes of low-carbon hydrogen, were in operation at the end of 2019, and more than twenty new projects have been announced for commissioning in the 2020s, mostly in countries surrounding the North Sea.

In recent years, the number of projects and installed electrolyser capacity have expanded considerably, from less than 1 MW in 2010 to more than 25 MW in 2019. Furthermore, project size has increased significantly: most projects in the early 2010s were below 0.5 MW, while the largest in 2017-19 were 6 MW and others fell into the 1 MW to 5 MW range.

In March 2020, a 10 MW project started operation in Japan, and a 20-MW project in Canada is under construction. Plus, there have been several announcements for developments in the order of hundreds of MWs that should begin operating in the early 2020s (see the IEA hydrogen project database and figure).



Global Electrolysis Capacity Becoming Operational Annually, 2014-2023, Historical and Announced (Source: https://bit.ly/36T8u5O)

IEA Hydrogen Tracking Report | worldwide (2/3)

Hydrogen use in transport

The fuel cell electric vehicle (FCEV) market is beginning to flourish, catalysed by developments in Asia. The global FCEV stock nearly doubled to 25,210 units at the end of 2019, with 12,350 new vehicles sold – more than doubling the 5,800 purchased in 2018. While US sales fell slightly in 2019 (2,100, compared with more than 2,300 in 2018), the United States remain the world leader in FCEV stock, with approximately one in three FCEVs running on US roads, followed by China, Japan and Korea. In the case of China, this impressive progress was stimulated by policies supporting the adoption of fuel cell buses (with a stock close to 4,300) and light-duty trucks (more than 1,800), making China the leader in global stock of fuel cell buses (97 %) and trucks (98 %).

At the end of 2019, 470 hydrogen refuelling stations (HRS) were in operation worldwide, an increase of more than 20 % from 2018.

Japan remains the leader with 113 stations, followed by Germany (81) and the United States (64). The number of stations in operation expanded considerably in Korea (+20), Japan (+13) and Germany (+12), whereas the United States added only one HRS in 2019.

Similar to FCEVs, the number of refuelling stations increased threefold in China in 2019 (from 20 to 61), giving China the fourth-largest number of stations, followed by Korea and France.

In non-road vehicles, new applications are gaining recognition. At the end of 2018, two fuel cell trains produced by Alstom became operational in Germany, and successful trials led to the announcement that another 14 will be put into service in 2021. The United Kingdom and the Netherlands have also shown interest in Alstom hydrogen trains, and a fuel cell tram began operating in Foshan (China) in 2019, with China exploring further possibilities for hydrogen-fuelled rail.

Injecting hydrogen into the gas grid

In addition to transport, the sectors domestic and industrial heating could raise low-carbon hydrogen demand for decarbonisation purposes. Existing infrastructure (such as gas grids) could be used to enable demand increases.

Injecting hydrogen into the gas distribution grid is a low-regret option for increasing low-carbon hydrogen demand for domestic and industrial heating. **Blending hydrogen up to 20 vol% into the gas grid requires minimal or potentially no modifications** to grid infrastructure or to domestic end-user appliances.

The GRHYD project in France, which began blending 6 vol% hydrogen into the natural gas grid in 2018, already reached 20 vol% in 2019, demonstrating the technical feasibility of this approach for domestic use.

Injecting hydrogen into the gas transmission grid is more challenging. This is due to material incompatibilities at high pressures and a lower hydrogen concentration tolerance in the blending that industrial users can accept. However, some pilot experiments are testing the feasibility of injecting hydrogen at the transmission level, and a project developed by Snam in Italy has already demonstrated the feasibility of blending hydrogen up to 10 vol%.

Several projects around the world are already injecting hydrogen into gas grids:

The largest (6 MW of electrical input) has been operational in Germany since 2015, and as this is a sector in continuous expansion, several more projects will be launched in the early 2020s. A growing number of countries is interested in gas grid hydrogen-blending because the increasing use of variable renewable electric generation leads to periods of surplus and curtailment.

Although interest was initially limited to Europe, since 2017 other countries (such as Australia, Canada and the United States) have become curious about how to make use of their robust gas grids to boost low-carbon hydrogen demand. Installations that can blend roughly 2,900 tonnes of hydrogen per year into the gas grid are currently in place around the world.

Industrial hydrogen demand

Of all sectors, industry has the highest hydrogen demand, especially for refining and chemical and steel manufacturing. As these industries use high-carbon hydrogen, replacing it with low-carbon hydrogen would be an ideal opportunity to ramp up demand while decreasing greenhouse gas emissions in the short term.

Although electrolytic hydrogen is still limited to some pilot or small-scale experiences, a number of important large-scale developments (up to 100 MW) were announced in 2019 and are expected to be operational in the early 2020s. Most of these announcements involve oil refining or methanol and ammonia production.

In addition, building on initial pilot projects currently under way in Europe, electrolytic hydrogen is gaining momentum in steelmaking. Without making any major changes to existing direct reduced iron furnaces, up to 35 % of the natural gas can be substituted by hydrogen. Several steelmakers are pursuing blending as a transition strategy to forge the way to the deployment of the pure hydrogen direct reduced iron route. A large pilot plant with electrolysis is under construction in Sweden and a first demonstration trial is projected for 2025.

Recommended actions

There is a strong link between the widespread production and use of low-carbon **hydrogen and climate change ambitions, which will continue to be its main driver. For these reasons, governments have a central role** in building the right environment for low-carbon hydrogen technologies to prosper and contribute to climate targets as well as other policy objectives, such as air quality and energy security. The

IEA Hydrogen Tracking Report | worldwide (3/3)

development of **robust policies and regulations** can incentivise private sector investment in low-carbon hydrogen, raising both supply and demand and eventually enabling financial self-sustainability in a greater number of sectors and countries.

Defining a **clear role for hydrogen in long-term policies and strategies** would instil in investors the confidence that hydrogen investments will be profitable for decades to come. Governments can therefore shape future expectations for the sector by establishing clear targets and pathways. Multilateral initiatives and projects can assist in knowledge-sharing, developing best practices and leveraging spill over benefits.

Existing infrastructure, such as natural gas grids, can provide significant opportunities to create and scale up low-carbon hydrogen demand. **Policies and regulations supporting hydrogen blending in the gas grid** (such as renewable fuel obligations and low-carbon fuel standards) can accelerate the deployment of low-carbon hydrogen by linking it with secure energy demand.

Even **blending at low concentrations** (around 5 vol%) can significantly increase the deployment of supply technologies and result in cost reductions. Once this low-concentration blending has been demonstrated as economically sustainable, it could be **raised by steps up to 20 vol% with almost no infrastructure modifications**.

Current regulations are restricting the uptake of low-carbon hydrogen. **Regulators** should therefore address all barriers and obstacles, and **adopt a harmonised set of standards** to facilitate widespread hydrogen use across all sectors and through different infrastructures.

Some barriers deserve **special attention** because they are impeding demand growth, and removing them could help to build social acceptance:

- blending limits in natural gas grids
- demonstration of the safety case for new applications, especially in the domestic and industrial sectors
- hydrogen refuelling standards and permitting processes for refuelling stations.

Impact of COVID-19 on hydrogen

The production and use of low carbon of hydrogen had gained unprecedented momentum before the Covid-19 crisis. Hydrogen FCEV sales accelerated impressively in 2019, and the early 2020s were expected to be record years for the deployment of electrolyser capacity. These trends may now be at risk due to slackening demonstration of key end-use technologies and delayed (or even cancelled) low-carbon production projects.

It is essential to ensure that hydrogen technology momentum is not lost during the Covid-19 crisis, and stimulus packages could help securing this objective. Supporting the deployment of CCUS infrastructure and electrolysis manufacturing would not only help to maintain momentum but would accelerate the uptake of hydrogen for sector integration and create employment for economic recovery after the crisis.

https://www.iea.org/reports/hydrogen

Roadmap Hydrogen Economy | South Korea (1/3)

"Hydrogen economy" refers to an economy where hydrogen is an important environmentally friendly energy source, brings out radical changes to the national economy and society as a whole, and is a driving force behind economic growth.

If South Korea's hydrogen economy grows, the volume of added value it creates by 2040 will exceed KRW 43 trillion, equivalent to 2.5% of the nation's 2017 GDP. It will create an estimated 420,000 jobs, or 75% of the entire 2018 workforce in the automobile industry.

South Korea has the potential to lead the hydrogen economy

Most importantly, South Korea's well-established **physical infrastructure** can effectively promote development of the hydrogen economy. Currently, large-scale **petrochemical complexes** (in Ulsan, Yeosu and Daesan) have a hydrogen pipeline and high purity production technology, producing, circulating and utilizing about 1.64 million tons of hydrogen annually. Moreover, the existing **LNG supply network** can make it possible to establish a nationwide hydrogen production and supply system in an easy, stable, and economically viable way without additional investment in infrastructure.

Market Creation

South Korea's hydrogen economy roadmap places top priority on market creation and developing hydrogen-utilizing industries towards achieving the world's largest market share in hydrogen fuel cell electric vehicles (FCEV) and fuel cells.

To create a market for **hydrogen FCEVs**, specific measures are planned to establish and expand a mass production system of hydrogen-powered vehicles, to convert public transportation to hydrogen taxis or buses, and utilize hydrogen trucks in the public sector. Hereby, the market size of hydrogen FCEVs is expected to expand from about 1,800 units in 2018 to 80,000 in 2022, and 6.2 million in 2040 (see figure A on the next page).

Roadmap Hydrogen Economy | South Korea (2/3)

In the beginning, the government will certainly bear some of the burden for establishment and operation of **hydrogen filling stations**, which will be built at major transportation bases within city centres, at points along highways such as rest stops, and at bus and taxi garages in affiliation with hydrogen vehicle distribution programs at the city and province level (see forecast in figure B).

In terms of **fuel cells for power generation**, an LNG billing system for fuel cells will be introduced, and weighted renewable supply certificates (RECs) for fuel cells will be maintained for a certain period to encourage the installation of fuel cells for power generation, thereby eliminating the uncertainty of investment and promoting economic efficiency.

This will expand the current capacity from 308 MW to 1.5 GW by 2022. The mass production is expected to reduce installation and power generation costs by 2025 to a level required by a small- or medium-sized gas turbine. Thus, the combined production volume for exports and domestic consumption is expected to expand to at least 15 GW by 2040 (see figure C).

The distribution of **home fuel cells** will be supported by gradual expansion of government budgets, introduction of a LNG-exclusive billing system, provision of financial incentives such as extension of the electricity tariff specialization system so as to ease the burden on the electrical grid, and mandatory installation of fuel cells at public institutions and new private buildings. Therefore, the current distribution of 7MW is expected to expand to 50 MW by 2022 and 2.1 GW or higher by 2040 (see figure D).

Large-scale R&D on electrolysis and demonstrations using surplus renewable energy will begin by 2022, and hydrogen production planned to be in affiliation with largescale renewable energy generation complexes, such as those harnessing offshore wind power and solar power.

In consideration of the limited capacity of eco-friendly hydrogen production, overseas hydrogen produced with renewable energy and brown coal in an eco-friendly way will be imported from 2030, with 70 % of demand for hydrogen met with eco-friendly, CO_2-free hydrogen by 2040 (see figure E).

Hydrogen Storage & related Transportation Sector

As mentioned above, development of hydrogen-utilizing industries will expand hydrogen production and naturally lead to growth of the storage and related transportation sector in this process.

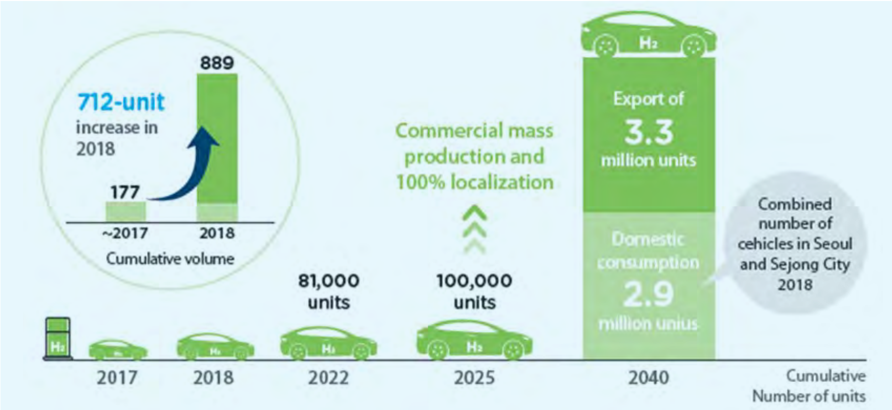


Fig. A: Market Creation for FCEVs (strategy p. 8)

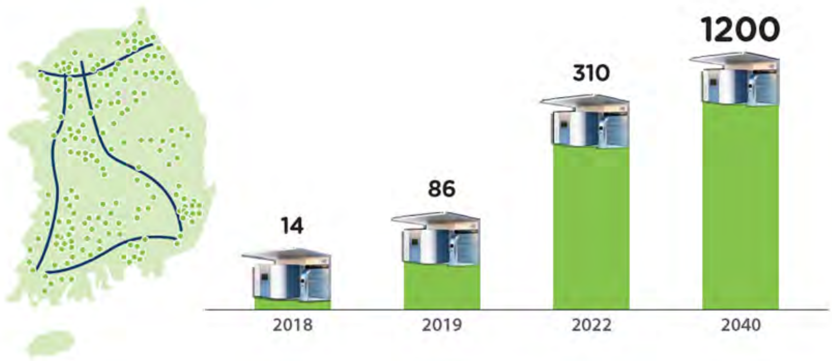


Fig. B: Market Creation for Hydrogen Fuelling Stations (strategy p. 8)

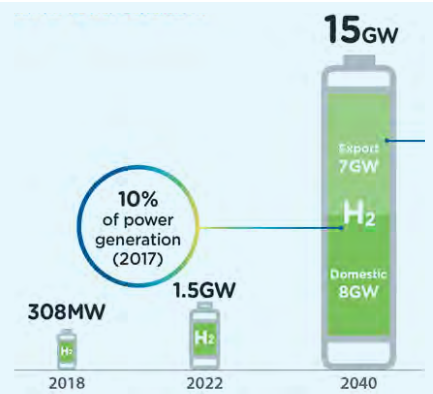


Fig. C: Market Creation for Fuel Cells for Power Generation (strategy p. 9)

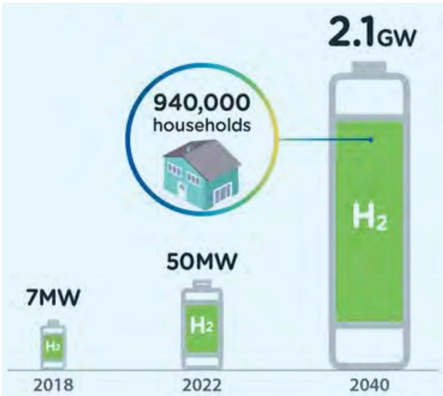
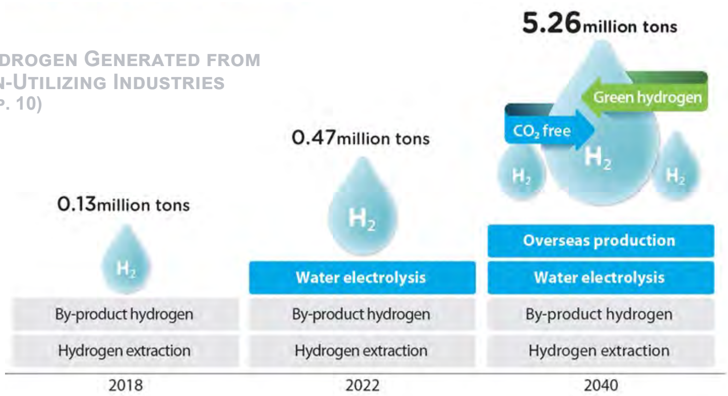


Fig. D: Market Creation for Fuel Cells for Homes and Buildings (strategy p. 9)

Fig. E: Hydrogen Generated from Hydrogen-Utilizing Industries (strategy p. 10)



Roadmap Hydrogen Economy | South Korea (3/3)

It will become difficult to accommodate the increasing need for hydrogen-related logistics with the current fleet of 500 low-pressure gas tube trailers and existing 200 km of hydrogen pipelines built near the sources of demand. To cope with this increasing demand for hydrogen logistics, development of **high-pressure (700 bar or more) tubes** is planned and will be used to transport the entire daily consumption (1 ton) of a small- to medium-sized city bus filling station with a single delivery.

In the long run, however, the government will support the development of new storage and transportation technologies such as those for liquefied hydrogen, liquid hydrogen and solid hydrogen to replace the compressed hydrogen system and its limited storage density, and is planning to use **liquid and liquefied hydrogen** tank lorries from 2030 in actual distribution of hydrogen.

In addition, we will develop a **pipeline** that successfully overcomes the problem of brittleness to transport hydrogen at a **high pressure of 50 bar** or more, and begin to expand it to include major sources of demand before making it a nationwide network in the mid- to long term.

https://bit.ly/36X6k57

Summary

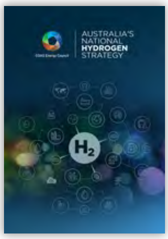
Core to the hydrogen economy roadmap is that such **market creation** and growth will accelerate development of the technology required by the market and establishment of a market-driven innovation system.

To build such a system, the government is planning a **roadmap to support all stages of technological development** throughout the entire value chain, from development of source technology in hydrogen-powered vehicles, core components of fuel cells, and storage and transportation, to demonstration, commercialization, and improvement of stability.

In addition, the government will establish safety standards for greater stability throughout the entire hydrogen economy and put such standards into law, while it results in providing legal and institutional support through enactment of a "**Hydrogen Economy Act**".

The **Hydrogen Economy Promotion Committee** has been set up by the South Korean government to put the Roadmap for Hydrogen Economy into action and to serve as a pan-government control tower. And the promotion team has been established for standardization, professional training for the needed manpower, development and support of small- & mid-sized companies, and international cooperation in order to create an ecosystem for hydrogen economy.

Hydrogen Strategy | Australia (1/2)



Australia has the resources, and the experience, to take advantage of increasing global momentum for clean hydrogen and make it to its next energy export. There is potential for thousands of new jobs, many in regional areas – and billions of dollars in economic growth between now and 2050. We can integrate more low-cost renewable generation, reduce dependence on imported fuels, and help reduce carbon emissions in Australia and around the world.

In total, the strategy identifies 57 joint actions. These actions by themselves will not achieve the vision. They are first steps, on which later actions can build. The actions consider hydrogen in relation to exports, transport, industrial use, gas networks, electricity systems, and cross-cutting issues such as safety, skills, and environmental impacts. The strategy targets domestic and industrial hydrogen demand in the sectors:

- using clean hydrogen for industrial feedstocks
- using hydrogen for heating
- blending of hydrogen in gas networks
- using hydrogen for long-distance heavy-duty transport and developing an associated refuelling infrastructure

Breakeven price points

This table shows the delivered prices hydrogen would need to achieve against competitor fuels.

Competitor fuel service	Hydrogen breakeven price ($/ kg H_2)
Drive 100 km using petrol (retail price $1.43/ L)[i]	$13.31
Drive 100 km using diesel (retail price $1.50/ L)[ii]	$11.21
Deliver 1 GJ heat using natural gas (wholesale price approximately $10/ GJ)[iv]	$1.20

Water inputs

Producing 1 kg of hydrogen requires at least:[v]	
Electrolysis	9 L
Coal gasification	9 L
Steam Methane Reforming (SMR)	4.5 L

These are theoretical amounts of water based on the chemical pathway for each process. In practice water requirements for hydrogen production will vary depending on production method and technology, water content of inputs, and additional water needs for processes like cooling and input water purification.

Emissions intensity of production

Production technology	Emissions (kg CO_{2-e}/kg hydrogen)[vi]
Electrolysis – Australian grid electricity[vii]	40.5
Electrolysis – 100% renewable electricity	0
Coal gasification, no CCS[viii]	12.7 - 16.8
Coal gasification + CCS – best case[ix]	0.71
Steam methane reforming (SMR), no CCS[x]	8.5
SMR + CCS – best case[xi]	0.76

Central Numbers for Hydrogen (strategy p. 16)

Hydrogen Strategy | Australia (2/2)

The Australian Government supports growth of a clean, innovative, safe and competitive Australian hydrogen industry.

⇒ **Smart, consistent, light-touch regulation**

The Australian Government will drive **national regulatory reform** to help remove barriers to industry development, while keeping Australians safe and protecting the environment.

It will ensure Australian **laws are reviewed and reformed** where necessary, to allow for the development of a strong hydrogen industry in Australia. It will ensure baselines under the Safeguard Mechanism are appropriate and provide investment certainty for new hydrogen facilities.

⇒ **Shaping international markets**

The Australian Government will establish **agreements with key international markets** to underpin investment. It has already signed a cooperation agreement with Japan and a letter of intent with Republic of Korea.

Australia will spearhead development of an **international certification scheme for hydrogen**, working closely with local and international companies. It will ensure the emerging global rules and regulations for hydrogen trade do not disadvantage Australia, by working with like-minded countries and in multi-lateral forums.

⇒ **Accelerating technology commercialisation**

The Australian Government supports investment in clean energy technology, including hydrogen, from research and development through to commercialisation.

Australia's Agreed Strategic Actions – selection out of 57 joint actions

Large-scale market activation - consider the most appropriate support to scale up the industry and activate markets (without mandatory national targets)

Hubs and sector coupling - support the hub model as a prospective early-stage approach to achieve the scale needed for a competitive industry ('Hubs' are clusters of large scale hydrogen demand i.e. at ports, in cities, or in regional or remote areas.)

Assessing our hydrogen infrastructure needs - complete an inaugural National Hydrogen Infrastructure Assessment by 2022. The assessment will consider hydrogen supply chain needs such as electricity and gas networks, water supply networks, refuelling stations, roads, rail and ports, while taking into account local community concerns and priorities.

Supporting research, pilots, trials and demonstrations along the supply chain - the following areas should be priorities for research, pilot projects, trials, and demonstration projects:

- Switching current industrial hydrogen users to clean hydrogen
- Investigating new opportunities for clean hydrogen such as clean ammonia exports, clean fertiliser exports, industrial heating, iron ore processing and steel making
- Using hydrogen in remote applications, such as in microgrids for mining and remote communities, in farming and marine applications, at remote defence facilities and as a fuel for heavy-duty mining vehicles
- Opportunities for backup power supply, such as for mobile phone towers, hospitals and other types of critical infrastructure
- Enabling blending of hydrogen with natural gas and eventual use of 100% hydrogen in gas networks
- Using hydrogen for transport, with a focus on heavy and long-range road transport, rail and shipping
- Optimising hydrogen and electricity system interactions, such as through timing hydrogen production to match variable renewable generation and through use of hydrogen for storage and dispatchable generation
- Testing and proving of technologies that reduce the cost of making, moving, storing and using hydrogen
- Using water from sustainable sources, such as waste water or seawater for hydrogen production
- Developing cross-sector linkages and deriving value from sector coupling.

Using clean hydrogen in Australian gas networks - support continuing pilots, trials and demonstrations of **hydrogen in gas distribution networks**, where distributors can satisfy relevant regulators that the infrastructure is safe and suitable for hydrogen blending. The effects of blending for gas network users of natural gas as chemical feedstock or for compressed natural gas have been considered and mitigated.

Cautious: Support the blending of hydrogen in existing gas transmission networks only if further evidence emerges that hydrogen embrittlement issues can be safely addressed.

Certainty around taxation, excise and other fees or levies for hydrogen - continue with the revenue arrangements that now apply to hydrogen, with the option to review them in the future.

Hydrogen certification - Australia will seek to play a lead role in the design and development of an international guarantee of origin scheme.

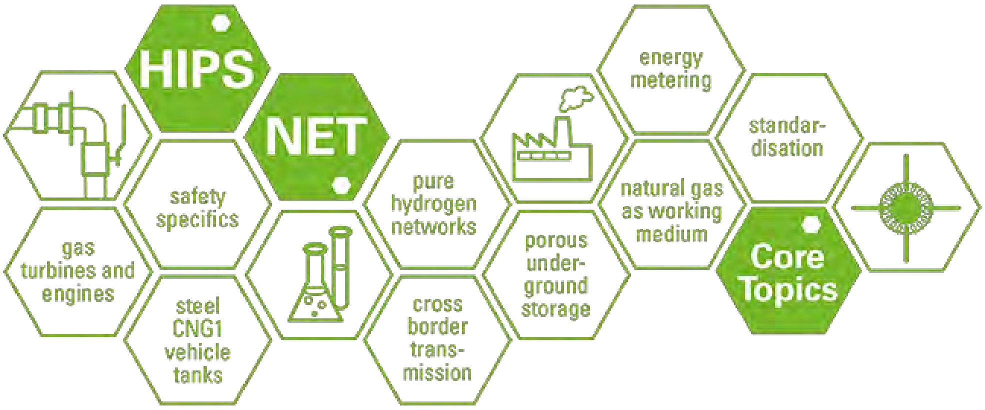
Building community knowledge and engagement - develop a community education program to provide clear and accessible information about risks, benefits and safe use. The program will communicate the particular benefits hydrogen development can bring to regions as well as more general benefits such as economic growth, lower carbon emissions and reduced air pollution.

Skills and training for the hydrogen economy - develop nationally consistent training materials and guidelines for procedures to do with the production, handling, transport and use of hydrogen including training for Australian emergency services and regulators.

https://bit.ly/3gqA65s

HIPS-NET CORE TOPICS

HIPS-NET Core Topics



EVENTS AND PARTNERS

Selection of Appointments

January 2021

13-14 Hydrogen Business for Climate | Belfort, France, *https://bit.ly/2TnThCl*

27-29 Intensive Virtual Course - Hydrogen | Online, *https://www.hydrogeneurope.eu/events/intensive-virtual-course-hydrogen*

February 2021

09-10 Hydrogen & P2X: Fuel Cells, Road Transport and Energy Production | Copenhagen, Denmark, *https://bit.ly/37neAvL*

10-11 HyVolution | Paris, France, *www.hyvolution-event.com*

10-11 Hypothesis XV | Muscat, Oman, *www.hypothesis.ws*

March 2021

03 Realising Hydrogen`s Future Role - at Speed and Scale | Online, *https://www.h2-view.com/event/h2-view-hydrogen-virtual-event-2021/*

17-18 Hydrogen & Fuel Cells Energy Summit | Porto, Portugal, *https://www.hydrogeneurope.eu/events/hydrogen-fuel-cells-energy-summit*

May 2021

04-05 HyVolution | Paris, France, *https://www.hyvolution-event.com/en*

05 4th International Workshop on Degradation Issues of Fuel Cells and Electrolysers | Corfu, Greece, *https://bit.ly/37LiXPS*

18-20 beyondgas 2021 | Oldenburg, Germany, *https://www.beyondgas.de/*

June 2021

09-10 The Hydrogen Technology Conference & Expo | Stuttgart, Germany, *https://www.hydrogen-worldexpo.com/*

20-24 WHTC - World Hydrogen Technologies Convention 2021 | Online, *www.whtc2021.org/*

Current Partners

Alliander AG, Areva H_2Gen,
Cadent, DGC, DNV GL, Enagás,
Enbridge, Energinet.dk, ENGIE,
EWE Netz, Gas Connect Austria GmbH,
Gasnetz Hamburg, Gasum OY,
Gasunie, GRTgaz, GRZI e.V. (FIGAWA),
Infraserv GmbH & Co. Höchst KG,
INERIS, innogy SE, ITM Power,
Joint Research Centre (JRC), EC,
KOGAS, NAFTA a.s,
Naturgy, ONTRAS, ÖVGW,
Open Grid Europe GmbH,
Polymer Consult Buchner GmbH,
RAG Austria AG,
Shell, Solar Turbines Europe S.A.,
Storengy, SVGW,
Synergrid, Teréga, TNO,
Uniper Energy Storage GmbH,
Verband der Chemischen Industrie (VCI),
Volkswagen AG, Wintershall Dea AG.

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HIPS-NET

“ESTABLISHING A PAN-EUROPEAN UNDERSTANDING OF ADMISSIBLE HYDROGEN CONCENTRATION IN THE NATURAL GAS GRID”

NEWSLETTER #31 **MAY, 2021**

Dear HIPS-NET Partners,

Topics around hydrogen are exploding in the past months also due to the commitment of governments and the European Union. Many projects receive funding, and the market conditions are not yet sufficient for market participants to invest – apart from selected exceptions. It is a good time to talk to decision makers about needed changes in the market as the study of the World Energy Council suggests. Have a read and find some well-reasoned arguments.

We need you to help us identifying central projects in your country. So please get in touch with us! Give us the information about the developments and projects and we will draft articles for the newsletter.

This HIPS-NET newsletter summarises articles around

- Spanish hydrogen Roadmap approved | Spain
- Hydrogen injection in transmission network | Germany
- Hydrogen in the IGU global gas report | worldwide
- Vision for Hybrid Heating System – a path including hydrogen | Germany
- ...

HIPS-NET Workshop
16th/17th June, 2021
online in the afternoon

We hope you find interesting information and enjoy reading.

The HIPS-NET workshop is coming soon. We are about the prepare the workshop and decided to meet online again this year. It is a pity, and we would have preferred to see each other in reality … it seems we need another year to see us live for a beer ;-). We are planning presentations and an interactive part for networking and discussion. **Do you have questions that you wish to talk about with HIPS-NET colleagues from other companies? Which topics are important to talk about, elaborate and develop views?** Please get in touch with Josephine.

Your HIPS-NET Team - Gert, Anja, and Josephine

Farewell from Anja:

I will leave HIPS-NET and DBI. It is time for me to head off to new tasks. I joined HIPS-NET almost at the start, I think with the 2nd newsletter. During this time, I have developed writing skills (not easy for a mathematic mind) and happened to become the lead author of HIPS-NET. I learned a lot about hydrogen and admixture development and am grateful for having the chance to shape and manage this network. I enjoyed the work for the network and the work with you. Thank you!

CONTENT

CONTENT NEWSLETTER #31

Spanish Hydrogen Roadmap Approved | Spain (1/2)

To achieve climate neutrality and a 100% renewable electricity system no later than 2050, the Spanish Government has approved in October 2020 the country's Hydrogen Roadmap: a commitment to renewable hydrogen.

This Hydrogen Roadmap identifies the challenges and opportunities for the full development of renewable hydrogen in Spain, providing a series of actions aimed at boosting investment action, taking advantage of the European consensus on the role that this energy sector should play in the context of green recovery.

Renewable hydrogen is set to become a valuable energy vector for end uses where it is the most efficient solution in the process of its decarbonisation, such as **hydrogen-intensive industry and high-temperature processes, long-distance heavy transport, maritime transport, rail transport or aviation**. **In addition**, the energy vector quality gives it great potential as an instrument for **energy storage and sector coupling**. Main focus is on sectors where electrification is not the most **efficient** solution or is not technically feasible in the medium term, including public transport, urban services or various uses in intermodal transport nodes such as ports, airports or logistics platforms. The role of hydrogen to store energy and/or decarbonise the **heat sector in both industry and homes**, must be assessed and prioritised in cases where electrification is not the most **competitive** solution.

In particular, the "**Vision 2030**" foresees **4 GW electrolyser capacity** and a series of milestones in the industrial, mobility and electricity sectors, for the period 2020-2030 (see figure right). It will be necessary to mobilise investments estimated at 8,900 million Euros during the period 2020-2030. However, as an **intermediate milestone** to reach the 4 GW target, it is estimated that **by 2024** it would be possible to have **between 300 and 600 MW** electrolyser capacity installed.

The creation of **hydrogen valleys** or clusters will play a very significant role, where production, transformation and consumption are specially concentrated.

The industry that uses hydrogen as a raw material (oil refining, fertilisers, and chemicals, among others) has a great potential to boost renewable hydrogen production in the short term. It needs ambitious but **common targets at EU level for industrial uses** of renewable hydrogen.

Renewable hydrogen should have **common standards in the EU** (targets, labelling, guarantees of origin), as these could facilitate its deployment and ensure a level playing field. Furthermore, taxation and the CO_2 market can help to provide the right signals to stakeholders and consumers to properly assess the renewable label.

The Roadmap's identified **60 (!) actions** to support producing and deploying renewable hydrogen. Just to give you an impression, see some of the actions:

ACTION 1: **Modify the classification** of on-site renewable hydrogen production at refuelling stations **as an industrial activity.**

ACTION 2: **Analyse** the different procedures for processing the operation and implementation of **small-scale** green hydrogen production **facilities** and assess whether they may be simplified.

ACTION 3: Promote the development of regulatory measures to simplify and facilitate the deployment of **direct electricity lines dedicated to renewable hydrogen production.** This requires a modification of the sector's legislation, avoiding undermining the economic and financial sustainability of the electricity and gas systems.

ACTION 4: In collaboration with European institutions, establish a system of **Guarantees of Origin** for renewable hydrogen to provide appropriate price signals to consumers.

ACTION 5: Consider the positive environmental effects of renewable hydrogen within the framework of green **taxation**, particularly indirect taxation.

ACTION 6: Establish a **national data system on hydrogen consumption and production** in Spain, differentiating by type of hydrogen and by consumption sector.

Main objectives of the Spanish Hydrogen Roadmap for 2030 (Roadmap p. 42)

Spanish Hydrogen Roadmap Approved | Spain (2/2)

ACTION 7: **Assess the feasibility of** establishing renewable hydrogen penetration **targets** for the period 2025-2030, following the path set out in the European Hydrogen Strategy.

MEASURE 8: **Design financial instruments** to support Spanish hydrogen-intensive industry in adapting its processes and infrastructures to the continuous supply of renewable hydrogen.

ACTION 9: Develop **long-term national decarbonisation strategies** based on renewable hydrogen in the most difficult to electrify sectors (based on sector-specific dialogue).

ACTION 10: Identify current hydrogen consumption hubs, promoting and encouraging the creation of "**hydrogen valleys or clusters**". The constitution of **Industrial Hydrogen Committees** will be promoted together with autonomous communities, local administrations, hydrogen consumers and promoters of renewable hydrogen production projects, encouraging the development of pilot projects.

ACTION 11: Promote the use of renewable hydrogen in the transport sector through the transposition of RED II.

ACTION 12 – ACTION 60: Please see the Spanish Hydrogen Roadmap for further detail.

Actions for hydrogen injection in the gas infrastructure

ACTION 29: Facilitate the use of green **hydrogen in electricity production**, providing a greater security of supply to the electricity system.

ACTION 30: **Review required technical, regulatory and quality aspects** of gases for the injection and use of **hydrogen into the gas grid**, with special emphasis on the use **of existing infrastructure** for the transport and/or dedicated storage of renewable hydrogen.

In particular, **safety requirements; metering, billing and administration mechanisms**; and the corresponding legal and regulatory frameworks to allow a higher concentration of renewable hydrogen into the gas network according to the proposed in European Hydrogen Strategy.

A **study on hydrogen injection limits** in the different installations of Spanish Gas System **will be promoted** in order to identify restrictions and establish local thresholds.

ACTION 31: **Assess** simultaneously the **necessity to modify gas-fired appliances** in industry and power generation **to allow safe operation with higher concentrations** of renewable hydrogen.

ACTION 32: Perform a prospective **analysis of retrofitting requirements of domestic gas appliances** (boilers, heaters etc.) to allow for the gradual integration of renewable hydrogen.

78 entities, organisations, associations and individuals contributed to the public consultation of the Roadmap. It will be updated every three years, to evaluate the progress towards the vision 2030 objectives, the degree of implementation of the measures and the quantification of their impact.

https://www.miteco.gob.es/es/ministerio/hoja-de-ruta-del-hidrogeno-renovable.aspx

Hydrogen Injection in Transmission Network | Germany

For the first time, green hydrogen converted in an electrolyser using renewable electricity from wind turbines was fed into the gas transmission pipeline system in Northern Germany in December 2020.

The green hydrogen is blended with the gas in the DEUDAN pipeline up to a **concentration of 2 vol%**. Thus, the gas quality remains within the applicable regulations. The pipeline stretches from the German-Danish border crossing at Ellund to Quarnstedt in Schleswig-Holstein. Extensive technical measures to realise the injection include the construction of a hydrogen blending facility, complete with metering and pressure-regulating equipment, two independent compressor units to raise the hydrogen pressure to the DEUDAN pipeline pressure, and the construction of two connecting pipelines, each 75 metres long.

The project Windgas HAURUP has a hydrogen production plant with a capacity of 1 MW (210 m³/hr hydrogen). It will operate on surplus electricity with an expected production of 3,000 MWh_{H2}/yr.

Project partners are Gasunie Germany, Open Grid Europe, Energie des Nordens with funding by the German Federal Ministry.

PS: The transmission operator ONTRAS together with UNIPER were the first companies in Germany injecting hydrogen in the transmission network (Eastern Germany).

www.windgas-haurup.de (in German)

Marko.bartelsen@windgas-haurup.de

Hydrogen in the IGU Global Gas Report 2020 | worldwide (1/2)

Hydrogen has been gaining momentum and attracting heightened attention from industry players and government agencies alike. The global gas report, therefore, has a **special section** detailing the **potential market size and the technological options and costs of hydrogen production, storage and transport, highlighting the important role of infrastructure for its development.** We also provide a list of actions (including ones on policy) that can be taken to reduce barriers for hydrogen's uptake, which in turn can help reduce carbon emissions in the 'hard-to-abate' sectors, and ultimately contribute to achieving our collective climate goals.

The current level of excitement around hydrogen presents an opportunity. Hydrogen is starting to garner policy support and, with enough investment, could **abate up to 37% of energy related greenhouse gas emissions**, according to BloombergNEF estimates. While clean hydrogen is not yet cost-competitive in many applications, delivered costs could reach around $2/kg in 2030, and $1/kg in 2050, opening up possibilities in a variety of applications. These include steel and cement making, chemicals, aviation, shipping and heavy-duty transport. For hydrogen to achieve its potential, not only will **strong policy action be needed** to drive scale, but there will also be a significant need for infrastructure investment. **Large-scale hydrogen networks will be necessary** to connect high-quality production and storage resources to users, which can help lower supply costs, increase security, enable competitive markets and facilitate international trade.

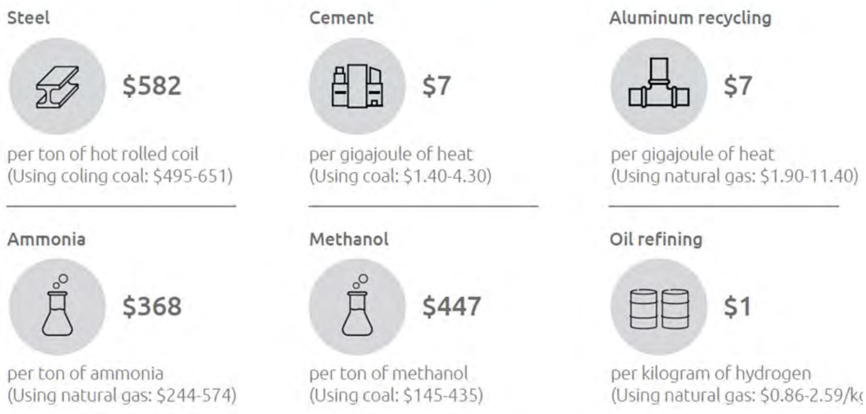
As the energy transition proceeds, gas **transport and storage infrastructure can be readied for hydrogen blending,** and indeed for pure hydrogen transport, at much lower cost than constructing new purpose-built hydrogen networks.

The report recognises the role of biomethane and renewable hydrogen and additionally promotes a third approach – low carbon hydrogen: The CO_2 intensity of natural gas can also be lowered substantially with carbon capture, utilisation and storage (CCUS) technologies. A combination of these three routes can enable the natural gas industry to continue to evolve and deliver low-carbon growth. **Modifying existing gas pipelines to carry either hydrogen or carbon dioxide** could be up **to 90% cheaper than building new** dedicated **networks** for these molecules.

A carbon price will be required for hydrogen to be competitive in regions where fossil fuel prices are very low, in all applications except road transport. **For example**, with **renewable hydrogen delivered at $1/kg**, the **carbon price needed to make it cost-competitive** with the cheapest fossil fuels in use today would be **$50/$t_{CO2}$ for steel making**, **$60/$t_{CO2}$ for heat in cement production**, **$78/$t_{CO2}$ for ammonia synthesis**, and **$90/$t_{CO2}$ for aluminium and glass** manufacturing.

With large-scale geological storage in place, hydrogen could be produced from renewable power that would otherwise be curtailed, then stored and transported back to a power generator at a cost of $8-14/MMBtu by 2050 in most locations. A carbon price of $115/$t_{CO2}$ in 2050 would be required for hydrogen to compete with the lowest-price natural gas on a total cost-of-energy basis. But if future gas turbines are hydrogen-ready, a carbon price of **$32/$t_{CO2}$ for electricity production** would be enough to drive fuel switching from $7/MMBtu natural gas to hydrogen (see additionally cost difference in figure below).

If supportive but **fragmented policy** to decarbonise and expand the use of hydrogen is in place, BNEF estimates that 187 million metric tons (MMT) of hydrogen could be in use by 2050, enough to meet 7% of projected final energy needs in a scenario where global warming is limited to 1.5 degrees. **If strong** and comprehensive decarbonisation and hydrogen industry **policy** is in force, 696 MMT of hydrogen could be used, enough to meet 24% of final energy in a 1.5 degree scenario.



Difference for production using hydrogen at 1$/kg (source: report p. 55)

The creation of a clean hydrogen industry of this magnitude would present big investment opportunities. **Over $11 trillion of spending on production, storage and transport infrastructure** would be required for hydrogen to meet around a quarter of global energy needs in 2050. **Annual sales of hydrogen would be $700 billion**, with billions more also spent on end-use equipment. **However**, if policy measures to meet emission targets and promote the use of hydrogen do not materialise, then demand is unlikely to increase significantly outside of current uses.

Water electrolysis is currently a small industry and hardware costs are high. Consequently, hydrogen produced in an electrolyser powered by renewables costs between $2.5-4.6/kg, or $19-34/MMBtu. However, these costs could fall rapidly due to a decline in the cost of electrolysers and renewable electricity.

Hydrogen in the IGU Global Gas Report 2020 | worldwide (2/2)

REGIONS	GASEOUS STATE: SALT CAVERNS	GASEOUS STATE: DEPLETED GAS FIELDS	GASEOUS STATE: ROCK CAVERNS	GASEOUS STATE: PRESSURIZED CONTAINERS	LIQUID STATE: LIQUID HYDROGEN	LIQUID STATE: AMMONIA	LIQUID STATE: LOHCS	SOLID STATE: METAL HYDRIDES
Main usage (volume and cycling)	Large volumes, months-weeks	Large volumes, seasonal	Medium volumes, months-weeks	Small volumes, daily	Small medium volumes, days-weeks	Large volumes, months-weeks	Large volumes, months-weeks	Small volumes, days-weeks
Working capacity (t-H_2)	300-10,000t per cavern	300-100,000t per field	300-2,500t per cavern	5-1,100kg per container	0.2-200t	1-10,000t	0.18-4,500t per tank	0.1-20kg
Benchmark LCOS ($/kg)[1]	$0.23	$1.90	$0.71	$0.19	$4.57	$2.83	$4.50	Not evaluated
Possible future LCOS[1]	$0.11	$1.07	$0.23	$0.17	$0.95	$0.87	$1.86	Not evaluated
Geographical availability	Limited	Limited	Limited	Not limited	Not limited	Not limited	Not limited	Not limited

Hydrogen Storage Options (source: report p. 59)

For instance, the price of alkaline electrolysers sold in North America and Europe fell 40% between 2014 and 2019. Chinese made systems are already sold for around 80% less than those in the West. This demonstrates that low production costs are readily achievable. Cost of units made in Europe should converge to the prices in China due to competition and offshoring of production, and could fall from around $1,200/kW today **to around $115/kW by 2030 and $80/kW by 2050**. Falling cost of wind and solar power, the cost of producing hydrogen around the world using renewable power could fall to $1.1-2.7/kg ($8-20/MMBtu) by 2030, and $0.7-1.6/kg ($5-12/MMBtu) by 2050. **This would make hydrogen competitive with current natural gas prices in Brazil, China, India, Germany and Scandinavia on an energy-equivalent basis**.

Storing hydrogen: please see the figure above as overview and read the report for details.

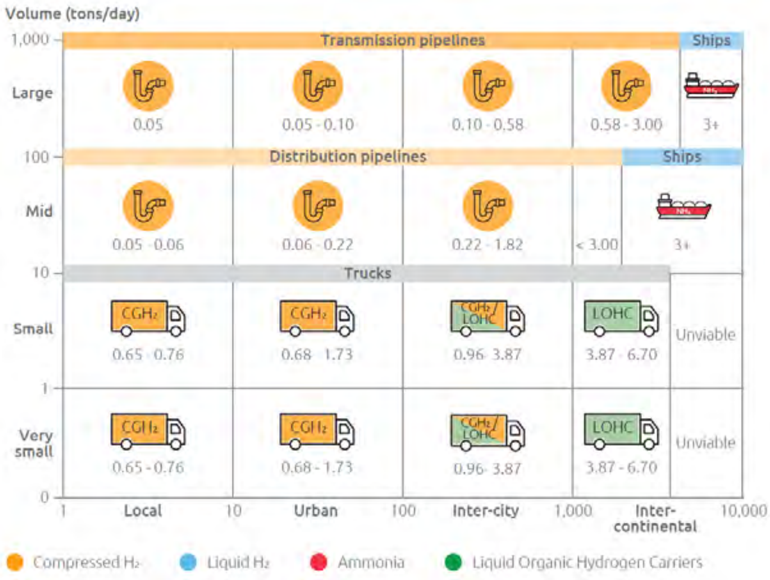
Transporting hydrogen

The report recognises the huge potential of the existing gas network and mentions hydrogen embrittlement; the technical compatibility is crucial. **Blends of up to 5-20 vol% hydrogen can generally be tolerated by the pipes used in gas distribution networks**, as these operate at lower pressures and often use different materials. Modern distribution pipes made of polyethylene could be used to transport pure hydrogen, as most plastic materials are not susceptible to hydrogen embrittlement. The **cost of hydrogen transport using pipelines is similar to that of natural gas, even though hydrogen is less dense.** This is **because** hydrogen is lighter than methane, so travels nearly three times faster through a pipe. The cost of the materials used for hydrogen pipes are also broadly comparable with gas pipes. These factors give pipelines a particular advantage over other modes of hydrogen transport. A 100 km journey via a high-capacity pipeline, moving more than 100 tons per day, costs around $0.10/kg today. This could fall to about $0.06/kg with better technology and wider adoption of large-scale hydrogen storage technologies.

The report emphasises the need for policy and summarises notable hydrogen funding commitments and subsidies in different countries (see p. 67).

Barriers to development are

1. Lack of **carbon prices** and long-term emissions reduction targets
2. **Regulatory barriers**: regulations that limit, prohibit or impede the use of hydrogen
3. Lack of **long-term investment signals**; investment mechanisms to drive private investment
4. **Weak heavy transport emissions standards**
5. Immature market for low **emissions materials**
6. Absence of coordinated plans to decarbonise industry
7. **Investment in incompatible equipment**: new investments are frequently being made in fossil fuel infrastructure without regard to its compatibility to transition to clean fuels like hydrogen.



H_2 Transport Costs Based on Distance and Volume, $/kg, 2019, (source: report p. 60)

Huge incentives are required

In the **short term**, to drive innovation and achieve delivered costs of $2/kg by 2030 BNEF estimates that around $15 billion per year of incentives or **$150 billion over the next 10 years** would be required, **to support around $300 billion of investment** in clean hydrogen projects. In the medium term, a suite of **supportive measures** are required. These could include carbon **pricing; specific industrial decarbonisation policies** such as tax concessions to help pay for converting infrastructure to hydrogen, stringent **emissions standards for heavy transport**; and green **product mandates** that require a percentage of products like steel to be sourced from near-zero emission producers.

The report is published by BloombergNEF, International Gas Union and Snam and relies in many parts on research by BloombergNEF in 2020.

https://www.igu.org/resources/global-gas-report-2020/

Vision for Hybrid Heating Systems | Europe

Simple facts undermine the need for accelerated action to reach climate goals in the building sector:

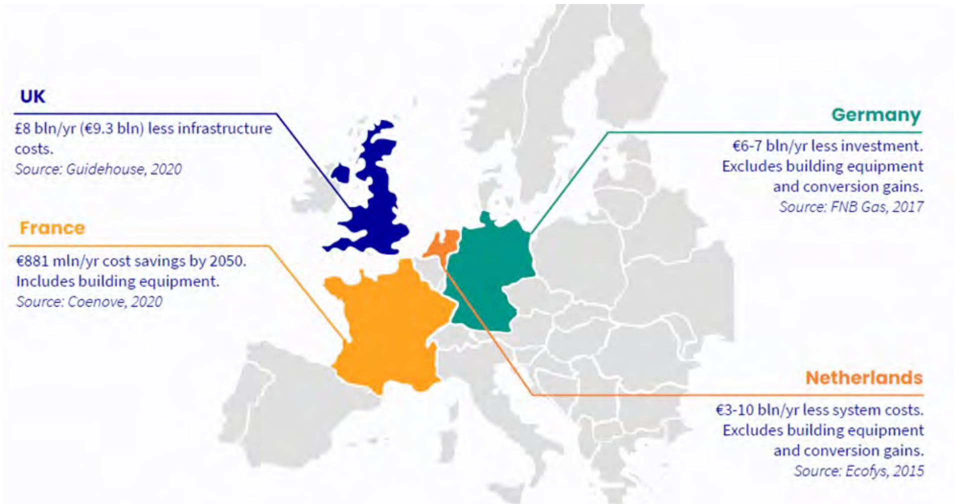
1. **We agreed to reach net zero emissions in Europe by 2050.**
2. **The building sector is responsible for more than 1/3 of the EU's emissions.**
3. **Energy renovations only reduce energy consumption by 1% per year.**
4. **Currently ¾ of the buildings is energy inefficient, yet around 90% of the buildings will still be in place in 2050.**

Effective action is crucial to reach the 2030 targets of 60% emission reduction and climate neutrality by 2050. The authors suggest installing hybrid heating. **Hybrid heating combines a hybrid heat pump with a regular boiler**. It combines various advantages. First of all, it is widely applicable and **easy to install**. The technology is mature and has entered the market already. In 2019, 32,000 units were installed in Italy, Germany, France, the Netherlands and the U.K.. Once installed, they can save cost and reduce emissions from buildings that have not undergone deep renovation yet. Hybrid heating solutions fit in a net-zero energy system by mid-century, when supplied with renewable electricity, biomethane and renewable and low-carbon hydrogen. **If a hydrogen-ready boiler is used, switching to hydrogen is prepared.**

Especially in older buildings with modest insulation levels, the consumer may not consider an all-electric heat pump solution due to the potential comfort risk (in case of insufficient capacity on the coldest days) or the high cost of bringing insulation to the necessary level to avoid this. Hybrid **heating systems do not require deep renovation**; radiators can remain and the installation of e.g. a floor heating system can be postponed. Its operation mode can gradually be shifted to more electric heat pump share when the building envelope is renovated over time.

Because of their wide immediate applicability and modest up-front cost, hybrid heat pumps are a no-regret option that can accelerate the speed of adoption of low carbon heating systems and so speed up the decarbonisation.

The consumer's **energy bill can be reduced** significantly **with smart controls** because of the high efficiency of the heat pump and the ability to switch to the lowest cost energy vector (gas or electricity) at any time when using a smart system which can respond to energy price signals. For the UK, savings of up to 50% were found. The effect will vary



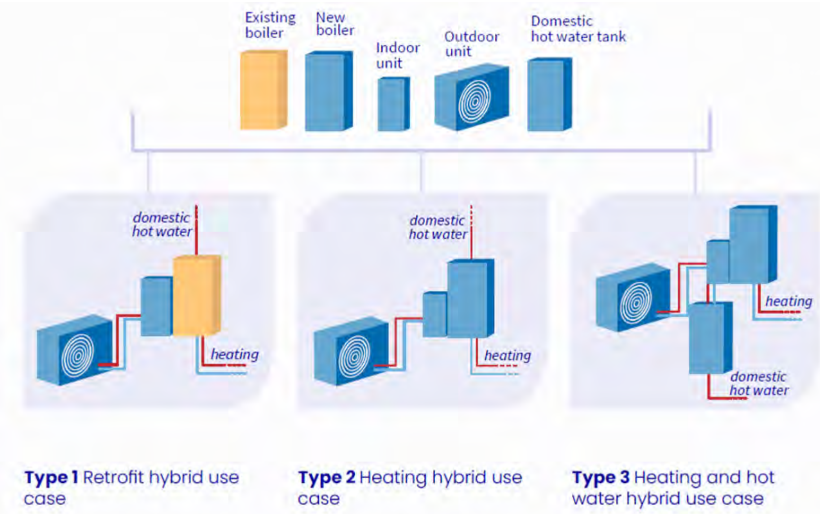
Examples for savings in electricity grid investments (p. 17)

significantly among countries depending on local energy prices, regulations, and the presence of additional incentives. For the Netherlands, recent testing data shows potential energy bill savings of up €600 annually. This effect however requires a difference in electricity prices between cheap and expensive hours.

Real emissions reduction from day one

Extensive field testing shows that hybrid systems can meet **70%-95% of heat demand using electricity**, immediately and significantly reducing natural gas consumption. With the high efficiency of the integrated heat pump, this directly **translates into as much as 55% CO2 emission reduction** compared to natural gas boilers alone.

The vision paper closes with recommendations, recognising some work ahead of us to realise the potential of hybrid heating systems.



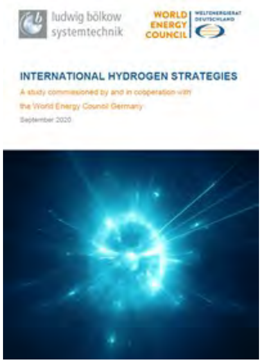
Three hybrid heating system use cases (source: p. 13)

https://bit.ly/3eSkRSn (vision paper)
https://bit.ly/3b0z8uW (webinar - requires registration)

Kees van der Leun at kees.van.der.leun@guidehouse.com

International Hydrogen Strategies | worldwide (1/2)

A study commissioned by and in cooperation with the World Energy Council



Hydrogen can play a significant role in a future energy system but **requires governmental support as well as a beneficial policy and regulatory environment.**

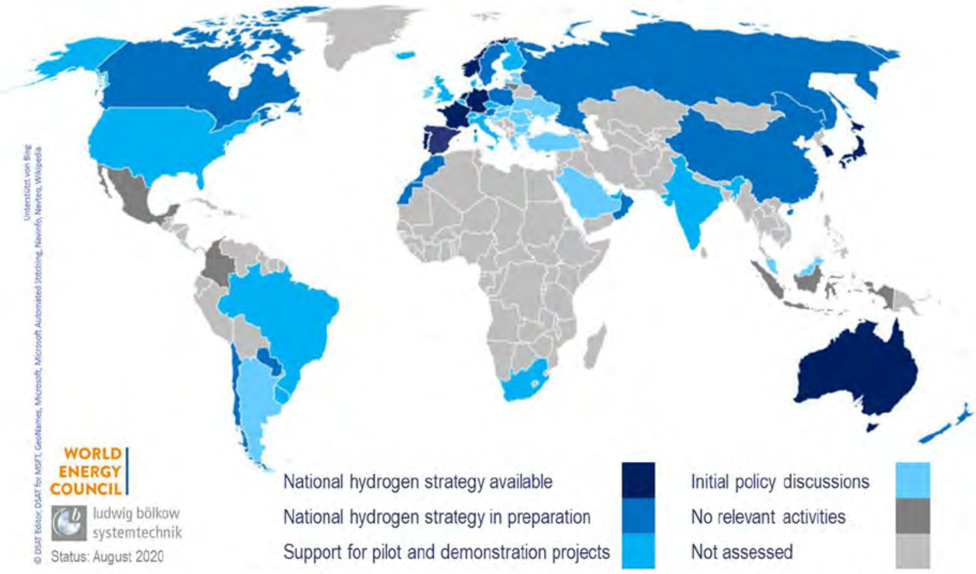
The study analyses government action for hydrogen in 16 countries (the United Kingdom, Japan, South Korea, Australia, the Netherlands, France, Italy, Spain, China, Ukraine, Germany, Switzerland, Morocco, California, Russia, and Norway) and in the European Union. It focuses on the respective national goals, targeted sectors and infrastructures, current support measures, requirements on the hydrogen used, and achievements so far. The aim of the analysis is to provide an informed factual input to policy discussions and corporate decision-making.

Hydrogen activities are well spread around the globe with **major interest** being located in Europe, **in the Asia and Pacific region, as well as in the Americas** (see figure right). By 2025, hydrogen strategies can be expected in countries representing over 80% of global GDP. Quickly emerging hydrogen strategies indicate a dynamically growing market.

In the long run, with a view towards a largely decarbonised world by 2050, **over half of the countries** analysed, **focus** on using **green hydrogen** sourced from renewable energy only; the emphasis on green hydrogen is particularly pronounced in the EU. However, in the interim other types of low carbon hydrogen are seen as an effective and pragmatic way to ramp up volumes and to get the associated hydrogen economies started. Green hydrogen is central to all strategies (see figure below).

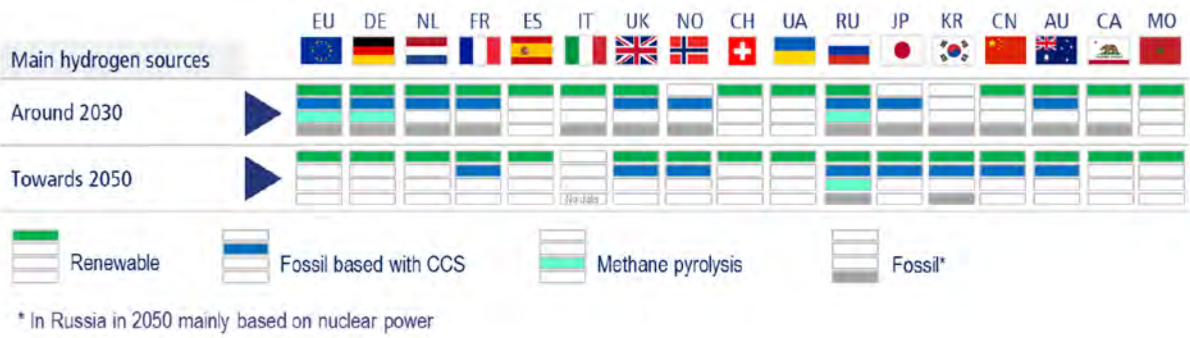
A large cumulative **market of over 40 billion € for green hydrogen** production equipment will develop **within the EU until 2030**. Gigawatt-size capacities are expected to develop within less than a decade and this points towards a massive growth path in the coming years and translates into a sizeable market.

Refineries and chemical industry to become the **first important large-scale hydrogen markets** in the mid-term. The EU Renewable Energy Directive recast (RED II) allows green hydrogen used in refineries to count towards the mandatory transport sector target of a 14% renewable energy share, creating a strong regulatory incentive. As a result, already now large-scale electrolysers are being planned in and around European refineries.



Status of international hydrogen activities of national governments (Aug 2020) (source: report p. 3)

Road transport and fuel cell market is currently stronger in Asia than in Europe. While Japanese, South Korean, and Chinese plans foresee a relevant role of fuel cell electric vehicles in all road transport sectors, European strategies mainly focus on heavy goods vehicles. Similarly, fuel cells in the building and power sector have a pronounced role in Asia while playing only a limited or no role in Europe.



Considered medium- and long-term hydrogen production options by country (source: report p. 7)

International Hydrogen Strategies | worldwide (2/2)

A study commissioned by and in cooperation with the World Energy Council

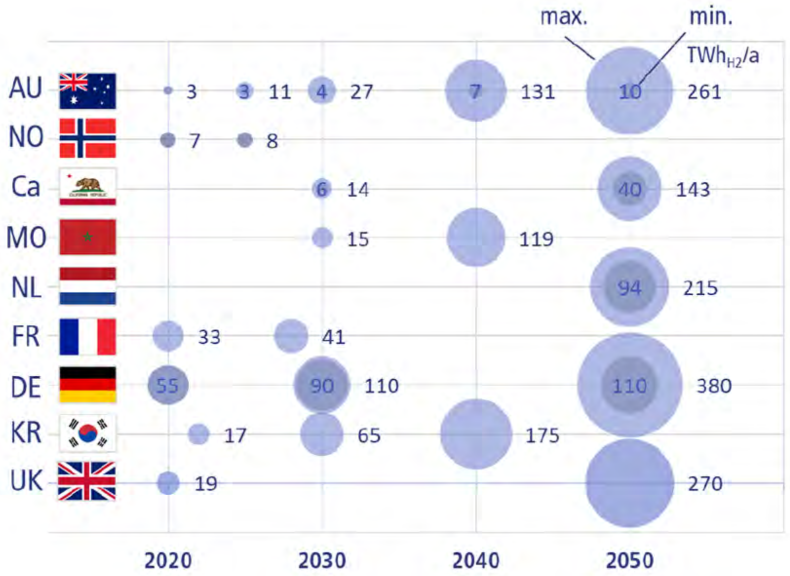
Current measures are insufficient to catalyse envisaged **strong growth**. Many policies in place concentrate on R&D oriented action, which remains relevant but less important than fostering commercialisation. **The time for policy discussions is now** and policymakers will likely be open to sensible approaches and good arguments.

The following measures appear particularly suitable considering successful deployment examples in the past.

Sectoral quota can stimulate large scale demand and create markets.

- Targeted support for establishing comprehensive value chains provides nuclei for sustainable business activity.
- Moving from CAPEX to **OPEX support** will be important to establish sustainable business cases for operators.
- **Globally high CO2 prices** would help to further reduce the cost gap.
- Instruments need to provide a long-term perspective and security of investment.
- A broadly agreed green or low carbon hydrogen certification mechanism is crucial for market development.
- Any activities should be complemented by measures supporting public acceptance.

See for further information the more than 40 pages of the main study and 100! pages annexes with valuable knowledge and overviews.



Expected annual hydrogen consumption in TWh$_{H2}$ per year (report p. 18)

https://bit.ly/3ujK0f5 (final report)
https://bit.ly/2QKHCQk (executive summary)
https://bit.ly/3ePpq8F (presentation)

Maira Kusch at
kusch@weltenergierat.de

Update European Hydrogen Backbone | Europe

We introduced the European Hydrogen Backbone in newsletter #29 – a TSO vision for a future hydrogen network. The updated version includes 10 more members, 11 more countries, 17,000 extra km and sinking costs per km (1080 - 2040 €/km). The map has new regions: the UK and the Republic of Ireland, Southern Europe with Greece, Northern Europe around the Baltic sea (Estonia, Finland and Sweden) and Eastern Europe (Austria, Czech Republic, Hungary, Poland, Slovakia and Slovenia). Get a glimpse here and see the report if you are curious.

Left: Emerging European Hydrogen Backbone in 2030 (source: update p. 7)
Right: Mature European Hydrogen Backbone by 2040 (source: update p. 3)

https://bit.ly/3udCMt8

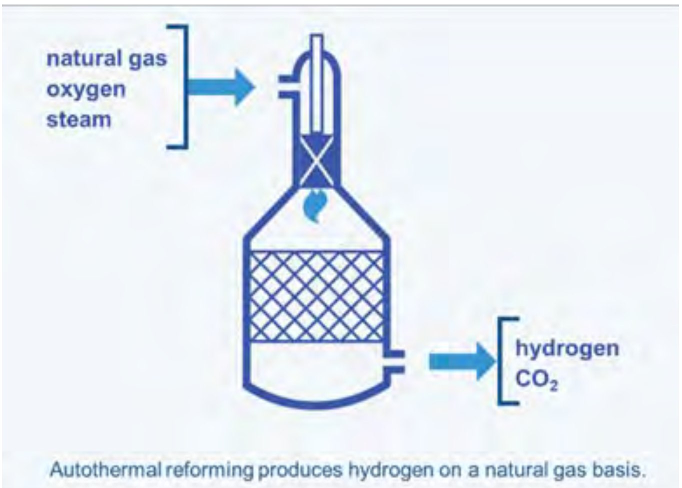
Kees van der Leun at
kees.van.der.leun@guidehouse.com

Feasibility Study for Hydrogen Infrastructure With New Hydrogen Reformer and CCS | Germany & Norway (1/2)

The goal of the project "H2morrow" is to develop a complete value chain for hydrogen from decarbonised natural gas. It should be ready for use in the second half of the 2020s to supply industry and other end customers in North-Western Germany. The blue hydrogen will be fed into the gas grid **utilising converted natural gas pipelines extended with limited new built pipelines**. Among others, a steel mill will be supplied with blue hydrogen in the future.

Blue hydrogen is grey hydrogen whose CO_2 is captured and stored during production (CCS). The CO_2 generated during hydrogen production is thus not released into the atmosphere and hydrogen production is almost CO_2-neutral. The CO_2 footprint is reduced by 95%. In this way, the four partners - Equinor, OGE, thyssengas and thyssenkrupp Steel Europe - want to realise an almost climate-neutral steel production. Another advantage of blue hydrogen is that it offers security of supply and can be produced in large quantities 24/7 at - according to the partners - competitive costs. Overall, the price is 58 euros per megawatt hour or 2.1 euros per kilogram of hydrogen. The CO_2 costs of the project are in the range of 50-70 euros per tonne of CO_2. The prerequisite for its use is the creation of a cross-regional transport infrastructure for hydrogen.

"H2morrow" uses **autothermal reforming (ATR)** to produce blue hydrogen. The process differs from conventional steam reforming. Conventional steam reforming can be combined with CO_2 capture, but this involves high costs due to the conversion of many separate production steps. ATR, on the other hand, produces hydrogen with steam and pure oxygen under high pressure (see figure below). The process runs autothermally, without any additional heat input. This has two advantages: Firstly, the natural gas can be converted into hydrogen even more efficiently , and secondly, CO_2 is under a higher partial pressure, higher concentrated. It can therefore be captured and stored cost-efficiently. There is potential for storing more than 67 billion tonnes in the Norwegian North Sea, which is currently equivalent to 80 years of total German CO_2 emissions.



Hydrogen from decarbonised natural gas (source: H2morrow)

Due to the secure supply of natural gas, such a reformer can provide a base-load capable hydrogen supply of 8.6 terawatt hours per year. This corresponds to the energy demand of 450,000 average four-person households per year.

To ease the transport of the produced CO_2, the gas will be liquefied directly next to the ATR at about -50 °C. For the first project phase the planning assumption is that the ATR is located in Eemshaven in the Netherlands. However, other potential sites at the German coast could present an alternative for following project phases. Potential CO_2 storage sites has been investigated. One option is the "Northern Lights" project in Norway or the Porthos project offshore of Rotterdam, of which Northern Lights is the most advanced one. The study concludes that depending on the production capacity, either ships or pipelines may be viable as CO_2 transport solutions. The Northern Lights option comprises the CO_2 transport per ship to the west coast of Norway. There, the CO_2 is fed into a 120-kilometre-long underwater pipeline, through which the CO_2 finally reaches the injection plant, which pumps the CO_2 2,600 metres deep into a saline aquifer for permanent storage (see next page).

Results of the feasibility study

The feasibility study showed that it is technically possible to set up a complete value chain for blue hydrogen and to supply Germany's largest steel mill with blue hydrogen. The study investigated various options for sourcing and transporting hydrogen to the steel mill. The transport and storage of CO_2 were also considered. Two different scenarios with production capacities of 1.4 GW and 2.7 GW were considered in the feasibility study.

Redundant and parallel gas pipelines

The identified pilot region (see figure next page) is particularly suitable because it is currently still supplied with L-gas (low calorific gas) and will have to be converted to H-gas (high calorific gas) by 2030. H-gas supply is already largely ensured via existing transport routes. This conversion of the gas infrastructure therefore creates a unique opportunity: infrastructure previously used for the transport of L-gas can now be used as hydrogen infrastructure.

In the pilot region, many pipelines are also laid in parallel, i.e. with two or more strings. With these parallel pipelines, one string can transport hydrogen while the other continues to supply natural gas. This approach creates the greatest possible flexibility for all connected customers and network operators. A customised solution can be found for all customers, as the hydrogen can either be delivered pure (pure hydrogen pipeline) or as controlled gas mixture. If requested

Feasibility Study for Hydrogen Infrastructure With New Hydrogen Reformer and CCS | Germany & Norway (2/2)

industrial customers can therefore switch to 100 % hydrogen soon. Distribution network operators with many household customers can add hydrogen to the heating network with fixed shares, while customers with highly sensitive production processes can continue to obtain natural gas. The project partners assume that it is necessary to have a consistent and calculable gas quality at all points in the network. Fluctuating hydrogen contents are not considered due to the inherent technical challenges.

OGE has examined a conversion of selected pipelines to 100 % hydrogen in the course of the feasibility study and was able to confirm the technical feasibility of the project. In the case of a conversion, the pipelines themselves as well as the individual components, such as compressors or seals, are tested by independent experts. Depending on the requirements and the results of the material testing, individual components are replaced or adapted for hydrogen use. After another independent test, the pipes are approved for hydrogen use by the competent authority. The complete conversion in cooperation with the competent authorities takes about five years, whereby the costs are significantly lower than for constructing new pipelines.

Conclusion of the feasibility study

The project partners demonstrated that hydrogen can be produced in large quantities and at very competitive cost. The feasibility study concludes that the political and regulatory framework in Germany and the EU needs to be clarified. The main issues here are the conversion of natural gas pipelines to hydrogen pipelines and the transport of hydrogen independently of the production technology. In addition, coordination between the Netherlands and Germany on network expansion and cross-country transport agreements are necessary. At EU level, we need a uniform and systematic approach to hydrogen of all production technologies, taking into account the respective CO_2 footprint, as well as a change in the legislation on CO_2 transport by ship. The project aims to be realised by 2030.

SCHEMATIC DESCRIPTION OF THE PROJECT (SOURCE: H2MORROW STEEL)

https://oge.net/de/wir/projekte/h2morrow (short report, in German only)
H2morrow-The Potential-of-Hydrogen-for-Decarbonization-of-German-Industry.pdf (management summary in English)

HyBlend™ Project Has Started | U.S.

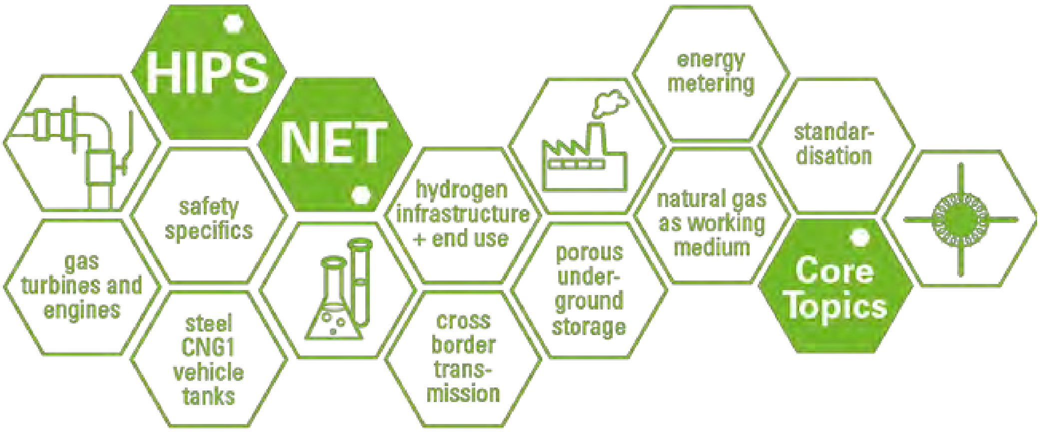
PHOTO FROM ISTOCK

The National Renewable Energy Laboratory (NREL) will lead a new collaborative research and development (R&D) project known as HyBlend™ to address the **technical barriers to blending hydrogen in natural gas pipelines.**

The HyBlend team comprises six national laboratories and more than 20 participants from industry and academia. This two-year project was selected by the U.S. Department of Energy's Hydrogen and Fuel Cell Technologies Office in the Office of Energy Efficiency and Renewable Energy (EERE) through the H2@Scale 2020 CRADA Call. The team will receive more than $10 million of funding from EERE, with an additional $4 to $5 million of contributions from participants.

https://bit.ly/3ujDlI5

HIPS-NET CORE TOPICS



EVENTS AND PARTNERS

Selection of Appointments

June 2021

09 American Hydrogen Forum | Houston, Texas, *https://www.ushydrogenforum.com/*

09-10 The Hydrogen Technology Conference & Expo | Stuttgart, Germany, *https://www.hydrogen-worldexpo.com/*

16-17 8th HIPS-NET Workshop | online, *https://www.dbi-gruppe.de/hips-net.html*

20-24 WHTC - World Hydrogen Technologies Convention 2021 | online, *www.whtc2021.org/*

22-23 3rd Global LNG & Hydrogen Forum | Milan, Italy, *https://lng-global.com/*

22-23 Hydrogen Dialogue 2021 - Summit & Expo | online, *https://www.hydrogendialogue.com/*

September 2021

07 Hydrogen and Fuel Cell Conference | Birmingham, UK, *https://bit.ly/33nCTGB*

September / October 2021

07-09 beyondgas 2021 | Oldenburg, Germany, *https://www.beyondgas.de/*

14-15 F-Cell 2021 - Emerging Hydrogen Business | Stuttgart, Germany, *https://f-cell.de/*

21-24 International Conference on Hydrogen Safety ICHS 2021 | Edinburgh, Scotland, *https://hysafe.info/ichs2021/*

30-02 4th International Workshop on Degradation Issues of Fuel Cells and Electrolysers | Corfu, Greece, *https://bit.ly/3tlnrpg*

October 2021

27-28 HyVolution | Paris, France, *https://www.hyvolution-event.com/en*

November 2021

24-25 GAT | WAT 2021 | online + Cologne, Germany, *https://www.gat-wat.de/*

Current Partners

Alliander AG, Areva H_2Gen,
Cadent, DGC, DNV GL, Enagás,
Enbridge, Energinet.dk, ENGIE,
EWE Netz, Gas Connect Austria GmbH,
Gasnetz Hamburg, Gasum OY,
Gasunie, GRTgaz, GRZI e.V. (FIGAWA),
Infraserv GmbH & Co. Höchst KG,
INERIS, innogy SE, ITM Power,
Joint Research Centre (JRC), EC,
KOGAS, NAFTA a.s,
Naturgy, ONTRAS, ÖVGW,
Open Grid Europe GmbH,
Polymer Consult Buchner GmbH,
RAG Austria AG,
Shell, Solar Turbines Europe S.A.,
Storengy, SVGW,
Synergrid, Teréga, TNO,
Uniper Energy Storage GmbH,
Verband der Chemischen Industrie (VCI),
Wintershall Dea AG.

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Certified DIN EN ISO 9001:2015

HIPS-NET

"ESTABLISHING A PAN-EUROPEAN UNDERSTANDING OF ADMISSIBLE HYDROGEN CONCENTRATION IN THE NATURAL GAS GRID"

NEWSLETTER #31 **MAY, 2021**

Dear HIPS-NET Partners,

Topics around hydrogen are exploding in the past months also due to the commitment of governments and the European Union. Many projects receive funding, and the market conditions are not yet sufficient for market participants to invest – apart from selected exceptions. It is a good time to talk to decision makers about needed changes in the market as the study of the World Energy Council suggests. Have a read and find some well-reasoned arguments.

We need you to help us identifying central projects in your country. So please get in touch with us! Give us the information about the developments and projects and we will draft articles for the newsletter.

This HIPS-NET newsletter summarises articles around

- Spanish hydrogen Roadmap approved | Spain
- Hydrogen injection in transmission network | Germany
- Hydrogen in the IGU global gas report | worldwide
- Vision for Hybrid Heating System – a path including hydrogen | Germany
- ...

HIPS-NET Workshop
16th/17th June, 2021
online in the afternoon

We hope you find interesting information and enjoy reading.

The HIPS-NET workshop is coming soon. We are about the prepare the workshop and decided to meet online again this year. It is a pity, and we would have preferred to see each other in reality … it seems we need another year to see us live for a beer ;-). We are planning presentations and an interactive part for networking and discussion. **Do you have questions that you wish to talk about with HIPS-NET colleagues from other companies? Which topics are important to talk about, elaborate and develop views?** Please get in touch with Josephine.

Your HIPS-NET Team - Gert, Anja, and Josephine

Farewell from Anja:

I will leave HIPS-NET and DBI. It is time for me to head off to new tasks. I joined HIPS-NET almost at the start, I think with the 2nd newsletter. During this time, I have developed writing skills (not easy for a mathematic mind) and happened to become the lead author of HIPS-NET. I learned a lot about hydrogen and admixture development and am grateful for having the chance to shape and manage this network. I enjoyed the work for the network and the work with you. Thank you!

CONTENT

CONTENT NEWSLETTER #31

Spanish Hydrogen Roadmap Approved | Spain (1/2)

To achieve climate neutrality and a 100% renewable electricity system no later than 2050, the Spanish Government has approved in October 2020 the country's Hydrogen Roadmap: a commitment to renewable hydrogen.

This Hydrogen Roadmap identifies the challenges and opportunities for the full development of renewable hydrogen in Spain, providing a series of actions aimed at boosting investment action, taking advantage of the European consensus on the role that this energy sector should play in the context of green recovery.

Renewable hydrogen is set to become a valuable energy vector for end uses where it is the most efficient solution in the process of its decarbonisation, such as **hydrogen-intensive industry and high-temperature processes, long-distance heavy transport, maritime transport, rail transport or aviation**. **In addition**, the energy vector quality gives it great potential as an instrument for **energy storage and sector coupling**. Main focus is on sectors where electrification is not the most **efficient** solution or is not technically feasible in the medium term, including public transport, urban services or various uses in intermodal transport nodes such as ports, airports or logistics platforms. The role of hydrogen to store energy and/or decarbonise the **heat sector in both industry and homes**, must be assessed and prioritised in cases where electrification is not the most **competitive** solution.

In particular, the "**Vision 2030**" foresees **4 GW electrolyser capacity** and a series of milestones in the industrial, mobility and electricity sectors, for the period 2020-2030 (see figure right). It will be necessary to mobilise investments estimated at 8,900 million Euros during the period 2020-2030. However, as an **intermediate milestone** to reach the 4 GW target, it is estimated that **by 2024** it would be possible to have **between 300 and 600 MW** electrolyser capacity installed.

The creation of **hydrogen valleys** or clusters will play a very significant role, where production, transformation and consumption are specially concentrated.

The industry that uses hydrogen as a raw material (oil refining, fertilisers, and chemicals, among others) has a great potential to boost renewable hydrogen production in the short term. It needs ambitious but **common targets at EU level for industrial uses** of renewable hydrogen.

Renewable hydrogen should have **common standards in the EU** (targets, labelling, guarantees of origin), as these could facilitate its deployment and ensure a level playing field. Furthermore, taxation and the CO_2 market can help to provide the right signals to stakeholders and consumers to properly assess the renewable label.

The Roadmap's identified **60 (!) actions** to support producing and deploying renewable hydrogen. Just to give you an impression, see some of the actions:

ACTION 1: **Modify the classification** of on-site renewable hydrogen production at refuelling stations **as an industrial activity.**

ACTION 2: **Analyse** the different procedures for processing the operation and implementation of **small-scale** green hydrogen production **facilities** and assess whether they may be simplified.

ACTION 3: Promote the development of regulatory measures to simplify and facilitate the deployment of **direct electricity lines dedicated to renewable hydrogen production.** This requires a modification of the sector's legislation, avoiding undermining the economic and financial sustainability of the electricity and gas systems.

ACTION 4: In collaboration with European institutions, establish a system of **Guarantees of Origin** for renewable hydrogen to provide appropriate price signals to consumers.

ACTION 5: Consider the positive environmental effects of renewable hydrogen within the framework of green **taxation**, particularly indirect taxation.

ACTION 6: Establish a **national data system on hydrogen consumption and production** in Spain, differentiating by type of hydrogen and by consumption sector.

Main objectives of the Spanish Hydrogen Roadmap for 2030 (Roadmap p. 42)

Spanish Hydrogen Roadmap Approved | Spain (2/2)

ACTION 7: **Assess the feasibility of** establishing renewable hydrogen penetration **targets** for the period 2025-2030, following the path set out in the European Hydrogen Strategy.

MEASURE 8: **Design financial instruments** to support Spanish hydrogen-intensive industry in adapting its processes and infrastructures to the continuous supply of renewable hydrogen.

ACTION 9: Develop **long-term national decarbonisation strategies** based on renewable hydrogen in the most difficult to electrify sectors (based on sector-specific dialogue).

ACTION 10: Identify current hydrogen consumption hubs, promoting and encouraging the creation of "**hydrogen valleys or clusters**". The constitution of **Industrial Hydrogen Committees** will be promoted together with autonomous communities, local administrations, hydrogen consumers and promoters of renewable hydrogen production projects, encouraging the development of pilot projects.

ACTION 11: Promote the use of renewable hydrogen in the transport sector through the transposition of RED II.

ACTION 12 – ACTION 60: Please see the Spanish Hydrogen Roadmap for further detail.

Actions for hydrogen injection in the gas infrastructure

ACTION 29: Facilitate the use of green **hydrogen in electricity production**, providing a greater security of supply to the electricity system.

ACTION 30: **Review required technical, regulatory and quality aspects** of gases for the injection and use of **hydrogen into the gas grid**, with special emphasis on the use **of existing infrastructure** for the transport and/or dedicated storage of renewable hydrogen.

In particular, **safety requirements; metering, billing and administration mechanisms**; and the corresponding legal and regulatory frameworks to allow a higher concentration of renewable hydrogen into the gas network according to the proposed in European Hydrogen Strategy.

A **study on hydrogen injection limits** in the different installations of Spanish Gas System **will be promoted** in order to identify restrictions and establish local thresholds.

ACTION 31: **Assess** simultaneously the **necessity to modify gas-fired appliances** in industry and power generation **to allow safe operation with higher concentrations** of renewable hydrogen.

ACTION 32: Perform a prospective **analysis of retrofitting requirements of domestic gas appliances** (boilers, heaters etc.) to allow for the gradual integration of renewable hydrogen.

78 entities, organisations, associations and individuals contributed to the public consultation of the Roadmap. It will be updated every three years, to evaluate the progress towards the vision 2030 objectives, the degree of implementation of the measures and the quantification of their impact.

https://www.miteco.gob.es/es/ministerio/hoja-de-ruta-del-hidrogeno-renovable.aspx

Hydrogen Injection in Transmission Network | Germany

For the first time, green hydrogen converted in an electrolyser using renewable electricity from wind turbines was fed into the gas transmission pipeline system in Northern Germany in December 2020.

The green hydrogen is blended with the gas in the DEUDAN pipeline up to a **concentration of 2 vol%**. Thus, the gas quality remains within the applicable regulations. The pipeline stretches from the German-Danish border crossing at Ellund to Quarnstedt in Schleswig-Holstein. Extensive technical measures to realise the injection include the construction of a hydrogen blending facility, complete with metering and pressure-regulating equipment, two independent compressor units to raise the hydrogen pressure to the DEUDAN pipeline pressure, and the construction of two connecting pipelines, each 75 metres long.

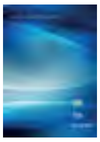
The project Windgas HAURUP has a hydrogen production plant with a capacity of 1 MW (210 m³/hr hydrogen). It will operate on surplus electricity with an expected production of 3,000 MWh_{H2}/yr.

Project partners are Gasunie Germany, Open Grid Europe, Energie des Nordens with funding by the German Federal Ministry.

PS: The transmission operator ONTRAS together with UNIPER were the first companies in Germany injecting hydrogen in the transmission network (Eastern Germany).

www.windgas-haurup.de (in German) Marko.bartelsen@windgas-haurup.de

HYDROGEN IN THE IGU GLOBAL GAS REPORT 2020 | WORLDWIDE (1/2)



Hydrogen has been gaining momentum and attracting heightened attention from industry players and government agencies alike. The global gas report, therefore, has a **special section** detailing the **potential market size and the technological options and costs of hydrogen production, storage and transport, highlighting the important role of infrastructure for its development.** We also provide a list of actions (including ones on policy) that can be taken to reduce barriers for hydrogen's uptake, which in turn can help reduce carbon emissions in the 'hard-to-abate' sectors, and ultimately contribute to achieving our collective climate goals.

The current level of excitement around hydrogen presents an opportunity. Hydrogen is starting to garner policy support and, with enough investment, could **abate up to 37% of energy related greenhouse gas emissions**, according to BloombergNEF estimates. While clean hydrogen is not yet cost-competitive in many applications, delivered costs could reach around $2/kg in 2030, and $1/kg in 2050, opening up possibilities in a variety of applications. These include steel and cement making, chemicals, aviation, shipping and heavy-duty transport. For hydrogen to achieve its potential, not only will **strong policy action be needed** to drive scale, but there will also be a significant need for infrastructure investment. **Large-scale hydrogen networks will be necessary** to connect high-quality production and storage resources to users, which can help lower supply costs, increase security, enable competitive markets and facilitate international trade.

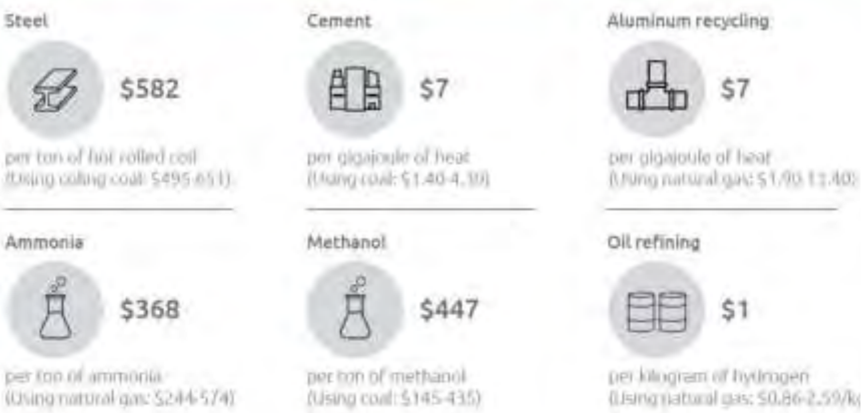
As the energy transition proceeds, gas **transport and storage infrastructure can be readied for hydrogen blending,** and indeed for pure hydrogen transport, at much lower cost than constructing new purpose-built hydrogen networks.

The report recognises the role of biomethane and renewable hydrogen and additionally promotes a third approach – low carbon hydrogen: The CO_2 intensity of natural gas can also be lowered substantially with carbon capture, utilisation and storage (CCUS) technologies. A combination of these three routes can enable the natural gas industry to continue to evolve and deliver low-carbon growth. **Modifying existing gas pipelines to carry either hydrogen or carbon dioxide** could be up **to 90% cheaper than building new** dedicated **networks** for these molecules.

A carbon price will be required for hydrogen to be competitive in regions where fossil fuel prices are very low, in all applications except road transport. **For example**, with **renewable hydrogen delivered at $1/kg**, the **carbon price needed to make it cost-competitive** with the cheapest fossil fuels in use today would be **$50/$t_{CO2}$ for steel making**, **$60/$t_{CO2}$ for heat in cement production**, **$78/$t_{CO2}$ for ammonia synthesis**, and **$90/$t_{CO2}$ for aluminium and glass** manufacturing.

With large-scale geological storage in place, hydrogen could be produced from renewable power that would otherwise be curtailed, then stored and transported back to a power generator at a cost of $8-14/MMBtu by 2050 in most locations. A carbon price of $115/$t_{CO2}$ in 2050 would be required for hydrogen to compete with the lowest-price natural gas on a total cost-of-energy basis. But if future gas turbines are hydrogen-ready, a carbon price of **$32/$t_{CO2}$ for electricity production** would be enough to drive fuel switching from $7/MMBtu natural gas to hydrogen (see additionally cost difference in figure below).

If supportive but **fragmented policy** to decarbonise and expand the use of hydrogen is in place, BNEF estimates that 187 million metric tons (MMT) of hydrogen could be in use by 2050, enough to meet 7% of projected final energy needs in a scenario where global warming is limited to 1.5 degrees. **If strong** and comprehensive decarbonisation and hydrogen industry **policy** is in force, 696 MMT of hydrogen could be used, enough to meet 24% of final energy in a 1.5 degree scenario.



DIFFERENCE FOR PRODUCTION USING HYDROGEN AT 1$/KG (SOURCE: REPORT P. 55)

The creation of a clean hydrogen industry of this magnitude would present big investment opportunities. **Over $11 trillion of spending on production, storage and transport infrastructure** would be required for hydrogen to meet around a quarter of global energy needs in 2050. **Annual sales of hydrogen would be $700 billion**, with billions more also spent on end-use equipment. **However**, if policy measures to meet emission targets and promote the use of hydrogen do not materialise, then demand is unlikely to increase significantly outside of current uses.

Water electrolysis is currently a small industry and hardware costs are high. Consequently, hydrogen produced in an electrolyser powered by renewables costs between $2.5-4.6/kg, or $19-34/MMBtu. However, these costs could fall rapidly due to a decline in the cost of electrolysers and renewable electricity.

Hydrogen in the IGU Global Gas Report 2020 | worldwide (2/2)

	Gaseous state				Liquid state			Solid state
Regions	Salt caverns	Depleted gas fields	Rock caverns	Pressurized containers	Liquid hydrogen	Ammonia	LOHCs	Metal hydrides
Main usage (volume and cycling)	Large volumes, months-weeks	Large volumes, seasonal	Medium volumes, months-weeks	Small volumes, daily	Small-medium volumes, days-weeks	Large volumes, months-weeks	Large volumes, months-weeks	Small volumes, days-weeks
Working capacity (t-H_2)	300-10,000t per cavern	300-100,000t per field	300-2,500t per cavern	5-1,100kg per container	0.2-200t	1-10,000t	0.18-4,500t per tank	0.1-20kg
Benchmark LCOS ($/kg)[1]	$0.23	$1.90	$0.71	$0.19	$4.57	$2.83	$4.50	Not evaluated
Possible future LCOS[2]	$0.11	$1.07	$0.23	$0.17	$0.95	$0.87	$1.86	Not evaluated
Geographical availability	Limited	Limited	Limited	Not limited	Not limited	Not limited	Not limited	Not limited

Hydrogen Storage Options (source: report p. 59)

For instance, the price of alkaline electrolysers sold in North America and Europe fell 40% between 2014 and 2019. Chinese made systems are already sold for around 80% less than those in the West. This demonstrates that low production costs are readily achievable. Cost of units made in Europe should converge to the prices in China due to competition and offshoring of production, and could fall from around $1,200/kW today **to around $115/kW by 2030 and $80/kW by 2050**. Falling cost of wind and solar power, the cost of producing hydrogen around the world using renewable power could fall to $1.1-2.7/kg ($8-20/MMBtu) by 2030, and $0.7-1.6/kg ($5-12/MMBtu) by 2050. **This would make hydrogen competitive with current natural gas prices in Brazil, China, India, Germany and Scandinavia on an energy-equivalent basis**.

Storing hydrogen: please see the figure above as overview and read the report for details.

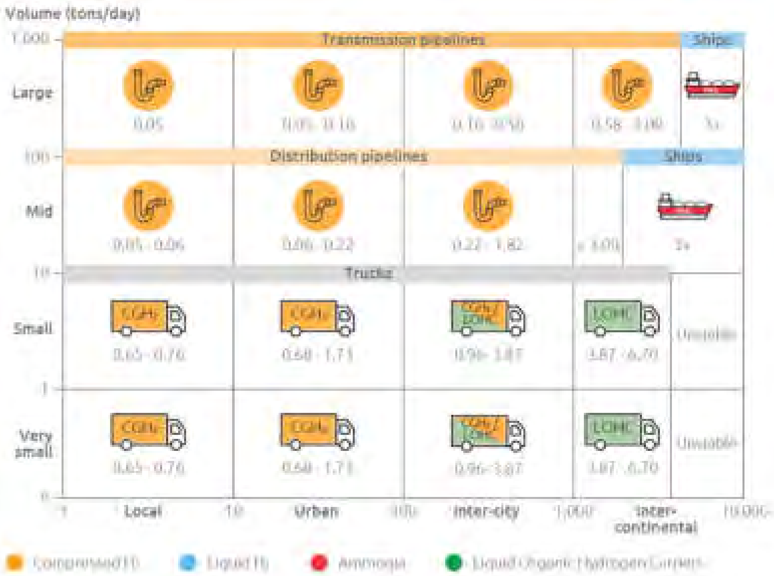
Transporting hydrogen

The report recognises the huge potential of the existing gas network and mentions hydrogen embrittlement; the technical compatibility is crucial. **Blends of up to 5-20 vol% hydrogen can generally be tolerated by the pipes used in gas distribution networks**, as these operate at lower pressures and often use different materials. Modern distribution pipes made of polyethylene could be used to transport pure hydrogen, as most plastic materials are not susceptible to hydrogen embrittlement. The **cost of hydrogen transport using pipelines is similar to that of natural gas, even though hydrogen is less dense.** This is **because** hydrogen is lighter than methane, so travels nearly three times faster through a pipe. The cost of the materials used for hydrogen pipes are also broadly comparable with gas pipes. These factors give pipelines a particular advantage over other modes of hydrogen transport. A 100 km journey via a high-capacity pipeline, moving more than 100 tons per day, costs around $0.10/kg today. This could fall to about $0.06/kg with better technology and wider adoption of large-scale hydrogen storage technologies.

The report emphasises the need for policy and summarises notable hydrogen funding commitments and subsidies in different countries (see p. 67).

Barriers to development are

1. Lack of **carbon prices** and long-term emissions reduction targets
2. **Regulatory barriers**: regulations that limit, prohibit or impede the use of hydrogen
3. Lack of **long-term investment signals**; investment mechanisms to drive private investment
4. **Weak heavy transport emissions standards**
5. Immature market for low **emissions materials**
6. Absence of coordinated plans to decarbonise industry
7. **Investment in incompatible equipment**: new investments are frequently being made in fossil fuel infrastructure without regard to its compatibility to transition to clean fuels like hydrogen.



H_2 Transport Costs Based on Distance and Volume, $/kg, 2019, (source: report p. 60)

Huge incentives are required

In the **short term**, to drive innovation and achieve delivered costs of $2/kg by 2030 BNEF estimates that around $15 billion per year of incentives or **$150 billion over the next 10 years** would be required, **to support around $300 billion of investment** in clean hydrogen projects. In the medium term, a suite of **supportive measures** are required. These could include carbon **pricing; specific industrial decarbonisation policies** such as tax concessions to help pay for converting infrastructure to hydrogen, stringent **emissions standards for heavy transport**; and green **product mandates** that require a percentage of products like steel to be sourced from near-zero emission producers.

The report is published by BloombergNEF, International Gas Union and Snam and relies in many parts on research by BloombergNEF in 2020.

https://www.igu.org/resources/global-gas-report-2020/

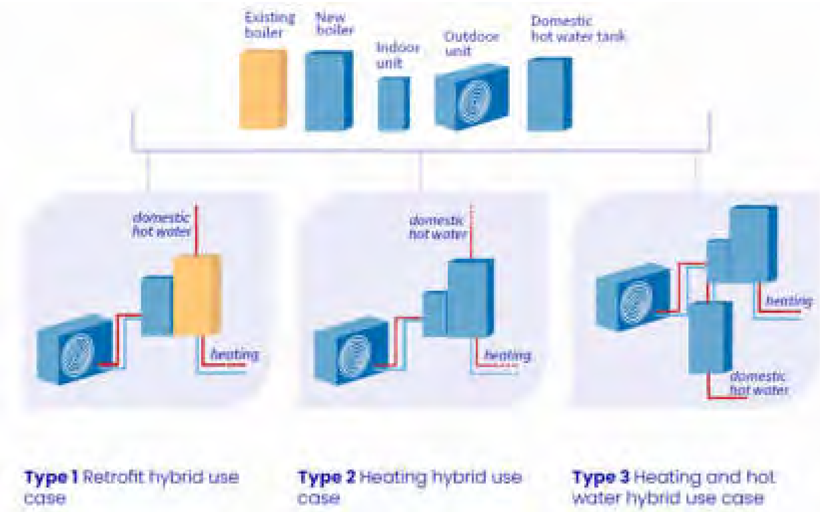
Vision for Hybrid Heating Systems | Europe

Simple facts undermine the need for accelerated action to reach climate goals in the building sector:

1. **We agreed to reach net zero emissions in Europe by 2050.**
2. **The building sector is responsible for more than 1/3 of the EU's emissions.**
3. **Energy renovations only reduce energy consumption by 1% per year.**
4. **Currently ¾ of the buildings is energy inefficient, yet around 90% of the buildings will still be in place in 2050.**

Effective action is crucial to reach the 2030 targets of 60% emission reduction and climate neutrality by 2050. The authors suggest installing hybrid heating. **Hybrid heating combines a hybrid heat pump with a regular boiler**. It combines various advantages. First of all, it is widely applicable and **easy to install**. The technology is mature and has entered the market already. In 2019, 32,000 units were installed in Italy, Germany, France, the Netherlands and the U.K.. Once installed, they can save cost and reduce emissions from buildings that have not undergone deep renovation yet. Hybrid heating solutions fit in a net-zero energy system by mid-century, when supplied with renewable electricity, biomethane and renewable and low-carbon hydrogen. **If a hydrogen-ready boiler is used, switching to hydrogen is prepared.**

Especially in older buildings with modest insulation levels, the consumer may not consider an all-electric heat pump solution due to the potential comfort risk (in case of insufficient capacity on the coldest days) or the high cost of bringing insulation to the necessary level to avoid this. Hybrid **heating systems do not require deep renovation**; radiators can remain and the installation of e.g. a floor heating system can be postponed. Its operation mode can gradually be shifted to more electric heat pump share when the building envelope is renovated over time.



Three hybrid heating system use cases (source: p. 13)

Because of their wide immediate applicability and modest up-front cost, hybrid heat pumps are a no-regret option that can accelerate the speed of adoption of low carbon heating systems and so speed up the decarbonisation.

The consumer's **energy bill can be reduced** significantly **with smart controls** because of the high efficiency of the heat pump and the ability to switch to the lowest cost energy vector (gas or electricity) at any time when using a smart system which can respond to energy price signals. For the UK, savings of up to 50% were found. The effect will vary

Examples for savings in electricity grid investments (p. 17)

significantly among countries depending on local energy prices, regulations, and the presence of additional incentives. For the Netherlands, recent testing data shows potential energy bill savings of up €600 annually. This effect however requires a difference in electricity prices between cheap and expensive hours.

Real emissions reduction from day one

Extensive field testing shows that hybrid systems can meet **70%-95% of heat demand using electricity**, immediately and significantly reducing natural gas consumption. With the high efficiency of the integrated heat pump, this directly **translates into as much as 55% CO2 emission reduction** compared to natural gas boilers alone.

The vision paper closes with recommendations, recognising some work ahead of us to realise the potential of hybrid heating systems.

https://bit.ly/3eSkRSn (vision paper)
https://bit.ly/3b0z8uW (webinar - requires registration)

Kees van der Leun at kees.van.der.leun@guidehouse.com

International Hydrogen Strategies | worldwide (1/2)

A study commissioned by and in cooperation with the World Energy Council

Hydrogen can play a significant role in a future energy system but **requires governmental support as well as a beneficial policy and regulatory environment.**

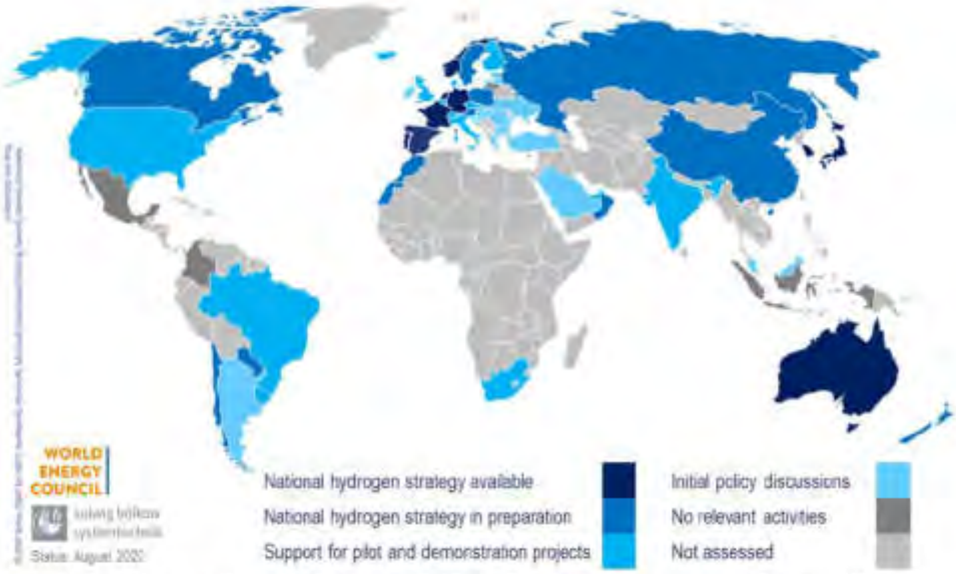
The study analyses government action for hydrogen in 16 countries (the United Kingdom, Japan, South Korea, Australia, the Netherlands, France, Italy, Spain, China, Ukraine, Germany, Switzerland, Morocco, California, Russia, and Norway) and in the European Union. It focuses on the respective national goals, targeted sectors and infrastructures, current support measures, requirements on the hydrogen used, and achievements so far. The aim of the analysis is to provide an informed factual input to policy discussions and corporate decision-making.

Hydrogen activities are well spread around the globe with **major interest** being located in Europe, **in the Asia and Pacific region, as well as in the Americas** (see figure right). By 2025, hydrogen strategies can be expected in countries representing over 80% of global GDP. Quickly emerging hydrogen strategies indicate a dynamically growing market.

In the long run, with a view towards a largely decarbonised world by 2050, **over half of the countries** analysed, **focus** on using **green hydrogen** sourced from renewable energy only; the emphasis on green hydrogen is particularly pronounced in the EU. However, in the interim other types of low carbon hydrogen are seen as an effective and pragmatic way to ramp up volumes and to get the associated hydrogen economies started. Green hydrogen is central to all strategies (see figure below).

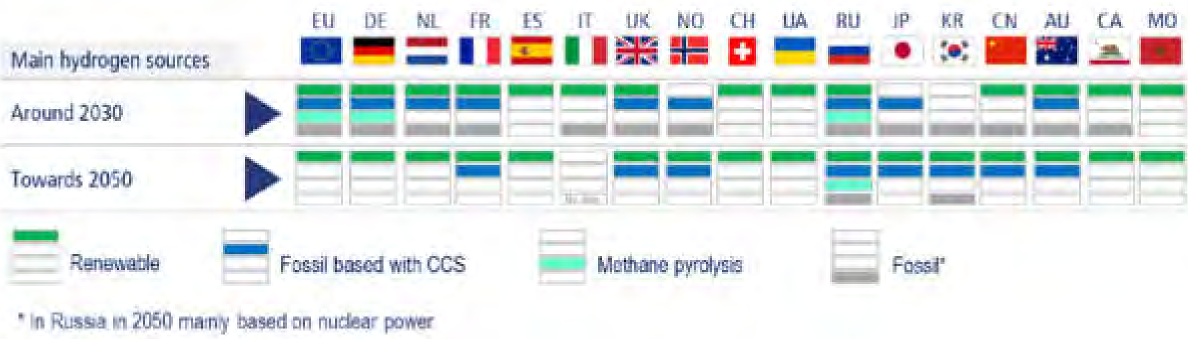
A large cumulative **market of over 40 billion € for green hydrogen** production equipment will develop **within the EU until 2030**. Gigawatt-size capacities are expected to develop within less than a decade and this points towards a massive growth path in the coming years and translates into a sizeable market.

Refineries and chemical industry to become the **first important large-scale hydrogen markets** in the mid-term. The EU Renewable Energy Directive recast (RED II) allows green hydrogen used in refineries to count towards the mandatory transport sector target of a 14% renewable energy share, creating a strong regulatory incentive. As a result, already now large-scale electrolysers are being planned in and around European refineries.



Status of international hydrogen activities of national governments (Aug 2020) (source: report p. 3)

Road transport and fuel cell market is currently stronger in Asia than in Europe. While Japanese, South Korean, and Chinese plans foresee a relevant role of fuel cell electric vehicles in all road transport sectors, European strategies mainly focus on heavy goods vehicles. Similarly, fuel cells in the building and power sector have a pronounced role in Asia while playing only a limited or no role in Europe.



Considered medium- and long-term hydrogen production options by country (source: report p. 7)

International Hydrogen Strategies | worldwide (2/2)

A study commissioned by and in cooperation with the World Energy Council

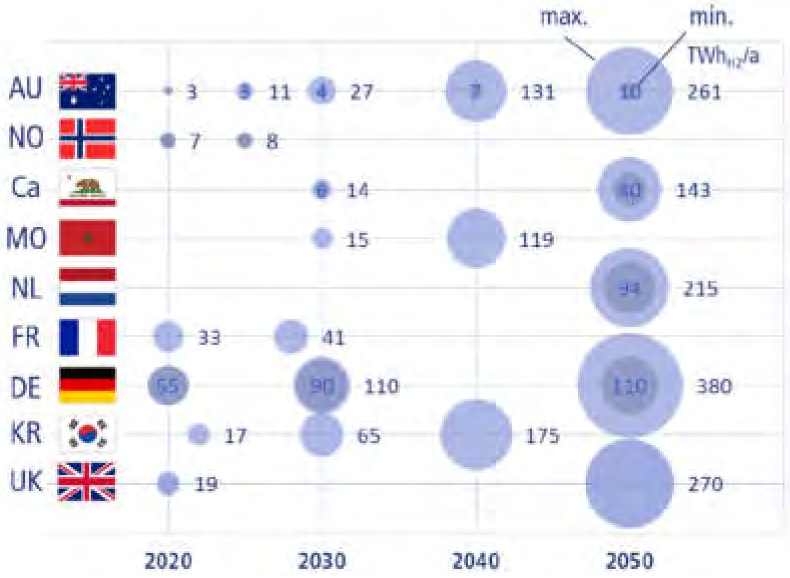
Current measures are insufficient to catalyse envisaged **strong growth**. Many policies in place concentrate on R&D oriented action, which remains relevant but less important than fostering commercialisation. **The time for policy discussions is now** and policymakers will likely be open to sensible approaches and good arguments.

The following measures appear particularly suitable considering successful deployment examples in the past.

Sectoral quota can stimulate large scale demand and create markets.

- Targeted support for establishing comprehensive value chains provides nuclei for sustainable business activity.
- Moving from CAPEX to **OPEX support** will be important to establish sustainable business cases for operators.
- **Globally high CO2 prices** would help to further reduce the cost gap.
- Instruments need to provide a long-term perspective and security of investment.
- A broadly agreed green or low carbon hydrogen certification mechanism is crucial for market development.
- Any activities should be complemented by measures supporting public acceptance.

See for further information the more than 40 pages of the main study and 100! pages annexes with valuable knowledge and overviews.



Expected annual hydrogen consumption in TWh_{H2} per year (report p. 18)

https://bit.ly/3ujK0f5 (final report)
https://bit.ly/2QKHCQk (executive summary)
https://bit.ly/3ePpg8F (presentation)

Maira Kusch at
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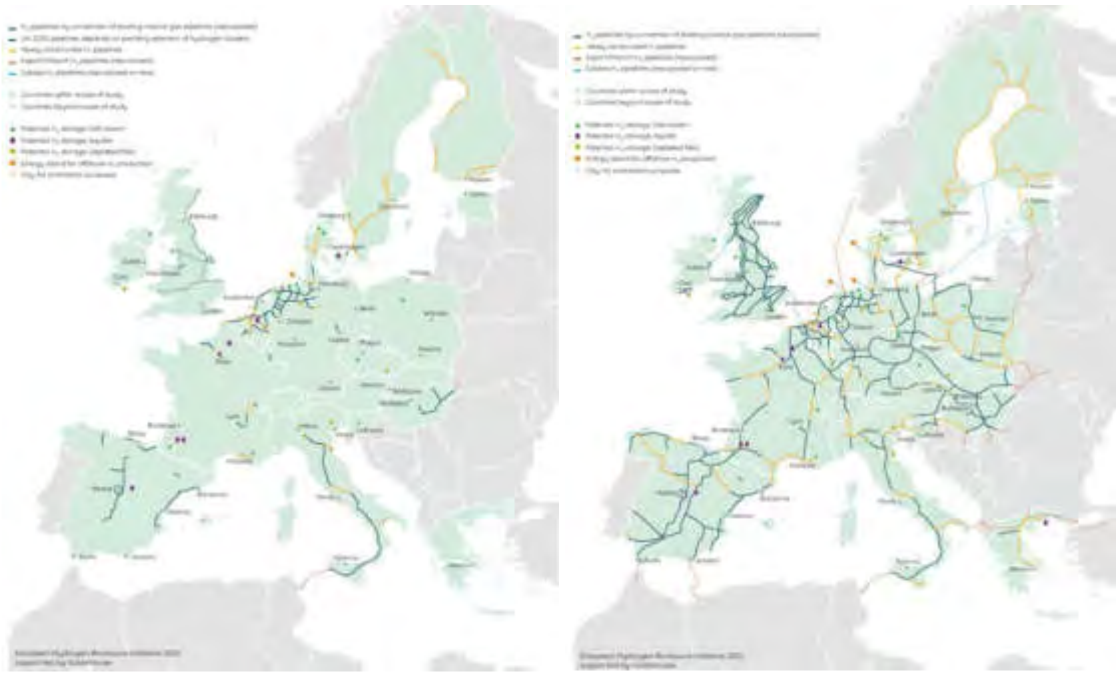
Update European Hydrogen Backbone | Europe



Left: Emerging European Hydrogen Backbone in 2030 (source: update p. 7)
Right: Mature European Hydrogen Backbone by 2040 (source: update p. 3)

We introduced the European Hydrogen Backbone in newsletter #29 – a TSO vision for a future hydrogen network. The updated version includes 10 more members, 11 more countries, 17,000 extra km and sinking costs per km (1080 - 2040 €/km). The map has new regions: the UK and the Republic of Ireland, Southern Europe with Greece, Northern Europe around the Baltic sea (Estonia, Finland and Sweden) and Eastern Europe (Austria, Czech Republic, Hungary, Poland, Slovakia and Slovenia). Get a glimpse here and see the report if you are curious.

https://bit.ly/3udCMt8

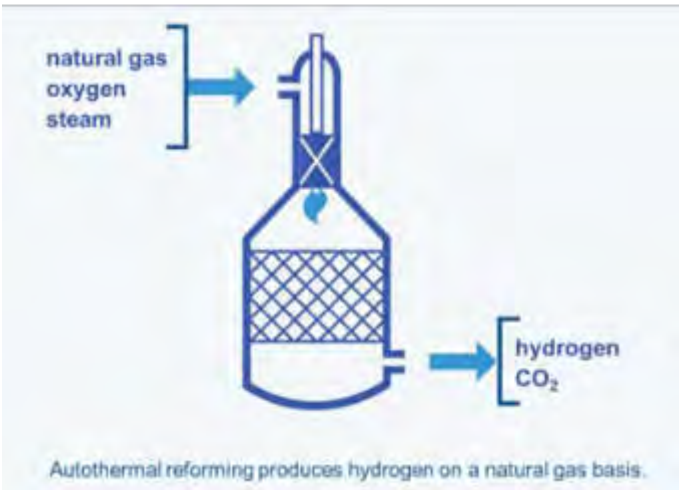
Kees van der Leun at
kees.van.der.leun@guidehouse.com

Feasibility Study for Hydrogen Infrastructure With New Hydrogen Reformer and CCS | Germany & Norway (1/2)

H2morrow The goal of the project "H2morrow" is to develop a complete value chain for hydrogen from decarbonised natural gas. It should be ready for use in the second half of the 2020s to supply industry and other end customers in North-Western Germany. The blue hydrogen will be fed into the gas grid **utilising converted natural gas pipelines extended with limited new built pipelines**. Among others, a steel mill will be supplied with blue hydrogen in the future.

Blue hydrogen is grey hydrogen whose CO_2 is captured and stored during production (CCS). The CO_2 generated during hydrogen production is thus not released into the atmosphere and hydrogen production is almost CO_2-neutral. The CO_2 footprint is reduced by 95%. In this way, the four partners - Equinor, OGE, thyssengas and thyssenkrupp Steel Europe - want to realise an almost climate-neutral steel production. Another advantage of blue hydrogen is that it offers security of supply and can be produced in large quantities 24/7 at - according to the partners - competitive costs. Overall, the price is 58 euros per megawatt hour or 2.1 euros per kilogram of hydrogen. The CO_2 costs of the project are in the range of 50-70 euros per tonne of CO_2. The prerequisite for its use is the creation of a cross-regional transport infrastructure for hydrogen.

"H2morrow" uses **autothermal reforming (ATR)** to produce blue hydrogen. The process differs from conventional steam reforming. Conventional steam reforming can be combined with CO_2 capture, but this involves high costs due to the conversion of many separate production steps. ATR, on the other hand, produces hydrogen with steam and pure oxygen under high pressure (see figure below). The process runs autothermally, without any additional heat input. This has two advantages: Firstly, the natural gas can be converted into hydrogen even more efficiently , and secondly, CO_2 is under a higher partial pressure, higher concentrated. It can therefore be captured and stored cost-efficiently. There is potential for storing more than 67 billion tonnes in the Norwegian North Sea, which is currently equivalent to 80 years of total German CO_2 emissions.



Hydrogen from decarbonised natural gas (source: H2morrow)

Due to the secure supply of natural gas, such a reformer can provide a base-load capable hydrogen supply of 8.6 terawatt hours per year. This corresponds to the energy demand of 450,000 average four-person households per year.

To ease the transport of the produced CO_2, the gas will be liquefied directly next to the ATR at about -50 °C. For the first project phase the planning assumption is that the ATR is located in Eemshaven in the Netherlands. However, other potential sites at the German coast could present an alternative for following project phases. Potential CO_2 storage sites has been investigated. One option is the “Northern Lights” project in Norway or the Porthos project offshore of Rotterdam, of which Northern Lights is the most advanced one. The study concludes that depending on the production capacity, either ships or pipelines may be viable as CO_2 transport solutions. The Northern Lights option comprises the CO_2 transport per ship to the west coast of Norway. There, the CO_2 is fed into a 120-kilometre-long underwater pipeline, through which the CO_2 finally reaches the injection plant, which pumps the CO_2 2,600 metres deep into a saline aquifer for permanent storage (see next page).

Results of the feasibility study

The feasibility study showed that it is technically possible to set up a complete value chain for blue hydrogen and to supply Germany's largest steel mill with blue hydrogen. The study investigated various options for sourcing and transporting hydrogen to the steel mill. The transport and storage of CO_2 were also considered. Two different scenarios with production capacities of 1.4 GW and 2.7 GW were considered in the feasibility study.

Redundant and parallel gas pipelines

The identified pilot region (see figure next page) is particularly suitable because it is currently still supplied with L-gas (low calorific gas) and will have to be converted to H-gas (high calorific gas) by 2030. H-gas supply is already largely ensured via existing transport routes. This conversion of the gas infrastructure therefore creates a unique opportunity: infrastructure previously used for the transport of L-gas can now be used as hydrogen infrastructure.

In the pilot region, many pipelines are also laid in parallel, i.e. with two or more strings. With these parallel pipelines, one string can transport hydrogen while the other continues to supply natural gas. This approach creates the greatest possible flexibility for all connected customers and network operators. A customised solution can be found for all customers, as the hydrogen can either be delivered pure (pure hydrogen pipeline) or as controlled gas mixture. If requested

Feasibility Study for Hydrogen Infrastructure With New Hydrogen Reformer and CCS | Germany & Norway (2/2)

industrial customers can therefore switch to 100 % hydrogen soon. Distribution network operators with many household customers can add hydrogen to the heating network with fixed shares, while customers with highly sensitive production processes can continue to obtain natural gas. The project partners assume that it is necessary to have a consistent and calculable gas quality at all points in the network. Fluctuating hydrogen contents are not considered due to the inherent technical challenges.

OGE has examined a conversion of selected pipelines to 100 % hydrogen in the course of the feasibility study and was able to confirm the technical feasibility of the project. In the case of a conversion, the pipelines themselves as well as the individual components, such as compressors or seals, are tested by independent experts. Depending on the requirements and the results of the material testing, individual components are replaced or adapted for hydrogen use. After another independent test, the pipes are approved for hydrogen use by the competent authority. The complete conversion in cooperation with the competent authorities takes about five years, whereby the costs are significantly lower than for constructing new pipelines.

Conclusion of the feasibility study

The project partners demonstrated that hydrogen can be produced in large quantities and at very competitive cost. The feasibility study concludes that the political and regulatory framework in Germany and the EU needs to be clarified. The main issues here are the conversion of natural gas pipelines to hydrogen pipelines and the transport of hydrogen independently of the production technology. In addition, coordination between the Netherlands and Germany on network expansion and cross-country transport agreements are necessary. At EU level, we need a uniform and systematic approach to hydrogen of all production technologies, taking into account the respective CO_2 footprint, as well as a change in the legislation on CO_2 transport by ship. The project aims to be realised by 2030.

Schematic description of the project (source: H2morrow steel)

https://oge.net/de/wir/projekte/h2morrow (short report, in German only)
H2morrow-The Potential-of-Hydrogen-for-Decarbonization-of-German-Industry.pdf
(management summary in English)

HyBlend™ Project Has Started | U.S.

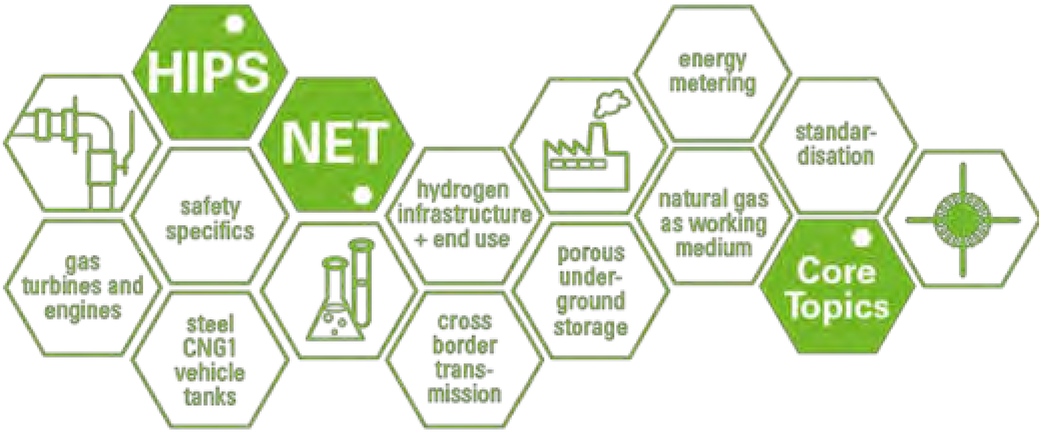
Photo from iStock

The National Renewable Energy Laboratory (NREL) will lead a new collaborative research and development (R&D) project known as HyBlend™ to address the **technical barriers to blending hydrogen in natural gas pipelines.**

The HyBlend team comprises six national laboratories and more than 20 participants from industry and academia. This two-year project was selected by the U.S. Department of Energy's Hydrogen and Fuel Cell Technologies Office in the Office of Energy Efficiency and Renewable Energy (EERE) through the H2@Scale 2020 CRADA Call. The team will receive more than $10 million of funding from EERE, with an additional $4 to $5 million of contributions from participants.

https://bit.ly/3ujDll5

HIPS-NET CORE TOPICS



EVENTS AND PARTNERS

Selection of Appointments

June 2021

09 **American Hydrogen Forum** | Houston, Texas, *https://www.ushydrogenforum.com/*

09-10 **The Hydrogen Technology Conference & Expo** | Stuttgart, Germany, *https://www.hydrogen-worldexpo.com/*

16-17 **8th HIPS-NET Workshop** | online, *https://www.dbi-gruppe.de/hips-net.html*

20-24 **WHTC - World Hydrogen Technologies Convention 2021** | online, *www.whtc2021.org/*

22-23 **3rd Global LNG & Hydrogen Forum** | Milan, Italy, *https://lng-global.com/*

22-23 **Hydrogen Dialogue 2021 - Summit & Expo** | online, *https://www.hydrogendialogue.com/*

September 2021

07 **Hydrogen and Fuel Cell Conference** | Birmingham, UK, *https://bit.ly/33nCTGB*

September / October 2021

07-09 **beyondgas 2021** | Oldenburg, Germany, *https://www.beyondgas.de/*

14-15 **F-Cell 2021 - Emerging Hydrogen Business** | Stuttgart, Germany, *https://f-cell.de/*

21-24 **International Conference on Hydrogen Safety ICHS 2021** | Edinburgh, Scotland, *https://hysafe.info/ichs2021/*

30-02 **4th International Workshop on Degradation Issues of Fuel Cells and Electrolysers** | Corfu, Greece, *https://bit.ly/3tlnrpg*

October 2021

27-28 **HyVolution** | Paris, France, *https://www.hyvolution-event.com/en*

November 2021

24-25 **GAT | WAT 2021** | online + Cologne, Germany, *https://www.gat-wat.de/*

Current Partners

Alliander AG, Areva H2Gen,
Cadent, DGC, DNV GL, Enagás,
Enbridge, Energinet.dk, ENGIE,
EWE Netz, Gas Connect Austria GmbH,
Gasnetz Hamburg, Gasum OY,
Gasunie, GRTgaz, grzi e.V. (figawa),
Infraserv GmbH & Co. Höchst KG,
INERIS, innogy SE, ITM Power,
Joint Research Centre (JRC), EC,
KOGAS, NAFTA a.s,
Naturgy, ONTRAS, ÖVGW,
Open Grid Europe GmbH,
Polymer Consult Buchner GmbH,
RAG Austria AG,
Shell, Solar Turbines Europe S.A.,
Storengy, SVGW,
Synergrid, Teréga, TNO,
Uniper Energy Storage GmbH,
Verband der Chemischen Industrie (VCI),
Wintershall Dea AG.

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Certified DIN EN ISO 9001:2015

HIPS-NET

"Establishing a pan-European understanding of admissible hydrogen concentration in the natural gas grid"

NEWSLETTER #32 **August, 2021**

Dear HIPS-NET Partners,

Our 8th HIPS-NET workshop was successfully held on the 16th and 17th June 2021 –online again. Thanks to all the participants for the interesting presentations and discussions.

We hope to see you next year in person. Save the date: 15th + 16th June 2022.

The 32nd HIPS-NET newsletter talks about:

- the Canadian hydrogen strategy
- the Dutch HyWay27 project
- the successful test of a gas regulator from a Dutch manufacturer
- worldwide Platforms for Hydrogen valleys

We hope you enjoy reading the articles and if you have ideas for new articles or information about projects in your country, please let us know!

Your HIPS-NET Team

Gert, Charlotte, and Ruven

CONTENT

CONTENT NEWSLETTER #32

Canadian Hydrogen Strategy | Canada

To diversify the future energy mix, generate economic benefits and achieve net-zero emissions by 2050, the Canadian Government introduced the Hydrogen strategy for Canada in December 2020.

The hydrogen strategy outlines Canada's advantages in becoming a world-leading hydrogen producer, user and exporter, as well as the opportunities hydrogen offers Canada. It identifies the remaining economical, technological and regulatory challenges, the vision for 2050 and presents recommendations.

The strategy sees Canada's advantages in **becoming world-leading in the field of hydrogen production** in the **rich feedstock** it has available thanks to its hydroelectrical generation capacity, its fossil fuel reserves and the use of nuclear power. Canada is one of the top ten hydrogen producers in the world today. It has **leading companies in hydrogen**, fuel cell and carbon capture technology. The country has established international **trade partnerships** and **infrastructure** assets that are seen as a significant **export opportunity**. With its hydrogen strategy, Canada aims to grow its economy, create more than 350,000 jobs and **reach net-zero emissions by 2050**.

Regarding the end-uses of hydrogen, the focus will be on energy-intensive applications, such as fuel for long-distance **transportation and power generation, heat for industry and buildings** and as a **feedstock for industrial processes**.

Canada sets its **vision for 2050** (see figure for excerpt). In consultation with stakeholders, the strategy has developed **32 recommendations** across the following **eight pillars** that will inform the development of specific actions. The actions will be coordinated through a Strategic Steering Committee and Working Groups.

Hydrogen opportunities for Canada until 2050

- Pillar 1: **Strategic Partnerships** – Strategically use existing and new partnerships to collaborate and map out the future of hydrogen in Canada.
- Pillar 2: **De-Risking of Investments** - Establish funding programs, long-term policies, and business models to encourage industry and governments to invest in growing the hydrogen economy.
- Pillar 3: **Innovation** - Take action to support further R&D, develop research priorities, and foster collaboration between stakeholders to ensure Canada maintains its competitive edge and global leadership in hydrogen and fuel cell technologies.
- Pillar 4: **Codes and Standards**- Modernize existing and develop new codes and standards to keep pace with this rapidly changing industry and remove barriers to deployment, domestically and internationally.
- Pillar 5: **Enabling Policies and Regulation** - Ensure hydrogen is integrated into clean energy roadmaps and strategies at all levels of government and incentivize its application.
- Pillar 6: **Awareness** - Lead at the national level to ensure individuals and communities are aware of hydrogen's safety, uses, and benefits during a time of rapidly developing technologies.
- Pillar 7: **Regional Blueprints** - Implement a multi-level, collaborative government effort to facilitate the development of regional hydrogen blueprints to identify specific opportunities and plans for hydrogen production and end use.
- Pillar 8: **International Markets** - Work with our international partners to ensure the global push for clean fuels including hydrogen, thus, Canadian industries thrive at home and abroad.

https://t1p.de/6mxq (full report)
https://t1p.de/hu1b (further information on the upcoming clean fuel standard)

HyWay 27 - Using the Existing Natural Gas Network for the Transport of Hydrogen | Netherlands

The project HyWay27 is a thorough policy analysis for the Dutch government to decide on the use of the existing gas infrastructure for hydrogen transport and storage and covers three work streams: hydrogen supply, demand, and storage; legal and financial prerequisites; and technology and safety requirements.

The Dutch Ministry of Economic Affairs and Climate Policy commissioned PwC/Strategy& and collaborated with the transmission system operators Gasunie and TenneT to answer the following questions:

1. Do we need a transmission network for hydrogen, and if so, when?
2. Can the existing natural gas network be used for hydrogen transmission, and if so, would that be desirable?
3. What government intervention will be required to create a transmission network for hydrogen?

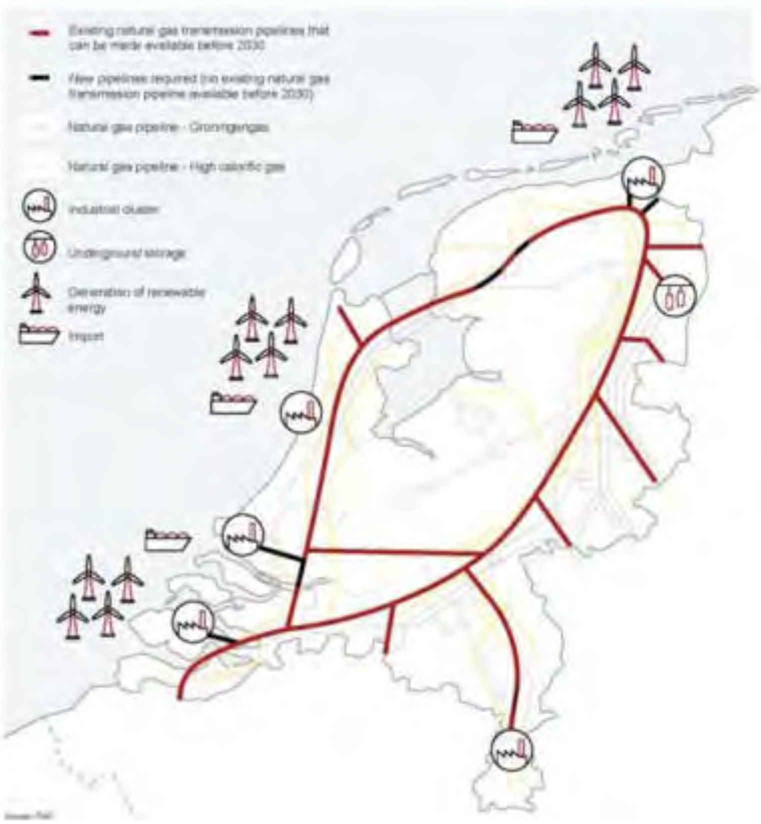
The study leads to the following conclusions and recommendations:

Make a decision in principle – Zero-carbon hydrogen requires new transmission supply chains. In this report, it is argued that reusing the existing natural gas transmission networks would provide a cost-effective basis to accommodate the hydrogen flows that will materialise in the long term. One key driver is the desire to realise the ambitions for 2030 from the Dutch Climate Agreement and the Government Strategy on Hydrogen. Given that these ambitions mean that transport demand will start to develop as early as over the coming years, several decisions will have to be made in the short term. The reports' advice is to decide in principle to use part of the existing natural gas networks for the transmission of hydrogen and to steer the further decision-making process towards working out the specifics (where, when) and implementation (who, how).

Draw up a rollout plan (what) – The next question is where and when to create the transmission network. For this, the HyWay27 project recommends drawing up a rollout plan. This rollout plan will have to be backed up as much as possible by a societal cost-benefit analysis and be based on objective principles that help prevent market disruption. Based on the 2030 ambitions, a rollout plan will primarily have to describe the targeted contours of the transport network in 2030, as well as the actions that will be needed for that over the next couple of years. It must also strike a balance between creating clarity for potential consumers and the gradual development of the network so that ongoing market developments can be taken into account.

Define the required market regulation for transmission (who) – As the hydrogen market grows, the transmission network is likely to develop into an infrastructure that requires access and tariff regulation. To be able to decide in the short term who is responsible for repurposing the natural gas networks and ultimately for the management of the newly created hydrogen transmission network, clarity is needed on how to regulate the hydrogen market. This includes clarity on possible access and/or tariff regulations and whether the transmission network will be publicly or privately owned.

Make a plan to kick-start the integrated supply chain (how and how much) – The ambition to have 3-4 GW of electrolysis capacity installed by 2030 can only be realised with a government intervention. In addition to supporting policy on pricing and standards, the core of this should be financial support for green hydrogen projects. Currently, no funds have been earmarked for that. This affects the transmission network, as investments in a transmission network will not produce financial and societal yields when there is little supply and demand for hydrogen.



Conclusions and recommedations of the HyWay 27 research (Source: https://t1p.de/xl6z)

The HyWay27 project advises the government to create clarity on the funds that are available to kick-start the supply chain. Additionally, a plan is needed, specifying which financial instruments can best be used to distribute those funds. Another advice is it to decide what part of the supply chain to subsidise (hydrogen production, consumption, transport, or combinations thereof) and what type of instrument would be the most effective in eliciting prompt investments and making sure public funds are spent efficiently.

https://t1p.de/g5vz (full report)
https://t1p.de/xl6z (further information)

RS350S regulator passes practical test with 100% hydrogen | Netherlands

On 22 and 23 October the Dutch institute KIWA was commissioned by the association Netbeheer Nederland to investigate whether existing gas pressure regulating stations for natural gas are suitable for use of 100% hydrogen. The Dutch grid operator Rendo provided a common gas pressure regulating station for this test. Among other things, this station contains a regulator RS350S DN50 by the manufacturer Wigersma & Sikkema. In addition, the gas pressure regulator station was equipped with the BMA and BDA system couplings to connect the PLEXOR inspection system. Furthermore, a UNIGAS 300 electronic volume converter from Wigersma & Sikkema was used in the test set-up to measure and record pressure, temperature, and flow. For several tests, the PLEXOR inspection system has been applied.

Gas pressure regulating station (district station) (source: Kiwa report)

Specifically, the following aspects were investigated in detail, both with natural gas (L gas) and with 100 % hydrogen:

- the external leak-tightness of the gas pressure regulating station when hydrogen is used
- the correct operation of the components when using hydrogen
- the internal leakage of the valves and safety devices
- the operation of the safety devices
- the operating and control behaviour of the regulator

In conclusion, the gas pressure regulating station designed for natural gas can be operated with 100 % hydrogen without any modifications. All components of the station as well as all auxiliary equipment used, such as UNIGAS 300 and the PLEXOR inspection system, could be operated with 100 % hydrogen without any problems.

https://t1p.de/9esv (complete KIWA test report)
https://wigersma-sikkema.com/en (further information)

Mission Innovation Hydrogen Valley Platform | worldwide

The European Union wants to support the development of an international hydrogen economy. Therefore, the Mission Innovation Hydrogen Valley Platform was developed under the framework of the Mission Innovation's Challenge #8 (IC#8) "Renewable and Clean Hydrogen". The platform features comprehensive insights into the most advanced and ambitious Hydrogen Valleys around the globe. It is a global collaboration platform for all information on large-scale hydrogen flagship projects and aims to facilitate a clean energy transition by promoting the emergence of integrated hydrogen projects along the value chain as well as by raising awareness among policy makers.

Objectives

As a clear sign of a growing and maturing hydrogen market, Hydrogen Valleys have started to emerge all around the world (see figure at the bottom of the page). A **Hydrogen Valley** is a geographical area – a city, a region, an island, or an industrial cluster - where several hydrogen applications are combined into an integrated hydrogen ecosystem that consumes a significant amount of hydrogen, improving the economics behind the project. It should ideally cover the entire hydrogen value chain: production, storage, distribution, and final use.

Based on extensive collection of primary data from the hydrogen projects, the platform provides information on technologies deployed, funding details, stakeholder management, barriers, and project success factors. Furthermore, the information includes best practices from the projects, a matchmaking section as well as a compilation of the most useful tools and studies available for project developers, policy makers and industry representatives.

It aims to facilitate the exchange of information about and between Hydrogen Valleys around the world to inform project developers, policy makers and the hydrogen industry alike, thereby advancing the further development of the new hydrogen economy and ultimately the green energy transition.

https://www.fch.europa.eu/page/mission-innovation-hydrogen-valleys-platform

Screenshot of www.h2.eu main page

Platform Structure and Content

On the Hydrogen Valley Platform homepage (screenshot above), the navigation elements *Hydrogen Valley*, *Analysis*, *Toolbox* and *Matchmaking* lead to various information and applications provided for the user. These sections contain the following in detail:

HYDROGEN VALLEYS

Hydrogen Valley Map There is an interactive map on which all Hydrogen Valleys currently represented on the

Hydrogen Valleys around the globe featured on the platform

platform are marked. If you would like more information on a particular valley, you can either click on the respective marker or look in the extensive list below the map.

ANALYSIS

Statistics This section is based on the most comprehensive survey that has ever been conducted on Hydrogen Valleys globally. More than 2,500 data points collected from more than 30 Hydrogen Valleys offer an exclusive look inside the projects and provide the user with details on the Valleys' fundamentals, technologies deployed, project development, financing aspects as well as overarching project goals and benefits.

Barriers Also based on the Hydrogen Valley Survey, this section explores the barriers that the Hydrogen Valleys indicated. Both during the preparation and the financing phase, the projects provide an exclusive look into their specific challenges and hurdles they faced or are facing to this day. On top of that, have a look at the most important regulations for successful projects according to the Hydrogen Valleys.

Best Practices The Best Practice section offers insights into various topics commonly identified as main hurdles and barriers for Hydrogen Valleys, ranging from how to successfully obtain both private and public funding, how to secure off-take commitments, manage technological risk, cooperate with project stakeholders and much more. The Best practices are based on comprehensive interviews with outstanding Hydrogen Valleys that have been managing selected challenges particularly well.

TOOLBOX

The toolbox section provides useful information about other hydrogen websites and platforms, features the most recent and important studies from key players and organizations in the hydrogen world, and presents insights about the Hydrogen Valley platform stakeholders.

MATCHMAKING

The matchmaking section is useful in the event that

- you would like to get personally in touch with a specific Hydrogen Valley,
- you are a project developer or another region that is entering the hydrogen economy,
- you see a potential to collaborate, or
- you are already a Hydrogen Valley that wants to get in touch with its peers.

By selecting the project you would like to contact and entering your details, your message will be sent to the specified project.

Background Information

Mission Innovation (MI) is a global initiative formed in 2015 to accelerate the clean energy transition, which includes 22 countries from across the world, as well as the European Union. Their primary goals are to double research and innovation in-

MEMBERS OF MISSION INNOVATION
(HTTP://MISSION-INNOVATION.NET/OUR-MEMBERS/)

vestment in clean energy by 2021 and facilitate greater private sector engagement in clean energy.

The **Renewable and Clean Hydrogen Challenge**, or **Innovation Challenge #8** (IC#8), was launched at MI-3, 23-24 May 2018 in Malmö. IC#8 recognises hydrogen as a key technology for the energy transition. Its objective is to accelerate the development of a global hydrogen market by identifying and overcoming key technology barriers to the production, distribution, storage, and use of hydrogen at gigawatt scale. The Innovation Challenge is co-led by Australia, Germany and the European Commission and has more than ten participating member countries around the world.

IC#8 can play an important role in addressing aspects related to broader energy system integration, business models, (global) market design and validation. In addition, enabling regulatory frameworks are key for hydrogen, and are not in the focus of Mission Innovation.

The Hydrogen Valleys Platform has been prepared for **the Fuel Cells and Hydrogen 2 Joint Undertaking** (FCH JU). This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme, Hydrogen Europe, and Hydrogen Europe Research. It is a unique public private partnership supporting research, technological development and demonstration activities in fuel cell and hydrogen energy technologies in Europe. Its aim is to accelerate the market introduction of these technologies, realising their potential as an instrument in achieving a carbon-clean energy system.

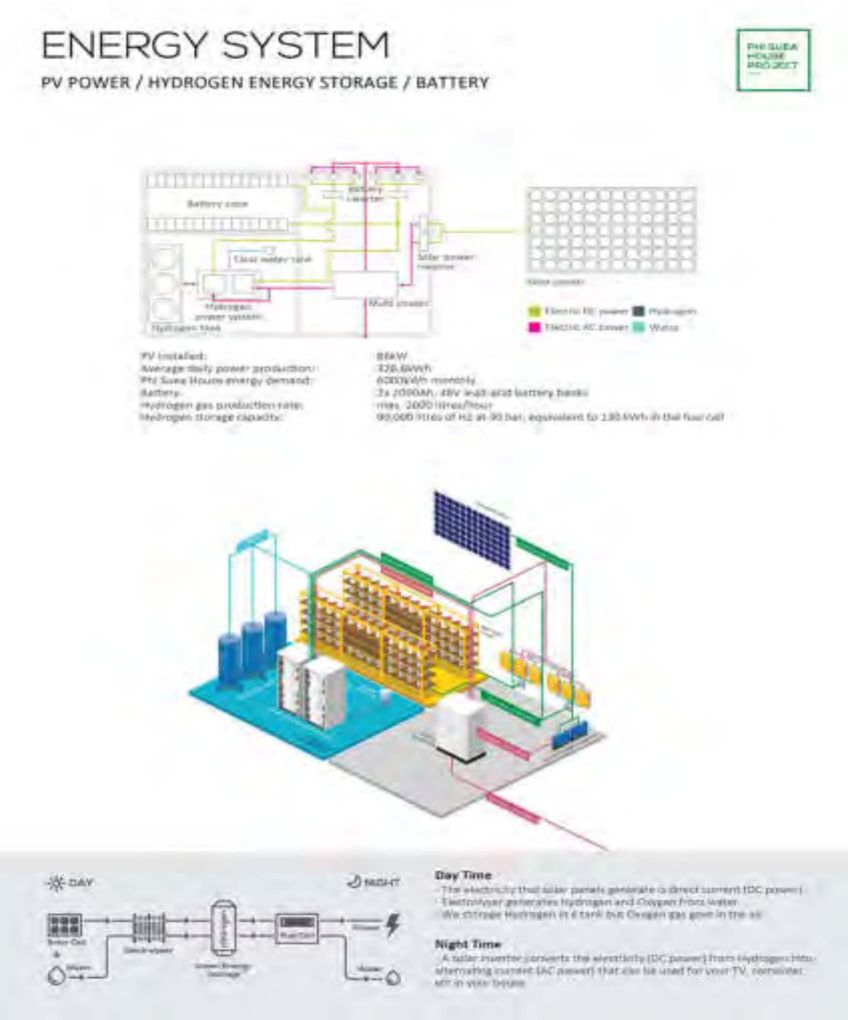
https://www.fch.europa.eu/page/mission-innovation-antwerp-2019
https://www.fch.europa.eu/page/who-we-are

https://www.h2v.eu/

Insight into Hydrogen Valleys

The Phi Suea House Project The new platform also includes a project by the Heidelberg-based hydrogen start-up Enapter in Thailand. The "Phi Suea House" is an innovation project that consists of several buildings and is powered exclusively by solar energy, a hybrid hydrogen battery storage system and hydrogen fuel cells. The idea came from Sebastian-Justus Schmidt, co-founder of Enapter. The company manufactures so-called anion exchange membrane (AEM) electrolysers, which are already in use in more than 30 countries. This year, Enapter also plans to become more active in Germany. For example, construction work on the company's first mass production plant in Saerbeck, North Rhine-Westphalia, is scheduled to begin in 2021 (energate reported). Starting in 2022, Enapter plans to produce 100,000 electrolyser modules annually there.

https://t1p.de/fds1



ENERGY SYSTEM OF THE PHI SUEA HOUSE PROJECT
(SOURCE: HTTPS://PHISUEAHOUSE.COM/EVENT_SUMMIT.PHP)

Fukushima Hydrogen Energy Research Field The Fukushima Hydrogen Energy Research Field (FH2R), the world's largest hydrogen-production facility, began operation in 2020 and constitutes a giant leap towards the realization of a hydrogen society. The consortium behind the project consists of the New Energy and Industrial Technology Development Organization (NEDO), Toshiba Energy Systems & Solutions Corporation (Toshiba ESS), Tohoku Electric Power Co., Inc., and Iwatani Corporation.

FH2R uses 20MW of solar power generation facilities on a 180,000m^2 site along with power from the grid for the electrolysis of water in a renewable energy-powered 10MW-class electrolyser, the largest in the world. It has the capacity to produce, store, and supply up to 1,200Nm^3 of hydrogen per hour.

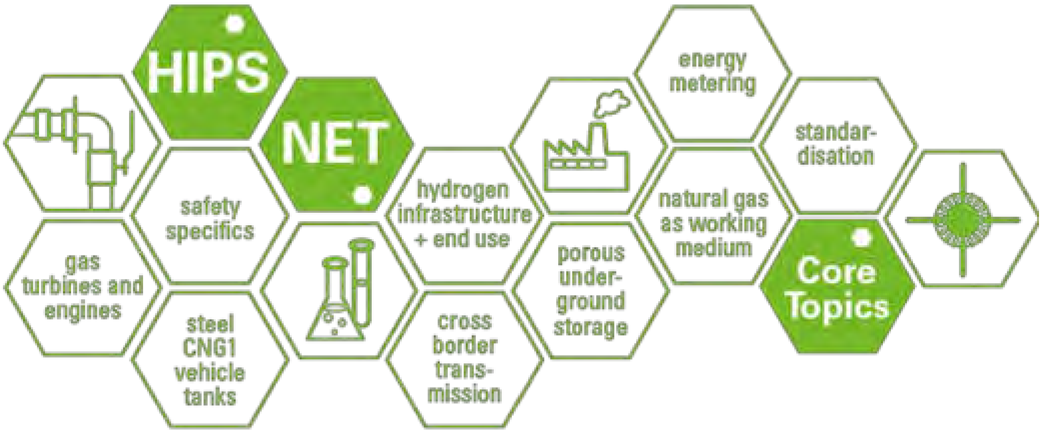
FH2R, FUNCTIONS OF FACILITIES
(SOURCE: HTTPS://WWW.BDI.FR/WP-CONTENT/UPLOADS/2020/03/FUKUSHIMA-HYDROGEN-ENERGY-RESEARCH-FIELDFH2R.PDF)

A particularly critical issue is responding to fluctuations in electrical power when the hydrogen is made from renewable energy sources. FH2R uses information from a hydrogen demand-and-supply forecasting system for predicting the market demand for hydrogen, and additional data from a power grid control system to maximize the use of electricity from renewable sources. The goal is to develop the most efficient hydrogen energy management system.

Hydrogen produced at FH2R will mainly be transported in hydrogen tube trailers and hydrogen bundles to be supplied to users in Fukushima Prefecture, the Tokyo Metropolitan area, including the Olympic Village area for the Tokyo 2020 Games, and other regions.

https://www.japan.go.jp/kizuna/2021/03/hydrogen-production_facility.html
https://www.toshiba-energy.com/en/info/info2020_0307.htm

HIPS-NET CORE TOPICS



EVENTS AND PARTNERS

Selection of Appointments

September 2021

14-15 **F-Cell 2021** | Stuttgart, Germany, *https://f-cell.de*

14-15 **Renmad Hydrogen 2021** | online, *https://atainsights.com/hydrogen*

21-24 **International Conference on Hydrogen Safety ICHS 2021** | Edinburgh, Scotland, *https://hysafe.info/ichs2021*

28-29 **DBI-Fachforum ENERGIESPEICHER** | Berlin, Germany, *https://www.dbi-gti.de/termine/dbi-fachforum-energiespeicher.html*

30-02 **4th International Workshop on Degradation Issues of Fuel Cells and Electrolysers** | Corfu, Greece, *https://bit.ly/3tlnrpg*

October 2021

20-21 **The Hydrogen Technology Conference & Expo** | Messe Bremen, Germany, *https://www.hydrogen-worldexpo.com*

27-28 **HyVolution** | Paris, France, *https://www.hyvolution-event.com/en*

November 2021

16 **Hydrogen and Fuel Cell Conference** | Birmingham, UK, *https://t1p.de/4vqc*

24-25 **GAT | WAT 2021** | online + Cologne, Germany, *https://www.gat-wat.de*

January 2022

13-14 **Hydrogen Business For Climate CONNECT** | online, *https://h2-bfc-connect.pvf.b2match.io/*

February 2022

23 **Online-Workshop "Zulassung - Zertifizierung - Normung"** | online, *https://www.ise.fraunhofer.de/de/veranstaltungen/wzzn-10.html*

March 2022

8-10 **World Hydrogen 2022 Summit & Exhibition** | Rotterdam, Netherlands, *https://www.world-hydrogen-summit.com/*

Current Partners

Alliander AG, Areva H_2Gen,
Cadent, DGC, DNV GL, Enagás,
Enbridge, Energinet.dk, ENGIE,
EWE Netz, Gas Connect Austria GmbH,
Gasnetz Hamburg, Gasum OY,
Gasunie, GRTgaz, grzi e.V. (figawa),
Infraserv GmbH & Co. Höchst KG,
INERIS, innogy SE, ITM Power,
Joint Research Centre (JRC), EC,
KOGAS, NAFTA a.s,
Naturgy, ONTRAS, ÖVGW,
Open Grid Europe GmbH,
Polymer Consult Buchner GmbH,
RAG Austria AG,
Shell, Solar Turbines Europe S.A.,
Storengy, SVGW,
Synergrid, Teréga, TNO,
Uniper Energy Storage GmbH,
Verband der Chemischen Industrie (VCI),
Wintershall Dea AG.

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Certified DIN EN ISO 9001:2015

HIPS-NET

"Establishing a pan-European understanding of admissible hydrogen concentration in the natural gas grid"

NEWSLETTER #33 **September, 2021**

Dear HIPS-NET Partners,

hydrogen is and remains an important topic worldwide. A strong perception is achieved however not in all areas where hydrogen could unfold undoubtable advantages. Especially in distribution grids, significant communication but also some R&D and standardisation activities still need to be addressed. In this context it is great to know the UN Climate Change Conference of the Parties (COP26) in Glasgow (November 2021) has announced a hydrogen day.

The 33rd HIPS-NET newsletter includes articles about:

- a German short study on hydrogen – colour theory
- a Partnership between FORCE and DGC in Denmark, that will provide easy access to hydrogen technology testing
- updates from the German HYPOS H2-Netz project
- the removal of barriers for green hydrogen within the Dutch project HyDelta
- and the use of a hydrogen train at the UN Climate Change Conference of the Parties (COP26) in Scotland

Enjoy reading the articles and if you have ideas for new articles or information about projects in your country, please let us know!

Your HIPS-NET Team

Gert, Charlotte, and Ruven

CONTENT

CONTENT NEWSLETTER #33

SHORT STUDY HYDROGEN – COLOUR THEORY | GERMANY

In December 2020, the Institute for Climate Protection, Energy and Mobility (IKEM) published a short study about the colour theory of hydrogen. To ensure that the wider use of hydrogen does not exacerbate climate change, a clear definition of the different "colours" of hydrogen and the discussion of their contribution to climate change were considered to be crucial. The colours derive from the source of energy for production, and the storage technologies.

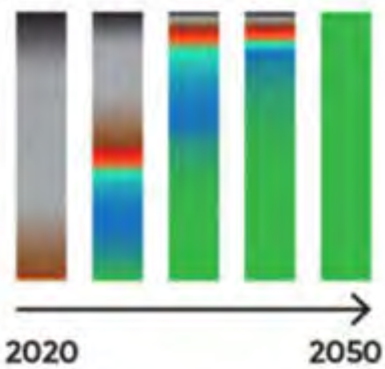
THE HYDROGEN RAINBOW

Black hydrogen is produced from hard coal and **brown hydrogen** is produced from brown coal. In both cases hydrogen is produced via gasification, in which hard or brown coal is converted into combustible gases using heat and water. By-products are carbon dioxide (CO_2) and carbon monoxide (CO). Hydrogen generated via steam reforming is called **grey hydrogen**. It uses natural gas together with heat and water vapour, its by-products are CO_2 and CO. If this process is combined with carbon capture and storage (CCS), its hydrogen is defined as **blue hydrogen**. It is seen as an important bridge technology, it but can only be rated as low-carbon and not as carbon-neutral, since greenhouse gases are released into the atmosphere. **Turquoise hydrogen** is produced via methane pyrolysis, in which natural gas splits under high temperature to hydrogen and solid carbon (which can be further processed or stored). If renewable energies are used to produce hydrogen via electrolysis, it is specified as **green hydrogen**. The electrolysis uses electricity to split water into hydrogen and oxygen. Hydrogen produced from bioenergy also has a renewable source, but the efficiency of its production chain is criticised (it can lead to scarcity of land, deforestation, decline of biodiversity and effects water resources), which is why it is not declared as green, but as **orange hydrogen**. **Red hydrogen** is produced from nuclear power via electrolysis or thermochemical water splitting, which uses high temperature to split water to hydrogen and oxygen. Nuclear power does not cause emissions, but it is a fossil resource and there are no long-term storage solutions for nuclear waste available. **White hydrogen** is hydrogen from natural sources, for example deposited in rock formations and is extracted via fracking, which is controversial due to possible environmental effects.

Today, most of the hydrogen produced is from fossil resources. It costs about 1.5 €/kg H_2, or in combination with CCS 2 €/kg H_2, which is cheaper than hydrogen from renewable energies with 2.5-5.5 €/kg H_2. Green hydrogen is not yet cost competitive, but it is aimed for the long term, because it does not emit CO_2, in contrast to fossil fuels. Therefore, CO_2 pricing and the subvention of renewable energies could change cost-competitivity.

Guarantees of origin are labelling and financing instruments by energy suppliers to offer the end consumer a "green" product. If hydrogen is produced via electricity from the grid, which is labelled as green electricity, the hydrogen can be promoted as green. However, in the current legal framework, there are no regulatory advantages to produce or use green hydrogen instead of hydrogen from fossil fuels. A uniform cross-sectoral legal framework needs to be built up, to define when hydrogen is green and to support green hydrogen.

Political strategies for hydrogen until 2050 are introduced by the European Commission. In Germany, several **investments** are made for different governmental programs regarding hydrogen. But a successful implementation requires a **plan** that shows, using specific figures, how these goals can be achieved in concrete terms.



ON THE WAY TO A GREEN HYDROGEN ECONOMY: DEVELOPMENT OF HYDROGEN COLOURS

To meet the future demand of green hydrogen, the **expansion of renewable energies** is essential. To increase the acceptance within the population, citizens could be encouraged to participate more in the energy transition, e.g. in energy cooperatives, crowdfunding or as prosumers. Moreover, the expansion of renewable energies creates jobs.

The debate about the hydrogen colours is not over yet. For example, the German environmental council suggested in June to define **dark green hydrogen**, which is not only produced from renewable energies, but its production meets ecological and social minimum standards.

https://t1p.de/5wui (IKEM short study)
https://t1p.de/1k3s (statement environment council)

Partnership will provide easy access to hydrogen technology testing | Denmark

The competences in hydrogen technology testing are spread out over a multitude of smaller actors. FORCE Technology and Danish Gas Technology Centre (DGC) will change this with a new partnership.

A small supplier here. A small supplier there. Lack of standards. Limited cooperation. Lack of common direction. The market for hydrogen technology testing is growing, but is still characterised by a very fragmented supplier situation, and FORCE Technology and DGC aim to change this by setting up a new partnership. The partnership will bring together competences in the field, create a coherent offer for the market, ensure a single entry to test services and ultimately boost the transition to Power-to-X and the use of hydrogen.

“First of all, we would like to be a strong partner for Danish companies within Power-to-X and facilitate the technological transformation they face. But ultimately, of course, we would like to support safe, green and sustainable development and an efficient transformation of the energy sector. When it comes to climate, we don't have time to hesitate," says Trine Nybo Lomholt, Programme Manager at FORCE Technology.

“It offers clear advantages for Danish companies that we pool knowledge and competences on hydrogen technology in one place and thus are able to provide the most qualified technical advice and the best services in the field. The Power-to-X transition is a comprehensive exercise that has only just begun. If we are to succeed in creating the necessary green growth in Denmark, it is important that companies can easily find the knowledge, testing facility and advice they need when handling or using hydrogen", says Thea Larsen, CEO of DGC.

Cooperation and standards

In the first few years, the partnership will focus on three issues in particular:

- To participate as one actor with its expertise in relevant projects, consortia, and other partnerships in the field of hydrogen technology and PTX.
- To take on commercial assignments.
- To take part in the standardisation work, where a whole range of tasks still need to be done.

Initially, the partnership is focussing on Danish producers, consumers, operators, and authorities in the field of hydrogen production, infrastructure and use. However, in the longer term, the partnership plans to extend its catalogue of services and to scale to the international market.

Portfolio of existing and planned hydrogen testing services

- Hydrogen analysis
  - Including analyses in accordance with standards for hydrogen used in fuel cells of vehicles
- Material and component testing
  - Hydrogen compatibility and sensitivity testing
  - Hydrogen permeation testing
  - Mechanical fracture testing
  - Large-scale component testing
- Measurement of emissions from consuming equipment and exhaust gases from energy consuming and chemical processes
- Efficiency and safety in energy systems
- Metrological services
  - Certification and calibration of hydrogen flow meters
  - Certification of hydrogen filling stations
- On-site inspection services - onshore and offshore
- Modelling and calculation
  - Flow simulations in hydrogen
  - Strength and fracture mechanical modelling in a hydrogen atmosphere
  - Digital Twins
  - Gas diffusion through polymers and steel

https://t1p.de/onm4 Asger Myken (amy@dgc.dk)

Updates from the HYPOS H2-Netz project: Examination of gas stop-off technologies under realistic conditions in high-pressure pipelines

Background

The HYPOS-project "H2-Netz" is focusing on the examination of a 100 % hydrogen infrastructure (strongly based on components/materials used for natural gas as well) under real conditions. The research infrastructure is located in a chemical park in Bitterfeld-Wolfen (Saxony-Anhalt, Germany). The hydrogen grid is 1.4 km long with 10 test pipeline sections and 3 pressure levels (DP25, DP10 and DP1). The sections differ according to the installation method and the pipeline materials. One research goal is to qualify modern plastic pipelines for a reliable transportation of hydrogen. Another goal of the project is to work out unresolved issues of the operation and the suitability of the system and its components. One of the research topics is the verification of technologies for shutting off gas flow in plastic pipelines. The tests were done on three pipeline sections with different pipeline materials. For proofing the suitability of the gas stop-off technologies, various measurement parameters such as leakage, tightness, permeation, and reverse forming of the plastic pipelines have been determined under hydrogen conditions.

Test description

In the high-pressure area of the grid (DP10) the following three different pipeline sections were exposed.

#	DN	SDR	Material
6	110	11	PE-Xa with EVOH-Layer
7	110	11	PE-Xa with PE-Layer
8	110	11	PE 100-RC

On these pipelines the gas stop-off technologies were tested under hydrogen conditions. First, the pipe squeezing was applied at an overpressure of 1 bar. The gas flow can be suppressed by squeezing the plastic pipeline until the inner pipeline walls touch each other. The approved amount of compression with the tube press is defined by a squeezing degree.

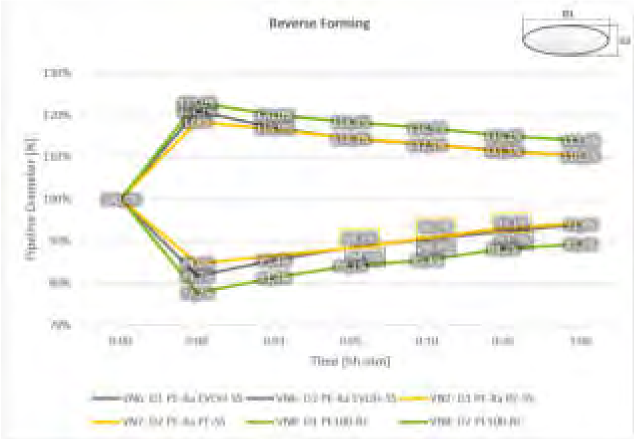
In a second examination, the gas stop-off bags were tested at a pressure of 4 bar. The gas stop-off bags need to be inserted into the pipelines with a specific device and the pipeline must be opened by drilling, which is for natural gas a well proved technology . To ensure safe operations, a pipeline socket is welded around the drilled holes. With the weld-on socket the stop-off bag device is screwed on, and the bags can be inserted and inflated with nitrogen.

Test results

The main purpose of the examination was to gain knowledge about leakage and tightness of the gas stop-off technologies. Furthermore, the permeation of the pipeline section after squeezing and the reverse forming of the plastic pipelines was measured.

<u>Reverse Forming</u>

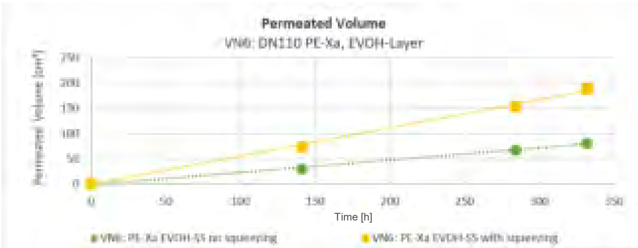
The reverse forming of the three plastic pipes was measured at different time steps in a 1-hour period. The values of the horizontal (D1) and vertical (D2) diameter were documented. The diagram shows, that the reverse forming characteristics of the two PE-Xa pipelines are slightly better than PE 100-RC. With a maximum of approx. 14 % deviation between the squeezed pipeline after one hour of natural reverse forming and the originally circular pipeline profile, there is no need for manual reverse forming to ensure a secure pipeline operation.



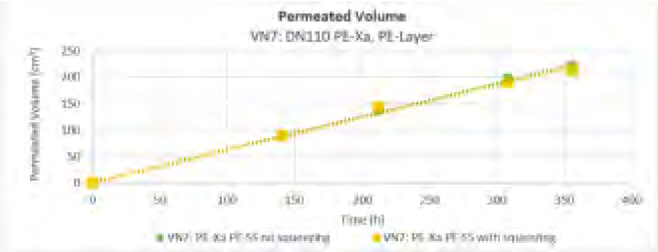
<u>Permeation</u>

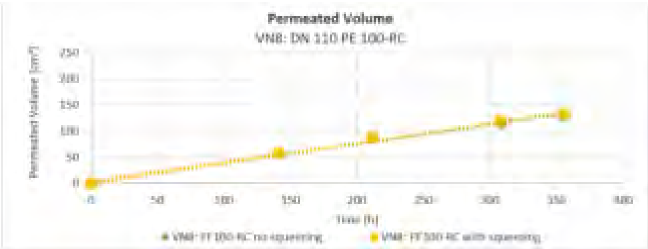
The measured permeation volume shows, that only at the PE-Xa pipeline with EVOH-layer a degradation due to the sueezing technology is noticeable. The permeated volume is about twice as high compared to the non-squeezed pipe. Nevertheless, the permeated volume is still very low and out of a safe-critical area.

For the PE-Xa pipeline with PE-Layer and the PE100-RC pipeline a destruction after squeezing of the piplines could not be found as the following diagrams proof.



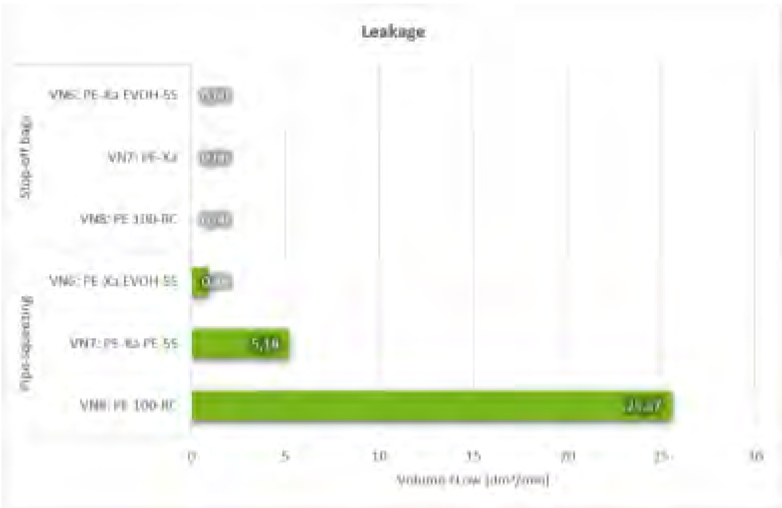
Leakage





The measurement of the leakage and tightness of the gas stop-off technologies was done three times for each pipeline section for 10 minutes. The average value is shown in the following bar chart. The comparison between gas stop-off bags and pipe-squeezing exposes that only the stop-off bag technology is suitable for 100 % hydrogen conditions. The squeezing technology does not shut-off the hydrogen volume flow completely. A rule given by the German department for accident insurance (DGUV-Rule 100-500) determines a maximum leakage of 30 l/h = 0,5 dm³/min. The PE-Xa pipeline with EVOH-layer shows the best shut-off characteristics, but still exceeds the given maximum value.

The examination of the gas stop-off technologies shows, that gas stop-off bags are very well suitable for 100 % hydrogen conditions up to an operating pressure of 4 bar. The technology is ready for usage in hydrogen infrastructures.



In case of a damaged pipeline and a gas leakage, pipe-squeezing can quickly prevent any further damage or even explosion. For safe operation of future hydrogen infrastructures, more research work on these technology needs to be done.

https://t1p.de/49x8 Robin Pischko (robin.pischko@dbi-gruppe.de)

HyDelta – Removal of Barriers for Green Hydrogen | Netherlands

HyDelta 1.0 is a national research program from the Netherlands (NL) aimed at the safe integration of hydrogen into the existing infrastructure for gas transport and distribution. The program has a strong collaboration with the Dutch Hydrogen Safety Innovation Programme, led by the standardization institute NEN. HyDelta wants to remove barriers to innovative hydrogen projects and has a preliminary duration from December 2020 until the end of January 2022. Innovations closest to market introduction are tackled first. HyDelta focuses on an integrated approach to solutions for the production, storage, transport and use of hydrogen to improve and accelerate the energy transition. Directly applicable research is central to this.

Participants in the program are the gas infrastructure company Gasunie, the technical certification and consulting companies DNV GL and Kiwa, the network operator organisation Netbeheer Nederland, the networking companies New Energy Coalition and TKI Nieuw Gas and the Dutch research institute TNO.

From summer 2020, the participants have focused on developing the HyDelta program. This process has produced a portfolio of **six connected work packages (WPs)** that can become urgent from an industry perspective individually and as a whole. Other WPs identified as less urgent (e.g. WP 5 and WP 6) have been postponed. To prevent research being conducted in the Netherlands that duplicates research in other countries where the priorities may be comparable, each WP starts with a thorough exploration of what is already known in the current research field and especially what is currently being researched elsewhere.

WP 1A safety and hydrogen is aimed at mapping out risks for the behavior of hydrogen in the case of leakages in houses and in the distribution network and defines control measures based on the risks.

WP 1B gas station deals with the questions whether the existing gas stations are suitable for hydrogen and which adjustments need to be done.

WP 1C main pipes, connection pipes and gas meter arrangement, indoor installation analyses how these parts contribute to the distribution of hydrogen and how possible adjustments could look like.

How hydrogen is measured, hydrogen meters are controlled and applied at Dutch house connections will be dealt within **WP 1D quantity measurement of hydrogen**.

The objective of **WP 1E flow speed impact on integrity** is to understand the impact of an increased flow velocity of hydrogen on different components of the existing gas infrastructure.

WP 1F existing valves for transport pipelines aims at gaining knowledge about the suitability of valves by performing leak tightness measurements.

WP 2 odorization wants to answer the questions, which odorant is most suitable for hydrogen, how stable an odorant/hydrogen mixture is, if the odorant influences fuel cells and combustion appliances, and what the consequences of not odorizing are.

WP 3 standards for hydrogen gives an insight in relevant standardization processes within the EU, analyses the gap between standardization and knowledge in NL at gas network operators as well as the development of the lack of knowledge and it safeguards the interests of hydrogen distribution in the NL.

WP 4 development of dedicated education tracks develops expected demand scenarios for skilled personnel in the hydrogen economy or energy transition.

WP 7A techno economic value chain analysis studies the market for end-user, the logistic for storage and transport capacities, the economics and sensitivities of value chains and transforms it into a knowledge database.

WP 7B scope identifies value chain elements, analyses technology development and innovation, creates a technology roadmap and reports a cost analysis.

WP 8 admixing & mandatory blending provides an overview with recommendations if and how a blending quota for green gasses/hydrogen can be implemented.

https://hydelta.nl/wat-is-hydelta
https://t1p.de/8vl1 (energate-messenger news)

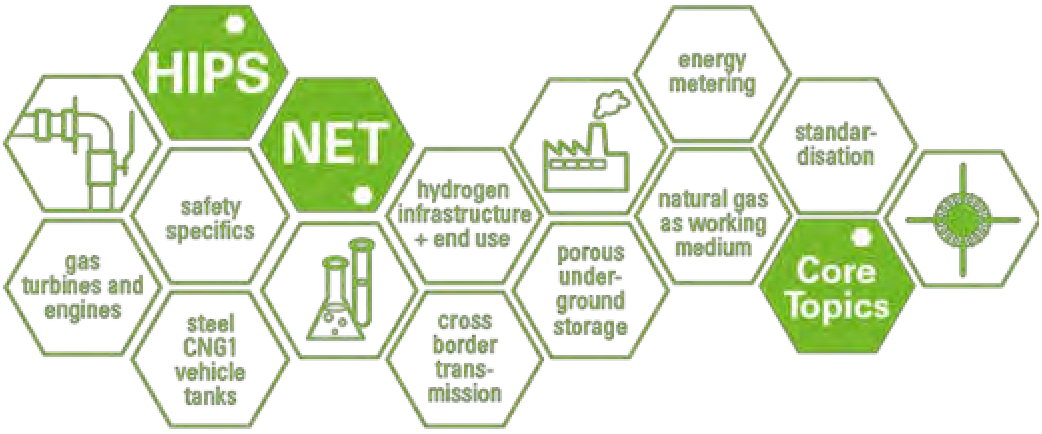
Arrival by hydrogen train at the UN Climate Change Conference of the Parties (COP26) | Scotland

This November, the UN Climate Change Conference of the Parties (COP26) is being held in Glasgow, Scotland. To demonstrate how rail will play its part in making a greener future, and to showcase the best of British low-carbon train technology, the delegates will be taken on a hydrogen-powered train ride. The HydroFlex, Scotland's first hydrogen-powered train, was rebuilt from a former ScotRail EMU by infrastructure manager Network Rail (NR) and Porterbrook. NR is also planning a similar event with Vivarail to bring an operational battery train to COP26.

HydroFlex train to be presented at COP26 in Glasgow (Source: https://t1p.de/fbfn)

https://www.railjournal.com/fleet/hydrogen-train-to-star-at-cop26/

HIPS-NET CORE TOPICS



EVENTS AND PARTNERS

Selection of Appointments

September 2021

28-29 DBI-Fachforum ENERGIESPEICHER | Berlin, Germany, *https://www.dbi-gti.de/termine/dbi-fachforum-energiespeicher.html*

30-02 4th International Workshop on Degradation Issues of Fuel Cells and Electrolysers | Corfu, Greece, *https://bit.ly/3tlnrpg*

October 2021

4-6 World Hydrogen Congress | Amsterdam, Netherlands, *https://t1p.de/jgs6*

8 Hydrogen Online Conference | online, *https://hydrogen-online-conference.com*

12-15 Energy Networks Innovation Conference | online, https://www.eniconference.org/agenda/full-agenda/

20-21 The Hydrogen Technology Conference & Expo | Messe Bremen, Germany, *https://www.hydrogen-worldexpo.com*

27-28 HyVolution | Paris, France, *https://www.hyvolution-event.com/en*

November 2021

16 Hydrogen and Fuel Cell Conference | Birmingham, UK, *https://t1p.de/4vqc*

24-25 GAT | WAT 2021 | online + Cologne, Germany, *https://www.gat-wat.de*

January 2022

13-14 Hydrogen Business For Climate CONNECT | online, *https://h2-bfc-connect.pvf.b2match.io*

February 2022

23 Online-Workshop "Zulassung - Zertifizierung - Normung" | online, *https://www.ise.fraunhofer.de/de/veranstaltungen/wzzn-10.html*

March 2022

7-10 17th Pipeline Technology Conference | Berlin & online, Germany, *https://www.pipeline-conference.com*

8-10 World Hydrogen 2022 Summit & Exhibition | Rotterdam, Netherlands, *https://www.world-hydrogen-summit.com*

Current Partners

Alliander AG, Cadent, DGC,
DNV GL, Elogen, Enagás,
Enbridge, Energinet.dk, ENGIE,
EWE Netz, Gas Connect Austria GmbH,
Gasnetz Hamburg, Gasum OY,
Gasunie, GRTgaz, GRZI e.V. (FIGAWA),
Infraserv GmbH & Co. Höchst KG,
INERIS, innogy SE, ITM Power,
Joint Research Centre (JRC), EC,
KOGAS, NAFTA a.s,
Naturgy, ONTRAS, ÖVGW,
Open Grid Europe GmbH,
Polymer Consult Buchner GmbH,
RAG Austria AG,
Shell, Solar Turbines Europe S.A.,
Storengy, SVGW,
Synergrid, Teréga, TNO,
Uniper Energy Storage GmbH,
Verband der Chemischen Industrie (VCI),
Wintershall Dea AG.

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HIPS-NET

"ESTABLISHING A PAN-EUROPEAN UNDERSTANDING OF ADMISSIBLE HYDROGEN CONCENTRATION IN THE NATURAL GAS GRID"

NEWSLETTER #34 **OCTOBER, 2021**

Dear HIPS-NET Partners,

For the 34th HIPS-NET newsletter we have compiled information on:

- the "regulatory sandbox" energy park Bad Lauchstädt in Germany, which will demonstrate the production, transport, storage and use of green hydrogen under real conditions on an industrial scale
- the odorization of hydrogen in Germany as part of the HYPOS project "H2-Netz"
- the cross-border cooperation between the Netherlands and Germany in the field of hydrogen
- the Hydrogen Transition Summit in Glasgow (UK)

Enjoy reading the articles and if you have ideas for new articles or information about projects in your country, please let us know!

Your HIPS-NET Team

Gert, Charlotte, and Ruven

CONTENT

CONTENT NEWSLETTER #34

Energiepark Bad Lauchstädt "Regulatory Sandbox" | Germany

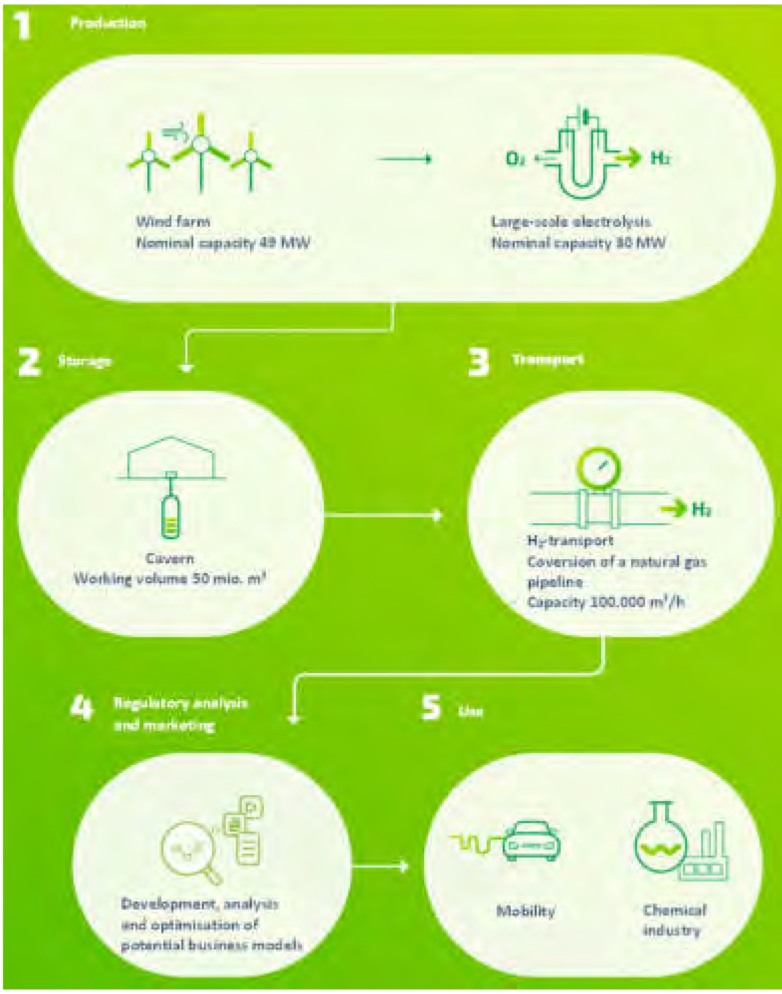
On 9th September 2021, the "Energiepark Bad Lauchstädt" received the legally approved funding commitments about 34 million euros as a regulatory sandbox for the energy transition. It is a joint project of several consortium partners. The project partners want to investigate the production, storage, transport, and economic use of green hydrogen under real conditions on an industrial scale. The common goal of the project is the development of Central Germany as a hydrogen model region.

In 2019, the Federal Ministry for Economic Affairs and Energy (BMWi) declared the project as a regulatory sandbox worthy of funding as part of the two-stage application process. In the meantime, those responsible for the involved company consortium have specified and advanced the plans. With the funding commitment now received, the project will start work immediately. Behind the "Energiepark Bad Lauchstädt" is a consortium of companies consisting of Terrawatt Planungsgesellschaft mbH, Uniper, VNG Gasspeicher GmbH (VGS), and ONTRAS Gastransport GmbH (ONTRAS), the DBI - Gastechnologisches Institut gGmbH Freiberg (DBI) and the VNG AG.

The aim of the joint project is it to cover the entire value chain for green hydrogen. Renewable electricity from a new-build wind farm will be converted into climate-friendly hydrogen within a large-scale electrolysis system with an output capacity of 30 megawatts (MW). This will be supplied to the chemical industry in neighbouring Leuna via a 20-kilometre-long converted natural gas pipeline from ONTRAS. In addition, the crucial preliminary work will be carried out to temporarily store the green hydrogen produced in a specially equipped, almost 180-metre-high salt cavern from 2026 onwards. The project has a total investment volume of around 140 million euros.

The development and construction of the energy park are basically planned in two phases, which will be processed and implemented independently of one another: The first phase starts this autumn. In this phase, hydrogen production and hydrogen transport as well as central components of hydrogen storage will be further developed and tested. The latter include, for example, efficient gas cleaning and safety technology. The second phase will start in 2026 and is not part of the current research project. Its aim will be to complete the cavern intended for hydrogen storage and integrate it into the value chain. Overall, the "Energiepark Bad Lauchstädt" is characterised by a high density of innovations and close interaction between the various stages of the value chain. It also contributes to the decarbonisation of the chemical industry, which is strongly represented in the region. In the future, the energy park can be integrated into the emerging European hydrogen infrastructure together with other hydrogen projects from eastern Germany.

With the National Hydrogen Strategy, the German Federal Government decided to use hydrogen as an energy carrier in the future energy system. Green hydrogen in particular was assigned a key role in this context, because it is produced from renewable electricity using electrolysis and is therefore highly environmentally friendly. As part of the 7th Energy Research Programme, the BMWi had previously launched the "Regulatory Sandboxes for the Energy Transition" ideas competition for the period from 2019 to 2022, offering funding of up to 100 million euros per year. The aim of these real laboratories for the energy transition is to promote the application of innovations in practice.



Value chain of the "Energiepark Bad Lauchstädt" (Source: https://energiepark-bad-lauchstaedt.de)

https://t1p.de/fmirf (press release)
https://energiepark-bad-lauchstaedt.de
info@energiepark-bad-lauchstaedt.de

Successful odorization of hydrogen with common sulphur-free and low-sulphur odorization as part of the HYPOS project „H2-Netz“ | Germany

In the last HIPS-NET newsletter (33), we already reported on the German "H2-Netz" project, which addresses several aspects on qualifying modern plastic pipes for a safe transport of hydrogen.

The odorization of hydrogen was also a research priority. In order to explore the interaction of common sulphur-free and low-sulphur odorization of the smallest amounts of hydrogen, an innovative micro-odorization system was designed and tested as part of the project.

Note on the following designation "low-sulphur odorization"

Spotleak®1009 is a sulphurous odorant. Due to its high olfactory intensity at very low concentration levels (minimum odorant concentration 3 mg/m³), the odorization is commonly referred to as "low-sulphur odorization".

Background and objectives

Currently, odorization of hydrogen in pure hydrogen pipelines is not state of the art. Therefore, an odorization system had to be designed first. The development and conception of a system, which can work with smallest gas amounts from 3 to 12 m³/h (standard conditions) was challenging. Dosing pumps in standard odorization systems are not qualified for these small amounts needed. The micro-odorization system realised has a special dosing pump, which steadily injects smallest odorant flow volumes. The dosing rates are between 0,24 µl/h and 1 l/h. For example:

- With a dosing rate of 5 µl/m³ NTP, a minimum gas flow rate of 0,04 m³/h can be odorized
- With a dosing rate of 25 µl/m³ NTP, a maximum gas flow rate of 43.461 m³/h can be odorized

Primary objectives of the odorization field tests were the examination and evaluation of the function and the efficiency of common sulphur-free (Gasodor®S-Free) and low-sulphur odorization (Spotleak®1009) in hydrogen systems. Additionally, questions regarding the stability of odorants and functional aspects of the designed micro-odorization system were considered in comparison to the natural gas sector.

Experimental setup

The odorization system and its injection nozzles were built to odorize in three pressure levels. Hydrogen from upstream is delivered at a pressure of 25 bar. In this pressure regulation and metering station, the pressure is regulated down to 17 bar. There, the first injection nozzle was placed to odorize the gas before it was transported into the grid. Further injection nozzles were installed in downstream pressure levels (mid-pressure grid) only in case of an incomplete odorant saturation. In this case, odorization at low pressure levels could have been ensured. End users are a fuel cell block-type thermal power station and a hydrogen flare. The flare works as a safety component. For temporary use, it increases the hydrogen flow rate. For continuous odorant detection, a gas chromatograph was installed. Sulphurous odorants as well as sulphur-free odorants have a negative impact on catalysts in fuel cells, which leads to irreversible performance reduction. The damage caused by sulphur-free odorants is not as intense as that caused by sulphureous odorants. For this reason, a deodorization system was installed in both cases to protect downstream fuel cell applications.

General results

The chemical and olfactory stability of common odorants used in the natural gas sector was demonstrated in a hydrogen matrix by periodic concentration measurements and olfactory controls. The saturation of the grid was achieved with sulphur-free (Gasodor®S-Free) and low-sulphur (Spotleak®1009) odorization. Depending on gas consumption and other influencing factors (dosing pump, nozzle location, end users), recovery rates were calculated. Compared to recovery rates known from the natural gas grid, the rates in a hydrogen matrix fulfilled expectations.

Field test results

The odorization with Gasodor®S-Free and Spotleak®1009 was tested under real conditions. Table 1 shows the detailed field test results.

	Gasodor®S-Free	Spotleak®1009
Ingredients	acrylate mixtures	mercaptan odorant, main component TBM
Odorant concentration	After a long operation phase (started in summer 2019), odorant concentrations above 8 mg/m³ NTP (required by DVGW G 280) were measured at end users despite lowest hydrogen amounts and pulsing odorant addition. The odorant concentration was about 1,16 µl/min in median. In this range, the dosing pump showed pulsations (uneven odorant emission). From a concentration of 3 µl/min, the system (with current configuration) operated without any fluctuations (hydrogen flow rate of 9 m³/h NTP). Fluctuations of the odorant concentration were caused by alternating gas consumption and mainly by temperature effects. These effects can be mitigated by thermostatting the pump or by mathematical temperature compensation.	The gas consumption was about 1 to 2 m³/h NTP (fuel cell BHKW), due to a low number of consumers and downtime. Accordingly, the saturation process of the grid took longer. Nevertheless, a saturation was registered and a stabilization of concentration in the gas phase was observed. The odorant concentration measured in the gas phase was fluctuating, which was mainly due to the operating range of the dosing pump. Further influencing factors were fluctuation of temperature and pressure. TBM, the main component of the odorant, was still measured in the gas phase / in the hydrogen matrix even after one month of downtime.
Recovery rates	Depending on operation mode, a grid saturation with high recovery rates was observed. Recovery rates of long operation phases are about 80 %. Recovery rates of clocked gas consumption are about 56 %. In accordance with framework conditions and influencing factors, this is a very good value.	In summary, very high recovery rates were determined on average for the odorant. Measures on chemical stability showed a positive result.
Olfactometry	Accompanying studies on olfactometry showed the presence of the typical odour of the odorant. No changes of smell characteristics in a hydrogen matrix were noticed.	Accompanying studies on olfactometry showed a positive result. The typical and strong gas odour was consistently detected
Result	Verification of Gasodor®S-Free in smallest amounts of hydrogen was successful.	Verification of Spotleak®1009 in smallest amounts of hydrogen was successful.

After successful saturation of the grid and odorant stability with Gasodor®S-Free, the odorization system was decommissioned in December 2019. In spring 2020, the system was converted to the use of the mercaptan mixture Spotleak®1009 and put back into operation. Since then, the low-sulphur odorization has been successfully tested.

Outlook

Further tests with an odorant specially developed for hydrogen (Gasodor®Hydrogen) are planned. The compatibility of the odorant with fuel cell technologies is advantageous.

About HYPOS

The project is part of the HYPOS Hydrogen Power Storage & Solutions East Germany e.V. and is funded by the German Federal Ministry of Education and Research within the "Zwanzig20" initiative. Partners are DBI Gas- und Umwelttechnik GmbH, Mitteldeutsche Netzgesellschaft Gas mbH, Rehau AG + Co, TÜV Süd, Industrie Service GmbH and Leipzig University of Applied Sciences.

Further information

HYPOS H2-Netz and H2-Home can be visited on open-door days. For further information, please use the OR-code.

R. Mothes, U. Lubenau und P. Damp, „Odorierung von Wasserstoff im HYPOS-Projekt „H2-Netz",“ gwf Gas + Energie, Nr. 10, pp. 1-7, 2021.

Raymond Mothes (DBI Gas- und Umwelttechnik GmbH)
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Cross-border cooperation between the Netherlands and Germany in the field of Hydrogen

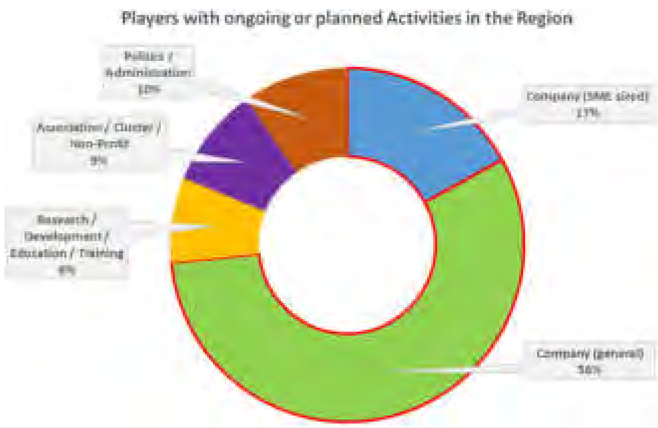
The study "Potential for Cross-Border Cooperation between the Northeast of the Netherlands and the Northwest of Germany in the field of Hydrogen as an Energy Carrier" was published on 15th December 2020 and is part of the H2LinkRegions project. It analyses opportunities of cross-border cooperation regarding hydrogen strategies between the Northwest of Germany and the Northeast of the Netherlands and gives recommendations for its improvement.

The H2LinkRegions project is co-financed within the framework of the INTERREG V A Programme Germany-Netherlands with resources from the European Regional Development Fund (ERDF) and by the Dutch provinces of Drenthe, Fryslân and Groningen as well as the German federal state of Niedersachsen. The study was commissioned by the New Energy Coalition (NEC) located in Groningen and the Oldenburger Energiecluster (OLEC).

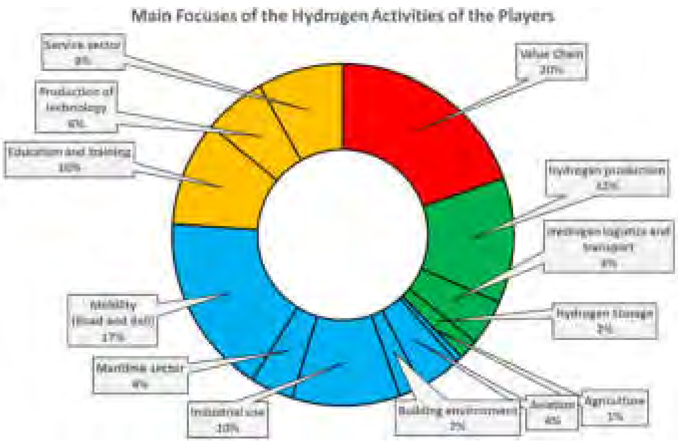
Germany and the Netherlands introduced their hydrogen strategies. These are supported at regional level by corresponding action strategies and programmes. They highlight the opportunities of cross-border cooperation, but this is the first study to analyse its potential.

The focus of this study was the investigation of the Dutch provinces of Groningen and Drenthe and the German federal state Niedersachsen. All these regions have important production sites for renewable energy and have sufficient storage capacities and a corresponding energy infrastructure. The energy sector is an important economic factor in the regions. Therefore, the regions have good prerequisites for the development of a hydrogen economy.

In this study, a survey of current and potential players as well as ongoing and planned hydrogen projects in the region was conducted. 218 companies and organisations were identified that are active in the hydrogen sector or are planning activities in the future. More than half of them are companies, while the share of small and medium-sized enterprises (SME) amounts to 17%. The remaining players represent research / development / education / training, associations / clusters / non-profit and politics / administration, as shown below. Half of the identified players are located in the investigated region.



67 ongoing and planned projects were identified, their focuses are shown in the Figure. Almost half of them focus on the use of hydrogen, while one third concentrates on its supply (production and logistics). Only three projects focus on cross-border cooperation.



In this study, an online survey was developed to gain more information on the potential for and obstacles to cross-border cooperation regarding hydrogen. The findings were confirmed by results from expert interviews. The main identified obstacles are the difference in the regulatory framework in both countries, differences in action strategies as well as financing issues. Other findings from the interviews are that SMEs see challenges in the cooperation with larger companies and struggle with unclear and confusing funding options. In general, most of the survey participants and interviewees see potential in cross-border cooperation. To explore this potential, the study developed the following recommendations:

A. Establishing a **central website** to make existing information on experiences, challenges, solutions, and advice available or easier to access.

B. Organising **regular online events** to promote news sharing and knowledge exchange and as a low-threshold opportunity for e.g. SMEs to get involved.

C. Intensifying connections between players from both countries via regular **in-person meetings** where specific topics, ideas and projects can be discussed and initiatives can be started.

D. Developing **solutions for institutional and regulatory cross-border barriers**, e.g. via round table dialogues, "real-world laboratories" (or "regulatory sandboxes") and/or a handbook that explains the state of the art in this field.

https://t1p.de/wank1

Hydrogen Transition Summit | United Kingdom

The Hydrogen Transition Summit is an in-person and online event on the 11th of November 2021 in Glasgow. It is part of the ClimateAction Innovation Zone (COP26) from 8th to the 11th of November 2021, together with the Sustainable Innovation Forum and the Agri-Food Transition Summit.

The Hydrogen Transition Summit is a full-day of presentations and discussions on hydrogen. Considered topics are industry, transport, policy and finance as well as energy decarbonisation and carbon capture. Sessions will share innovations, ideas and case studies. The focus will be on the question "What are the benefits and compromises to be made in making hydrogen economies a reality?". Presentations will be held from international speakers working on hydrogen projects and programmes as well as those developing energy and financial policies. The Summit is a platform for investors, project developers, policy-makers and innovators to share insights and expertise.

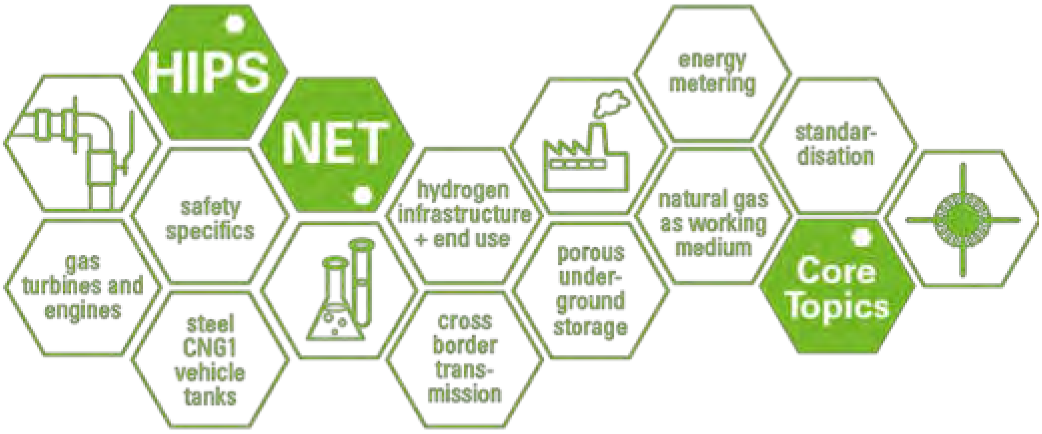
The deadline of in-person application is already expired, but the registration for the online access is still possible. The standard online access to the event is available for free.

Registration to online access:

https://cop26.uk/innovation-zone/registration/digital

https://events.climateaction.org/transition-summits/hydrogen

HIPS-NET CORE TOPICS



EVENTS AND PARTNERS

Selection of Appointments

November 2021

16 Hydrogen and Fuel Cell Conference | Birmingham, UK, *https://t1p.de/4vqc*

24-25 GAT | WAT 2021 | online + Cologne, Germany, *https://www.gat-wat.de*

25 Compressor Day | online, *https://www.neuman-esser.de/compressors/cd-2021-goes-virtual*

December 2021

9 Energy Saxony Summit | Dresden, Germany, *https://www.energy-saxony.net/events/energy-saxony-summit/SUMMIT-2021.html*

January 2022

24-28 Kraftstoffe der Zukunft | online, *https://www.kraftstoffe-der-zukunft.com*

March 2022

7-10 17th Pipeline Technology Conference | Berlin & online, Germany, *https://www.pipeline-conference.com*

8-10 World Hydrogen 2022 Summit & Exhibition | Rotterdam, Netherlands, *https://www.world-hydrogen-summit.com*

April 2022

4-5 H2 Forum Berlin | Berlin & online, Germany, *https://www.h2-forum.eu/#h2forum22*

May 2022

18-20 European Hydrogen Energy Conference (EHEC) | Madrid, Spain, *http://www.ehec.info*

June 2022

21-23 Beyondgas | Oldenburg, Germany, *https://www.beyondgas.de/beyondgas2021*

Current Partners

Alliander AG, Cadent, DGC,
DNV GL, Elogen, Enagás,
Enbridge, Energinet.dk, ENGIE,
EWE Netz, Gas Connect Austria GmbH,
Gasnetz Hamburg, Gasum OY,
Gasunie, GRTgaz, GRZI e.V. (FIGAWA),
Infraserv GmbH & Co. Höchst KG,
INERIS, innogy SE, ITM Power,
Joint Research Centre (JRC), EC,
KOGAS, NAFTA a.s,
Naturgy, ONTRAS, ÖVGW,
Open Grid Europe GmbH,
Polymer Consult Buchner GmbH,
RAG Austria AG,
Shell, Solar Turbines Europe S.A.,
Storengy, SVGW,
Synergrid, Teréga, TNO,
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Certified DIN EN ISO 9001:2015

HIPS-NET

"ESTABLISHING A PAN-EUROPEAN UNDERSTANDING OF ADMISSIBLE HYDROGEN CONCENTRATION IN THE NATURAL GAS GRID"

NEWSLETTER #35 **DECEMBER, 2021**

Dear HIPS-NET Partners,

The 35th HIPS-NET newsletter is the last one in 2021. We wish you a happy Christmas time and relaxing holidays!

This newsletter talks about:

- the European Re-Stream study on the repurposing of oil and gas pipelines for H_2 and CO_2 transport
- the injection of 20 % H_2 in the German gas distribution grid
- the German project Westküste100, which aims to enable green heating with hydrogen and
- the European initiative Ready4H2

Enjoy reading the articles and if you have ideas for new articles or information about projects in your country, please let us know!

Your HIPS-NET Team

Gert, Charlotte and Ruven

CONTENT

CONTENT NEWSLETTER #35

Re-Stream study on the repurposing of oil and gas pipelines for H_2 and CO_2 transport published | Europe

The uniqueness of this study lies in the variety of contributors: 32 Transmission System Operators (TSOs), 18 operators of onshore oil pipelines, and 15 operators of offshore oil and gas infrastructure. In total, over 80,000 km of pipelines were considered for reuse to transport H_2 or CO_2. CARBON LIMITS and DNV provided the technical analyses. The study's purpose is to provide fact-based results on technical aspects and cost-related information in time for the publication of the upcoming European Hydrogen and Decarbonised Gas Market Package and the Carbon capture, usage and storage (CCUS) Strategy.

In a first step, a technical screening of the pipelines was conducted to evaluate their repurposability. The criteria used were the material of construction and pipeline design characteristics (e.g., for CO_2, the resistance against running ductile fracture), the internal pipeline condition, safety matters, age, and transport capacity. For the calculations, design pressures have been adapted according to standards and flow requirements. Other parameters such as the chemical composition, the heat treatments of the material, the welding procedure specification, and the way a pipeline has been operated in the past could not be considered at this stage.

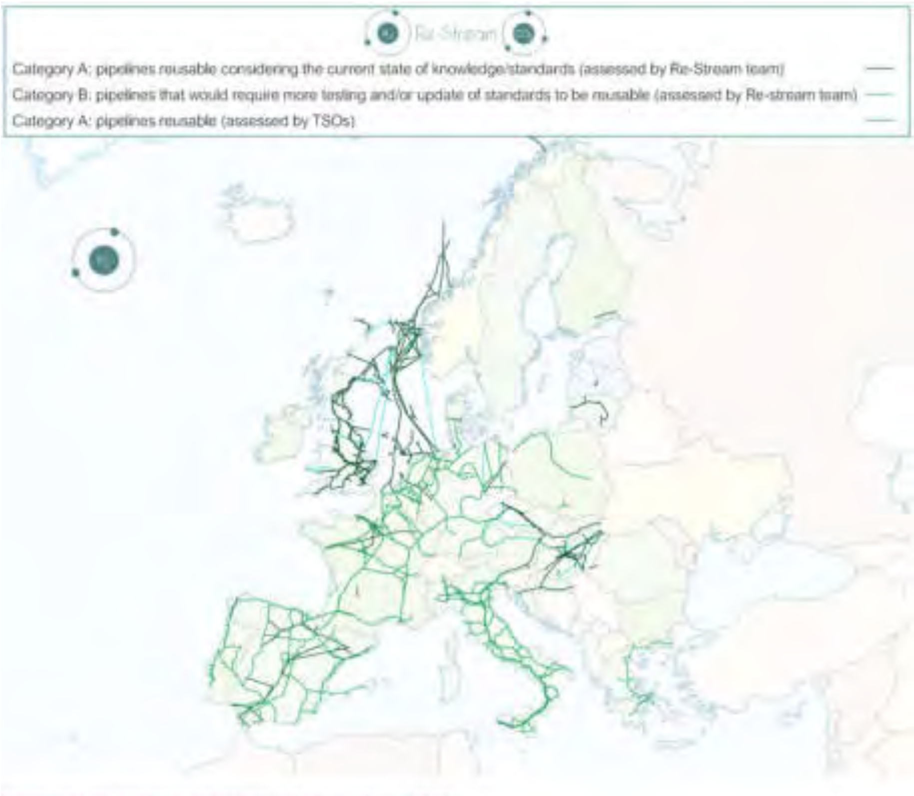
For CO_2 transport, mature guidelines are already available (DNVGL-RP-F104 and ISO 27913:2016). There is, however, still a need for research on the running ductile fracture phenomenon. For H_2, the ASME B31.12 standard was used. Yet, there is a general agreement amongst material experts of the participating operators that the criteria defined in this standard are very conservative for high-grade steel and research on this topic is ongoing. For offshore H_2 pipelines, there is currently no specific standard. DNV is therefore currently running a Joint Industry Project to close this gap. The draft guideline and initial test program are expected by 2022.

A main difference between onshore and offshore pipelines is the maximum allowed pressure, which is usually higher for offshore pipelines. This characteristic is relevant for the transport of CO_2, because at high pressures, the CO_2 can be transported in dense phase, which enables higher mass flows. In most onshore pipelines, the CO_2 can only be transported as gas.

In relation to H_2, based on the current state of knowledge and standards, almost 70 % of the pipeline's total length can be reused. The remaining length of the pipelines is promising for reuse but would require more testing or updates of standards to be reusable. None of the analysed pipelines can be categorically excluded from reuse as of today.

In a second step, pipelines that connect future production sites with future consumption or storage areas were identified. On this basis, six economic assessments were performed. The costs were then compared with those for respective new-built infrastructure. The latter have significantly higher costs due to costs for material, pipe laying, and contingency. The cost reduction of repurposing is therefore estimated to be between 1 and 2 MEUR/km or up to 82 % in relative terms.

https://t1p.de/kgtf (full report)



Re-Stream assessment of reuse of oil and gas pipelines for 100 % H_2 transport

Source: data provided by pipeline operators, Re-Stream team analysis

Injection of 20 % H_2 in the German gas distribution grid | Germany

As already introduced in the HIPS-NET newsletter no. 24, Avacon, an E.ON subsidiary, is planning to raise the hydrogen admixture in its natural gas grid to 20 vol.-%. The joint project of Avacon and the DVGW (Deutscher Verein des Gas - und Wasserfaches e. V.) is intended to demonstrate the technical feasibility of hydrogen injection into an existing gas network at a higher percentage than provided for in the DVGW's technical regulations. The results of the project serve as a model for the future use of hydrogen in gas distribution networks.

A gas distribution network section in Saxony-Anhalt, Germany, was selected for the project. The network infrastructure there is representative of the entire Avacon gas distribution network and the results can be transferred.

In the first phase of the project, in cooperation with the Gas- und Wärme-Institut Essen (GWI) and the gas appliance manufacturers, all gas appliances installed by customers were recorded and checked for operational and safety technology as well as hydrogen compatibility. Almost all gas appliances surveyed were rated positively. Four unsuitable devices are being replaced by hydrogen-compatible devices. The technical planning and construction of the hydrogen admixing system ran parallel to the reviews of the installed technology.

Due to some delay, the feed-in of hydrogen is now planned over the two heating periods 2021/22 and 2022/23 in stages of 10, 15 and 20 % hydrogen admixture. Moreover, fluctuating hydrogen concentrations are now planned in order to simulate the volatile renewable energies as hydrogen sources and to investigate the effects of fluctuating hydrogen contents in operation.

https://t1p.de/oopc (DVGW)
https://t1p.de/t2fzs (Avacon)

Westküste100 - Green heating with hydrogen | Germany

Energy transition in practice: Stadtwerke Heide, Thüga and Open Grid Europe are launching a model project for climate-friendly heating. For this purpose, hydrogen is injected into a separate gas grid with around 200 households in the city of Heide, Schleswig-Holstein, Germany. This task is part of the WESTKÜSTE100 project, which is one of the regulatory sand boxes ("Reallabore") funded by the Federal Ministry of Economic Affairs and Energy in Germany.

The "Green Heating" sub-project demonstrates the transformation of the heating sector towards renewable gases – on a cost-neutral base for customers. In a first step, an H_2-blend of 10 % by volume is conducted, after which the share of hydrogen in the gas mixture is planned to be increased up to 20 %.

Source: Thüga

Research focus

The project aims to analyse the usability of existing gas grid components for hydrogen concentrations. In-depths analysis of developments regarding tightness, corrosion resistance and general material compatibility with regards to hydrogen exposure will be conducted.

In addition, the project generates empirical data and experiences regarding the supply characteristics of hydrogen as a new energy source in the heating market. For the operational use of hydrogen, a calibrated measurement and billing system for customers as well as a security concept in cooperation with the DBI GUT, Leipzig, Germany will be developed.

The hydrogen injection is planned from 2024 onwards - after a thorough check of all households' gas systems by the DBI.

WESTKÜSTE100 - blueprint for the energy transition

Ten partners have joined forces for the WESTKÜSTE100 project. Their goal: to develop and apply a sector coupling approach under real conditions to significantly reduce CO2 emissions in the three sectors of industry, mobility and energy. To achieve this, the partners plan to produce hydrogen with green electricity from regional wind energy and use it across these different sectors in the Heide region.

www.westkueste100.de
https://t1p.de/9wrh (Thüga)

READY4H2 | EUROPE

Distribution network operators from 13 European countries are launching the joint initiative Ready4H2 to bundle hydrogen know-how. The project aims to create a common understanding of how distribution network operators and their gas networks can contribute to simplifying the feed-in and use of hydrogen. The Ready4H2 project is scheduled to run until February 2022 and includes three studies with different focuses.

The first study **bundles the "hydrogen knowledge"** of the distribution network operators. It will be a collection of the experience that the European distribution network operators have with hydrogen projects and hydrogen infrastructure. In addition, it will also examine how the distribution network operators are involved in the hydrogen development in their country and how far the country's hydrogen strategy has been developed.

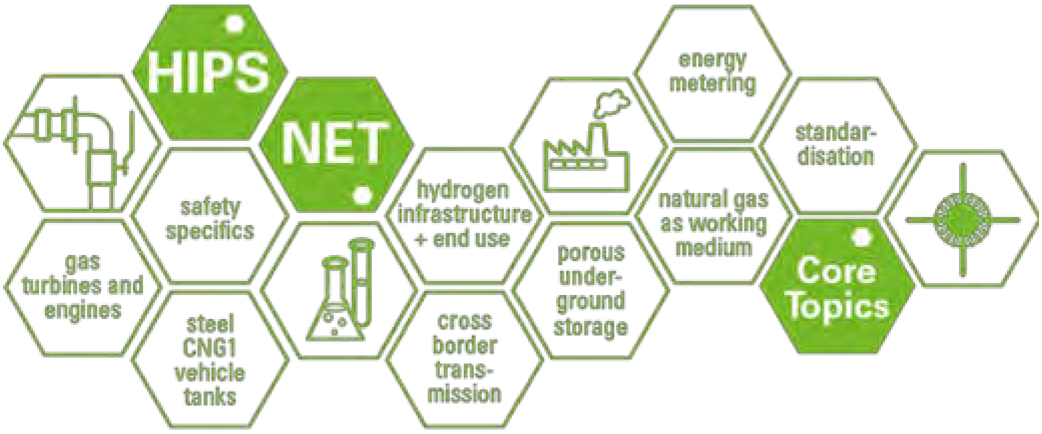
The second study shows **how distribution network operators can contribute** to the hydrogen value chain. It will build on the first study by examining how European distribution system operators can contribute to hydrogen development. The experience and knowledge of the distribution network operators are analysed and converted into value proposals for the hydrogen value chain. The unique position of the distribution network operators and their contribution to strategic spatial planning will also be addressed. Furthermore, it highlights the historical and currently evolving role of distribution network operators in the gas market and how the historical experience and competencies in the hydrogen sectors can be used.

The third study presents a roadmap on **how distribution networks will become a primary "hydrogen distribution infrastructure"** in Europe. The roadmap will consist of concrete initiatives on how the distribution network operators at European and national level can be a link between hydrogen producers and consumers. It will describe possible obstacles and opportunities on the way to transforming the natural gas distribution network operator into the primary distribution infrastructure for hydrogen.

Germany is represented in Ready4H2 by the German distribution network initiative "**H2vorOrt**", in which around 40 distribution network operators in the DVGW (Deutsche Verein des Gas- und Wasserfaches e. V.) cooperate with the VKU (Verband kommunaler Unternehmen e. V.). Their aim is to investigate the question of how a **regional and safe supply of climate-neutral gases** can be implemented nationwide in the future. Hydrogen can make a decisive contribution to achieving the climate goals safely and economically efficiently. The project partners have developed a transformation path for this infrastructure towards climate neutrality based on the following assumptions: A 100 percent supply of hydrogen via the distribution networks is technically possible and reasonable. The energy source is available to everyone via the regional gas infrastructure and can decarbonise both regional industry and household heating. For the climate-neutral gas supply in the regions and the local generation of hydrogen via decentralized power-to-gas systems, the lines must be made H_2-ready. The gas networks must be quickly made fit for hydrogen and other climate-neutral gases.

https://www.ready4h2.com
https://t1p.de/bf5c (DVGW)
https://t1p.de/en7y (H2vorOrt)

HIPS-NET CORE TOPICS



EVENTS AND PARTNERS

Selection of Appointments

December 2021

9 Energy Saxony Summit | Dresden, Germany, *https://www.energy-saxony.net/events/energy-saxony-summit/SUMMIT-2021.html*

January 2022

24-28 Kraftstoffe der Zukunft | online, *https://www.kraftstoffe-der-zukunft.com*

March 2022

3 HOW - Mission Hydrogen | online, *https://www.hydrogen-online-workshop.com*

7-10 17th Pipeline Technology Conference | Berlin & online, Germany, *https://www.pipeline-conference.com*

8 SHK ESSEN | online, *https://www.shkessen.de/branchentreff*

8-10 World Hydrogen 2022 Summit & Exhibition | Rotterdam, Netherlands, *https://www.world-hydrogen-summit.com*

April 2022

4-5 H2 Forum Berlin | Berlin & online, Germany, *https://www.h2-forum.eu/#h2forum22*

May 2022

18-20 European Hydrogen Energy Conference (EHEC) | Madrid, Spain, *http://www.ehec.info*

31-1 FC³ - Fuel Cell Conference Chemnitz | Chemnitz, Germany, *https://hzwo.eu/veranstaltungen/fc3-2021*

June 2022

21-23 Beyondgas | Oldenburg, Germany, *https://www.beyondgas.de/beyondgas2021*

Oktober 2022

11 HOC—Mission Hydrogen | online, *https://hydrogen-online-conference.com*

Current Partners

Alliander AG, Cadent, DGC,
DNV GL, Elogen, Enagás,
Enbridge, Energinet.dk, ENGIE,
EWE Netz, Gas Connect Austria GmbH,
Gasnetz Hamburg, Gasum OY,
Gasunie, GRTgaz, GRZI e.V. (FIGAWA),
Infraserv GmbH & Co. Höchst KG,
INERIS, innogy SE, ITM Power,
Joint Research Centre (JRC), EC,
KOGAS, NAFTA a.s,
Naturgy, ONTRAS, ÖVGW,
Open Grid Europe GmbH,
Polymer Consult Buchner GmbH,
RAG Austria AG,
Shell, Solar Turbines Europe S.A.,
Storengy, SVGW,
Synergrid, Teréga, TNO,
Uniper Energy Storage GmbH,
Verband der Chemischen Industrie (VCI),
Wintershall Dea AG.

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Certified DIN EN ISO 9001:2015

HIPS-NET

“Establishing a pan-European understanding of admissible hydrogen concentration in the natural gas grid”

NEWSLETTER #36 **February, 2022**

Dear HIPS-NET Partners,

we hope you had a wonderful start into 2022! Regarding our common topic hydrogen, we do see that the transformation of the energy-system is becoming reality. We have ambitious goals at national and European level as well as common challenges, e.g. from the gas package as the perspective of gas grids beyond 2050 or the question of who will be legally allowed to operate hydrogen gas grids in the future.

We want to support you in this new chapter of the energy transformation, which focuses on projects/transition activities that bring significant amounts of hydrogen into the gas system and to supply customers. Therefore, we will focus increasingly on projects, measures and findings that can support you on your transformation path or prepare you for the coming energy carrier. If you have any thoughts, ideas, or requests in this context, we would be delighted if you got in contact with us.

We are glad to have you with us and look forward to continuing our work with you! As usual, we will conduct our workshop in June, but we may have to look for a new date since the planned date (15th and 16th June 2022) overlaps with the EGATECH in Hamburg. For this reason, we prepared a doodle poll (see e-mail) to evaluate whether another date (e.g. 1st or 2nd June 2022) would suit all of us better. For the time being, we are preparing for both a workshop in presence and alternatively an online event. Please be prepared for both, too. It would be great to have a reunion in person!

This newsletter talks about:

- News from the European Project HyReady on Subsurface Storage and Injection Facilities
- Reducing Obstacles to Innovation for Large-Scale Electrolysis in the German Project H2Giga
- Efficient and Safe Operation of Hydrogen Distribution Grids in the German Project H_2-Infra
- Pioneering Solar Technology Planned in Utility-Scale Plant to Produce 60 Tonnes of Green Hydrogen per Year

Enjoy reading the articles and if you have inspiration for new articles or information about projects in your country, please let us know!

Your HIPS-NET Team

Gert, Charlotte and Ruven

CONTENT

CONTENT NEWSLETTER #36

News from HyReady: WPs on Subsurface Storage and Injection Facilities Finalised I Worldwide

Surface Facility of an UGS

In the context of energy transition towards an energy system that is based on renewables, underground (or subsurface) gas storages are a key enabler due to their large storage capacities and their ability to balance seasonal and daily variations of renewable energy production and demand. Further, hydrogen can be used not only for energy supply but also as feedstock in various industrial processes. The transformation of these industrial sectors is another crucial aspect of the energy transition.

The joint industry project "HyReady" investigates the impact of hydrogen on the energy infrastructure and develops practical guidelines to support TSOs and DSOs in particular. Aspects addressed in the different work packages are transmission, distribution, end use, subsurface storage, and alternatives such as injection facilities, separation and hydrogen refuelling infrastructure. This was already reported on in several past HIPS-NET newsletters.

In 2021, the work packages on subsurface storage and injection facilities were finalised and are summarized in the following chapters.

Subsurface Storage

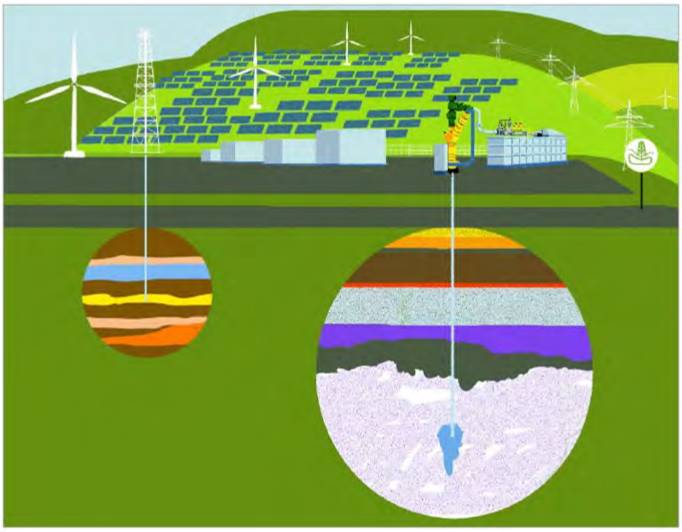
The required future hydrogen storage capacities are discussed in different energy concepts in various countries of the world. It is necessary to assess the theoretically available hydrogen storage capacities and to initiate measures to prepare for the conversion of current natural gas UGS facilities for hydrogen storage.

Based on publicly available sources, databases, and input from the HyReady project stakeholders, the theoretically available hydrogen storage capacity for Europe, USA and Canada was assessed based on the natural gas storage capacity, the type of UGS facility and its characteristic geological and technical parameters. The 725 assessed UGS facilities with a total natural gas storage capacity of 4,537.22 TWh (398,002.08 million Nm3) are able to store 2,637.93 TWh (231,397.12 million Nm3) of hydrogen. The lower hydrogen storage capacity compared to the natural gas (in the same facilities) results from two different aspects:

the lower density and compressibility of hydrogen compared to natural gas, resulting in a reduced storage volume at the same minimum and maximum operating pressures and the same geometrical volume (caverns) or same pore volume (depleted fields and aquifers) compared to natural gas, and

lower heating values of hydrogen compared to natural gas and thus a further reduction of the energetical storage capacity on top of the reduced volume.

Approximately three quarters of the theoretically available storage capacities exist in depleted field UGS.



Scheme of different UGS options
Left: in porous formations, right: in caverns

In terms of storage operation, caverns are much more flexible than aquifer and depleted field UGS: withdrawal rates do not depend on the geology, especially porosity and permeability, but only on tubing size and well completion. In addition, the expected gas conversion processes have a substantially smaller impact compared to porous UGS facilities. The operation of existing UGS facilities with hydrogen generally leads to:

- Higher well head pressures for the same given bottom-hole pressure compared to natural gas due to hydrogen's lower density. This is important to consider when designing the compressors and the injection facilities.
- The negative Joule-Thompson coefficient of hydrogen leads to an increasing gas temperature during withdrawal.
- The flow velocities of hydrogen in the well / tubing are slightly higher compared to natural gas due to hydrogen's lower density .

In porous UGS facilities, possible gas conversion processes due to microbial activity must be considered, which can cause a change in gas quality and can lead to increased requirements for gas treatment. The following processes are difficult to quantify and are subject to case-by-case investigations: methanogenesis (methane-producing archaea), acetogenesis, sulphate reduction, Iron (III) reduction, biofilm formation and pore plugging.

All of these processes can occur because hydrogen is easily consumed by many microbial species.

Methanogenesis leads to formation of methane, which changes the gas quality, whereas sulphate reduction results in the generation of toxic H2S, which requires special safety installations at the UGS. Gases containing H2S shares of > 1 Vol.-% are classified as sour gas. The generation of biofilms can lead to the plugging of pores, which alters the flow behaviour in the reservoir and eventually reduces the maximum possible withdrawal rates over time.

Microbial conversion processes can theoretically also occur in cavern UGS facilities. This could be the case if microbial cultures are introduced into the cavern during the leaching and/or flooding processes and reactions then take place with the sump, especially with hydrocarbons remaining in it . Currently, however, there are no caverns known that have difficulties with microbial activity, since the highly saline habitat of a cavern is generally a hostile environment for most species.

Injection Facilities

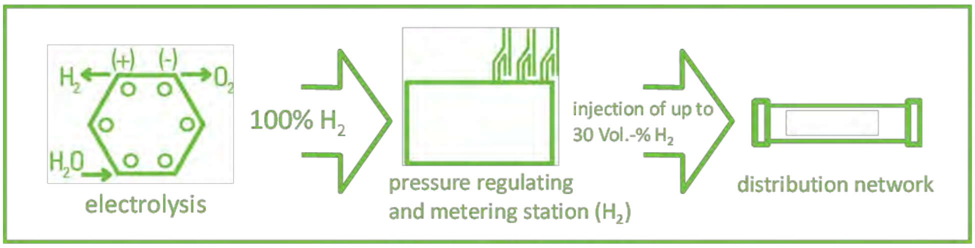
A further aim of the WP was to develop an exemplary basic design of a hydrogen injection station that represents the minimum requirements for construction and safety but can still be realised cost-efficiently. Based on the experience with earlier planned hydrogen injection stations as well as further research and in accordance with currently valid standards and guidelines, a design was developed and tested for hydrogen suitability. The requirements for the components and the material selection were established and considered during this process.

To cover the entire value chain, the necessary parameters were considered for both the transmission network and the distribution network.

As a result of this work, the following documents were prepared for each of the two facility types:

- Brief description of the functionality of the hydrogen injection station
- P&I and corresponding orienting and high-level object lists
- Recommendation and brief description of gas-quality measurement devices
- Approximate estimation of the building size of the station

The Hyready project will continue with the preparation of new guidelines. From 2022, we will start the new work packages on hydrogen separation and focus on 100 % distribution networks. The consortium continues to welcome new partners who will gain access to all guidelines previously developed and enable future work.



CHARACTERISTIC DESIGN OF APPLICATION (PRESSURE REGULATION) FOR THE DISTRIBUTION GRID (DPD OF THE HYDROGEN INJECTION FACILITIES <= 16 BAR)

	Transmission network	Distribution network
Vn (Flow rate 100% H_2)	200,000 m^3/h*	450 m^3/h**
DPu (design pressure upstream)	DP 40 bar	DP 40 bar
MOPu (maximum operating pressure upstream)	MOP 30 bar	MOP 30 bar
DPd (design pressure downstream)	DP 70 bar	DP 16 bar
MOPd (maximum operating pressure downstream)	MOP 55 bar	MOP 4 bar

**(approx. 5 MW ELY), * (approx. 1 GW ELY)

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https://t1p.de/srst (DNV website)

S. Bauer, „Underground Sun.Storage - Publizierbarer Endbericht - 3.1," RAG, Vienna, 2017

H2Giga - Reducing Obstacles to Innovation for Large-scale Electrolysis I Germany

The DBI Group is participating in one of Germany`s largest projects concerning hydrogen, the H2Giga project. H2Giga is one of the current lighthouse projects on hydrogen, designated and funded by the German Government. The project consists of numerous individual projects and research associations with the overarching aim to upscale the production of electrolysis units to an industrial production level. Current electrolysers are often tailor-made products involving several manual elements. H2Giga aims to establish an automised production process for gigawatt-scale electrolysers. This will be achieved for the three most widely used types of electrolysers (PEM electrolysis, alkaline water electrolysis and high-temperature electrolysis).

To achieve this overall objective, the DBI Group participates in the “Technology Platform Electrolysis (TPE)” under the umbrella of H2Giga. The TPE innovation pool is intended to reduce three obstacles to innovation that have previously been identified. First, **standardisation and testing** have been identified as a bottleneck to electrolyser innovation; second, the **legal framework** contains conditions that hinder the planning and operation of electrolysers; and third, there is a **lack of knowledge** about electrolysis in vocational and further advanced training. The innovation pool is designed as a cycle. Holistic integration of operators and manufacturers is another aim. Economic partners can communicate research needs and knowledge gaps, which the innovation pool can then integrate into its activities.

Leitprojekt H_2Giga

https://www.dbi-gruppe.de/h2giga.html

H2-Infrastructure - Efficient and Safe Operation of Hydrogen Distribution Grids [H_2-Infra] I Germany

The H_2-Infra project as part of the "Innovations- und Forschungsplattform [H2-InFo]“ (English: "Innovation and research platform for urban energy supply with hydrogen”) focuses on ensuring the functionality of a hydrogen distribution grid including all components tested under dynamic operating conditions. The consortium is systematically continuing the research work of the HYPOS initiative and projects funded by the “zwanzig20”– partnership for innovation” programme of the German Federal Ministry of Education and Research (BMBF).

The unique infrastructure of a hydrogen distribution grid in Bitterfeld-Wolfen, which was developed in the aforementioned projects, will be used and improved. The project partners DBI Gas- und Umwelttechnik GmbH (DBI), Mitteldeutsche Netzgesellschaft Gas mbH (MITNETZ Gas) and the Leipzig University of Applied Science (HTWK) are continuing their research work together with new research aims.

The main goal of the project is to guarantee the functionality of the hydrogen distribution grid, including all components under dynamic load conditions, while ensuring an extremely high gas quality for future hydrogen applications. An economical, ecological and safe hydrogen distribution grid based on highly efficient plastic pipes with preferably long service lives is to be qualified. The pipeline materials and system components will be tested under realistic conditions with the aim of demonstrating the long-term performance of the materials, components, and safety technologies. It has become evident that the materials used discharge substances that contaminate the gas. The contamination is above the permissible limits, e. g. for fuel cell applications. These contamination substances and their sources (e. g. pipeline materials, production processes) are to be identified within the framework of the project. Furthermore, the production processes of pipeline materials for the distribution of hydrogen with high purity are to be carefully reviewed and qualified. The safety of the distribution grid infrastructure will be verified through an extensive monitoring programme. Additionally, the evaluation of the greenhouse gas emissions will demonstrate and highlight the ecological and economic advantages of a pipeline-based hydrogen supply for consumer technologies.

Furthermore, a research platform will be established that offers the opportunity to connect research projects on urban energy supply with hydrogen. The “Innovation and research platform for urban energy supply with hydrogen” is the seamless connection to the previous projects “H_2-Netz” and “H_2-Home”. This platform is intended to link separate research projects on the topic of hydrogen infrastructure and usage in the future. Its purpose is to identify research and development needs and to close the research gap. The clarification of these questions is necessary to realise a demand-oriented, cost-effective, environmentally friendly, and safe hydrogen supply, especially for the public and businesses aside from the large-scale consumers, e. g. in the chemical industry, and thus the implementation of Germany’s national hydrogen strategy. The research work aims to achieve a high Technology Readiness Level (TRL) of the tested hydrogen infrastructure and the related systems.

Further research topics are:

- Definition of quality requirements for pipeline materials
- Security of supply for future hydrogen application technologies
- Advancement of servicing and maintenance strategies for hydrogen assets
- Evaluation of occupational safety and security concepts
- LCA (life cycle assessment) of the hydrogen value chain
- Economic analysis of the hydrogen grid and transfer to future infrastructures

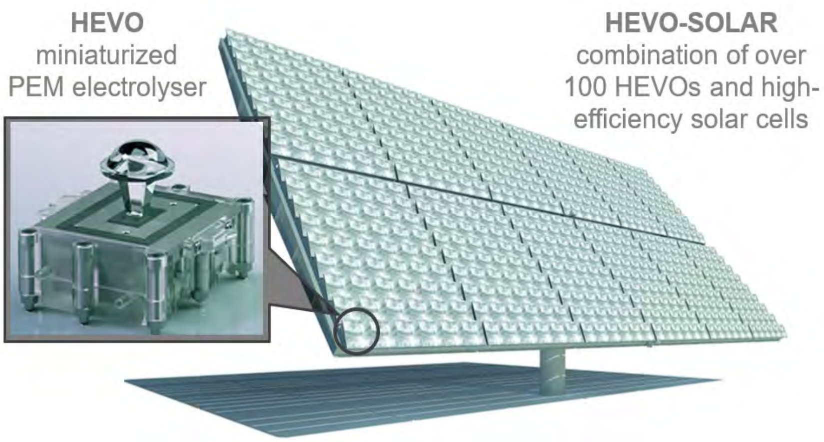
Duration: Jan 2022 - Dec 2024

Supported by:
Federal Ministry for Economic Affairs and Climate Action
on the basis of a decision by the German Bundestag

Robin Pischko (DBI GUT):
robin.pischko@dbi-gruppe.de

SOURCE: HOCHSCHULE FÜR TECHNIK, WIRTSCHAFT UND KULTUR LEIPZIG

Pioneering Solar Technology Planned in Utility-Scale Plant to Produce 60 Tonnes of Green Hydrogen per Year | Portugal



HEVO AN HEVO-SOLAR
(SOURCE: HTTPS://WWW.FUSION-FUEL.EU/TECH/)

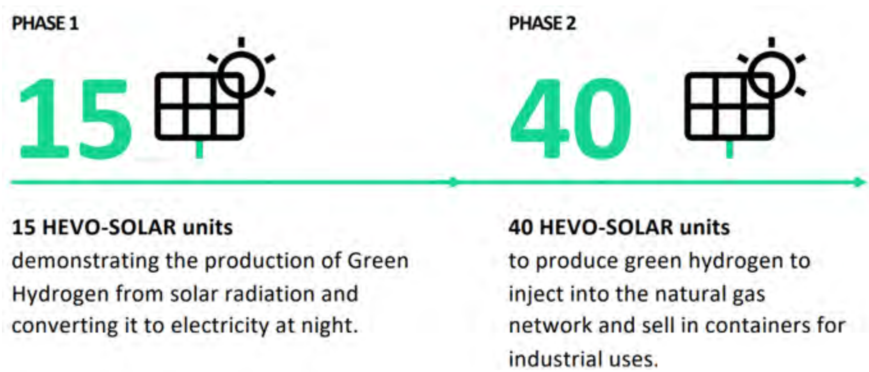
The Fusion Fuel company designed a solution to use 100 % of the sun's energy to produce green hydrogen in a highly efficient and cost-effective way with its HEVO-SOLAR (see fig. 1). A solar panel concentrates solar radiation about 1,400 times onto a high-efficiency solar cell to reach a high solar-to-electric conversion rate (40 %). The remaining energy (60 %) is used to preheat water, which is fed into a miniaturised PEM electrolyser (HEVO – Hydrogen Evolution, see fig. 1). Each HEVO-SOLAR unit (surface area approx. 100 m^2) can produce 1 tonne of hydrogen per year (with average solar irradiance in southern Portugal). It generates its own electricity from the solar cell system, so that it is completely off-grid.

In Évora, Portugal, HEVO-Solar units will be installed in two phases. As an end result, 55 HEVO-SOLAR units will produce approx. 60 tonnes of green hydrogen per year.

Phase 1 – H2Évora (0,3 MW electrolysis equivalent capacity)

H2Évora is the utility-scale demonstration project that will validate the integrated solar-to-hydrogen technology. Installation of H2Évora has already been completed. Final permits from the Portuguese regulator are still pending (expected by the end of the first quarter of 2022). In the meantime, however, hydrogen generators are running continuously for assessment purposes. The generators are performing roughly 10 % above expectation (evaluation by independent engineering firm "Grupo ISQ"). Any hydrogen produced must be released into the air until the official permit is issued. Part of H2Évora is a pilot project to convert green hydrogen into electricity using a Ballard Power Systems FCwave fuel cell. Electricity produced in this way will be fed into the local electric grid.

Phase 2 – Green Gas (0,9 MW electrolysis equivalent capacity)



PROJECT PHASES (SOURCE: HTTPS://T1P.DE/5HNJF)

GreenGas will pilot grid injection of green hydrogen. The installation of this facility is still underway. The GreenGas plant will be connected to the Autonomous Regasification Unit (UAG) of the city of Évora, which is owned by Galp Gás Natural Distribuição (GGND). Green hydrogen will then be blended into the gas infrastructure, starting at 5 % up to a maximum hydrogen content of 20 %. It will be transported in a pipeline (1.4 km) at a pressure of 4 bar.

Both phases have been financed by Fusion Fuel. H2Évora was supported by the Portuguese government (grant). At the moment, Fusion Fuel is unable to disclose the total capital investment in the projects.

By using HEVO-SOLAR technology, more than 600 tonnes of CO_2 emissions will be saved annually compared to grey hydrogen production. According to the company, the hydrogen produced could become cost-competitive with grey hydrogen by 2023.

SOURCE: HTTPS://T1P.DE/YF1N

contact@fusion-fuel.eu

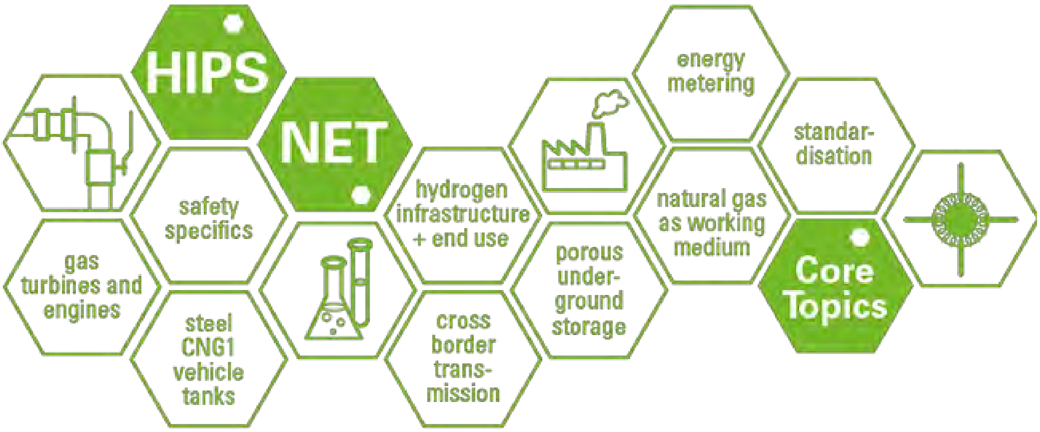
Ben Schwarz:
bschwarz@fusion-fuel.eu

https://www.fusion-fuel.eu/projects
(project at companies' website)

https://t1p.de/5hnjf
(companies' presentation)

https://t1p.de/yf1n
(article, only in German)

HIPS-NET CORE TOPICS



EVENTS AND PARTNERS

Selection of Appointments

February 2022

23 Innovation Bridge North America Presents Hydrogen Startups Canada | online, *https://t1p.de/7pg6*

March 2022

3 HOW - Mission Hydrogen | online, *https://www.hydrogen-online-workshop.com*

7-10 17th Pipeline Technology Conference | Berlin & online, Germany, *https://www.pipeline-conference.com*

April 2022

4-5 H2 Forum Berlin | Berlin & online, Germany, *https://www.h2-forum.eu/#h2forum22*

May 2022

9-11 World Hydrogen 2022 Summit & Exhibition | Rotterdam, Netherlands, *https://www.world-hydrogen-summit.com*

18-20 European Hydrogen Energy Conference (EHEC) | Madrid, Spain, *http://www.ehec.info*

31-1 FC³ - Fuel Cell Conference Chemnitz | Chemnitz, Germany, *https://hzwo.eu/veranstaltungen/fc3-2021*

June 2022

21-23 E-world energy & water 2022 | Essen, Germany, *https://news.e-world-essen.com/*

September 2022

13-15 Beyondgas | Oldenburg, Germany, *https://www.beyondgas.de/beyondgas2021*

6-9 SHK ESSEN | online, *https://www.shkessen.de/branchentreff*

Oktober 2022

11 HOC—Mission Hydrogen | online, *https://hydrogen-online-conference.com*

19-20 Hydrogen Technology European Expo | Bremen, Germany, *https://www.hydrogen-worldexpo.com*

Current Partners

Alliander AG, Cadent, DGC, DNV GL, Elogen, Enagás, Enbridge, Energinet.dk, ENGIE, EWE Netz, Gas Connect Austria GmbH, Gasnetz Hamburg, Gasum OY, Gasunie, GRTgaz, GRZI e.V. (FIGAWA), Infraserv GmbH & Co. Höchst KG, INERIS, innogy SE, ITM Power, Joint Research Centre (JRC), EC, KOGAS, NAFTA a.s, Naturgy, ONTRAS, ÖVGW, Open Grid Europe GmbH, Polymer Consult Buchner GmbH, RAG Austria AG, Shell, Solar Turbines Europe S.A., Storengy, SVGW, Synergrid, Teréga, TNO, Uniper Energy Storage GmbH, Verband der Chemischen Industrie (VCI), Wintershall Dea AG.

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Certified DIN EN ISO 9001:2015

HIPS-NET

"ESTABLISHING A PAN-EUROPEAN UNDERSTANDING OF ADMISSIBLE HYDROGEN CONCENTRATION IN THE NATURAL GAS GRID"

NEWSLETTER #37 **APRIL, 2022**

Dear HIPS-Net members,

we are delighted to bring to you today the latest HIPS-NET Newsletter and hope it makes for an interesting read. Our last newsletter was sent out only two months ago, but since then the world has changed significantly. The war in Ukraine, brings (as war always does) unbelievable suffering to people, which cannot be undone. We sincerely hope that this suffering will end as soon as possible. As probably all of you as well, as a lot of organisations are active to support people that needs help now, we do not initiate a further action. Nevertheless, we appreciate any support that is provide to the people that are put in dramatic situation. However, that are many on Earth including the Earth itself. Regarding the ladder we all contribute with our commitment in HIPS NET a little bit.

Outstanding incidents, even wars, can lead to a certain improvement of cognition. The war in the Ukraine unveils the importance of energy and a diversified structure of energy supplies and leads to a fast growing interest in alternative energy carriers, such as hydrogen. Beyond this the share that gas is covering in the energy supply is now more visible and understood than in the years before.

At the European level, we see increased activity with regard to the Hydrogen and decarbonised gas markets package as well as the recently announced REPowerEU programme, details of which will become available in April 2022. What is sure, though, is that these and other initiatives will present opportunities as well as challenges for our common hydrogen topic and we are keen on lending support to your needs. As already announced, we will increasingly focus on projects, measures and findings that can support you on your transformation path or prepare you for the coming energy carrier. If you have thoughts, ideas, or wishes in this context, we would appreciate it if you would get in touch with us.

A wonderful occasion to discuss the recent opportunities and challenges will be our 9th HIPS-NET workshop. Having provided you with a poll in February/March 2022, we are happy to announce today that the workshop will take place on 15th and 16th June 2022. At the moment we are quite optimistic that an face-to-face meeting in Brussels will be possible, but we are also planning an online event as back-up. In any case, please save the date (15th and 16th June 2022) in your calendar. Currently, we are finalising the workshop agenda and are excited about the many very topical presentations on a variety of highly relevant hydrogen developments we will be able to offer. Please watch out for the invitation with further details.

The current newsletter features exciting developments on the following topics:

- Hydrogen storage in salt caverns – H2CAST Etzel, Germany
- Optimal choice of steel for hydrogen pipelines – the PIPELHYNE project, France
- Hydrogen as a solution to the issue of offshore energy storage - the DOSTA Project, the Netherlands
- The hydrogen experience centre for demo and training – KIWA, the Netherlands

Enjoy reading the articles and if you have inspiration for new articles or information about projects in your country, please let us know!

Your HIPS-NET Team

Gert, Josephine, Charlotte and Ruven

HIPS-NET

"ESTABLISHING A PAN-EUROPEAN UNDERSTANDING OF ADMISSIBLE HYDROGEN CONCENTRATION IN THE NATURAL GAS GRID"

CONTENT

CONTENT NEWSLETTER #37

Storage of Hydrogen Salt Caverns — H2CAST Etzel | GERMANY

STORAG ETZEL and EKB Storage, together with their consortium partners, have received funding approval for the H2CAST Etzel R&D hydrogen pilot project under the Lower Saxony Hydrogen Directive. H2CAST stands for H2 Cavern Storage Transition, i.e. the conversion of existing caverns and facilities in Etzel for the future necessary storage of hydrogen as a building block for a future energy system.

On the part of research institutions, this project is supported by the Clausthal University of Technology and the Deutsche Zentrum für Luft- und Raumfahrt e.V.” (DLR) – Institute of Networked Energy Systems.

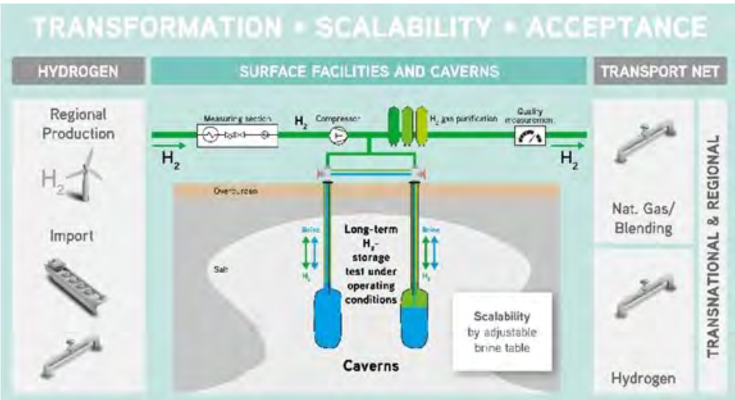
The H2CAST Etzel project

H2CAST Etzel is intended to demonstrate the feasibility of large-volume underground storage of hydrogen and to prove the suitability of the salt caverns in Etzel for hydrogen storage. Operational hydrogen storage operations will be tested and serve to build a hydrogen service industry.

The project in detail

H2CAST Etzel focuses specifically on the adaptation and rededication of existing gas caverns and relevant surface facilities as part of the transition process to an H2 economy in Germany and Europe. In this context, the Etzel pipeline and network hub in particular offers a wide range of cooperation and funding opportunities for the development of an H2 economy in the Friesland / Ostfriesland / Wilhelmshaven region in northwestern Germany.

Expansion opportunities are also offered by the integration of power generation through offshore wind energy, Etzel's cross-border pipeline connection to the Netherlands and the H2 import by ship via an H2 terminal in the nearby the deep-water port of Wilhelmshaven.



Overview of Planned Set-Up for Salt Cavern
source: STORAG Etzel

Quote from the Ministry of the Environment of Lower Saxony

Energy and Environment Minister Olaf Lies: "Hydrogen will be an integral part of the future energy economy. This will not succeed without storage. With H2CAST Etzel, we are promoting a pilot project on an industrial scale. A competent and experienced project consortium from industry and science has come together for this purpose. A special feature is that existing oil and gas caverns in Lower Saxony are to be converted for hydrogen here for the first time. Also, the intended brine shuttle operation has not yet been implemented in this way. The pilot project is the starting point for a possible local value chain. We are creating knowledge that is likely to be in demand elsewhere. With the funding, we are helping to ensure that we will continue to have a secure energy supply in the future, ultimately without oil and natural gas, and maintain local value creation in the energy hub of Lower Saxony."

Aerial Photograph of the H2Cast Project site
Source: STORAG Etzel

Quotes from the responsible persons at STORAG ETZEL and EKB Storage

Boris Richter, commercial director of STORAG ETZEL GmbH, is pleased about the forward-looking support from the state of Lower Saxony: "We want to make the Etzel site in Lower Saxony "H2-ready", i.e. prepare it for the foreseeable ramp-up of the hydrogen economy, which will help to decarbonize German industry, i.e. make it CO2-free and therefore more climate-friendly. This will ensure a secure supply of CO2-free energy in the future. The location is crucial for northwestern Europe in this regard."

Boris Richter emphasises, "The energy turnaround will need these large-scale storage facilities from 2030 at the latest, as H2 supply and demand will diverge in time and space. Setting up the site in a sustainable way for future generations, that is our goal!"

Christian Rohde, Managing Director of EKB Storage, adds that "extremely flexible, large-volume underground storage facilities are essential for the energy transition, as they act as a variable buffer to secure supply chains and provide a link between hydrogen production or import and consumers on the market. The Etzel site is particularly predestined for this due to its existing infrastructural importance."

Project partners of H2CAST Etzel

The project "H2CAST Etzel" includes the following project partners:

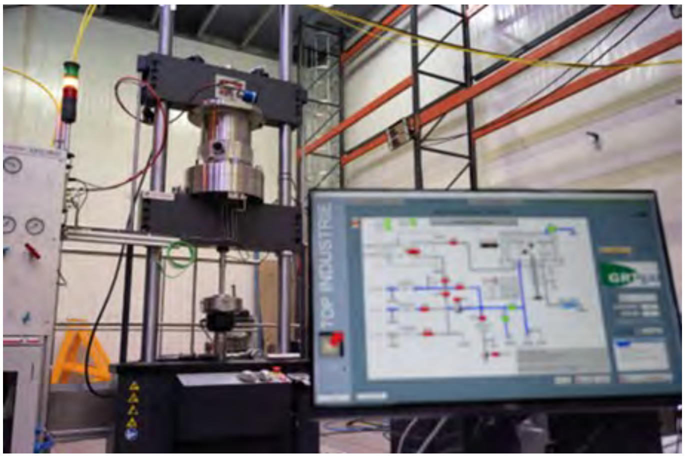
- STORAG ETZEL: project coordinator, underground storage, borehole integrity, retrofitting, mission statement development, public relations
- EKB Storage: surface facility, H2 conditioning, cavern connection, processing, gas quality
- DEEP.KBB: condition assessments, engineering, test execution and evaluations
- DLR: overall system modeling, modes of operation, energetic overall system assessment
- HARTMANN Valves: H2-adapted bore protection, valve technology, material suitability and leak tests, maintenance
- SOCON: measurement technology and tests for tightness of caverns and equipment

Clausthal University of Technology: investigations and verification of storage integrity and tightness of the salt rock, rock mechanics and stability, with multi-cycle operation

Further information on the H2 initiative is available at www.h2cast.com or https://www.storag-etzel.de/en/environment/h2cast-etzel.

Steel Grades in Hydrogen Networks- the PIPELHYNE Project I FRANCE

PIPELHYNE (PIPELines for HYdrogen Networks) is a Joint Industry Project (JIP) contracted in 2021 between ENGIE, FLUXYS, GRTgaz and National Grid. It aims at characterising 8 steel grades that meet new hydrogen (H2) specifications under a 100 % H2 atmosphere at 100 bar. In addition to the project partners, European tube manufacturers are also part of the project to supply test material. The project is divided into 3 main programmes that will be carried out between 2021 and 2028. The tests of the project are conducted on GRTgaz's hydrogen test platform, FenHYx. The platform was inaugurated on 23 November 2021 and is located in Alfortville, France.



Test performed with the FenHYx platform
source: https://t1p.de/g97vm

These tests aim at gaining a better understanding of the mechanical behaviour of the materials that make up gas transport networks under hydrogen in order to take into account particular features in the procedures that ensure the safety of networks. This approach aims to support the development of hydrogen in the years to come, a major vector for the decarbonisation of the energy system.

Types of tests

The first type of tests within this project are fracture toughness (FT) tests. They involve measuring the pipe's ability to resist immediate failure due to internal pressure.

The second type of tests are fatigue crack growth rate (FCGR) tests. They aim to determine the propagation speed of a crack as a function of the applied mechanical load, which corresponds to the pipe's capacity to resist a time-delayed failure due to the accumulation of pressure cycles. These tests are carried out at different loading ratios R (ratio between minimum and maximum force) to simulate the pressure variations to which a pipe may be subjected in service. All tests are carried out at a cyclic loading frequency of f=1Hz.

Within both test types, reference curves are measured with 100 % Methane (CH4).

Programme 1: Effect of O2 as inhibitor of H2 embrittlement

The first programme aims to demonstrate the beneficial effect of oxygen (O2) as an inhibitor of the effect of hydrogen on steel. The L360NE HFI steel will be tested under conditions of 100 bar with H2 and some O2 to study the inhibiting effect of oxygen on embrittlement of the pipe. The programme is running from July 2021 until December 2022. The FCGR is measured at a load ratio of R=0.5. FT tests are performed. 3 different O2 concentrations are tested.

Programme 2: New "H2 compatible" pipeline steels

In the second programme, eight different base metals will be tested to characterise their mechanical behaviour under H_2. This programme is planned to run from January 2022 until March 2026. The FCGR is measured at R=0.3, 0.5 and 0.7. FT tests are performed. All tests are carried out in triplicate.

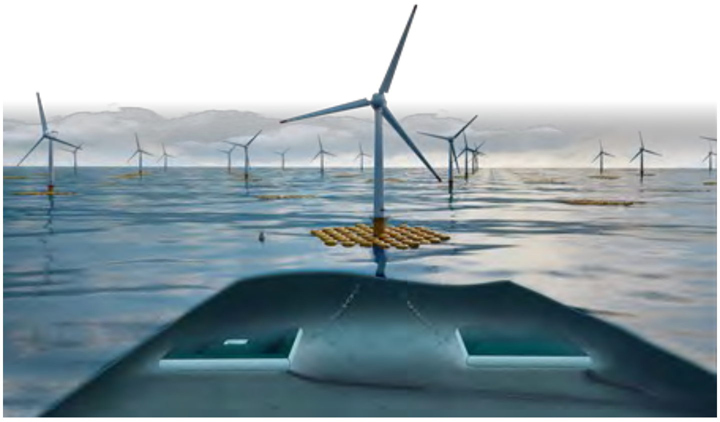
Programme 3: Effect of O2 and another inhibitor of H2 embrittlement

The third programme aims to validate the effect of oxygen on the steel grades other than those tested in the first programme. Moreover, it considers a second inhibitor, which has not yet been defined at this stage. This programme is planned from January 2023 until December 2028. The O_2 inhibition will be tested on 7 remaining "new" steels. Another inhibitor will be tested on the base metal L360NE HFI in collaboration with a chemical company. As in the second programme, the FCGR is measured at R=0.3, 0.5 and 0.7 and FT tests will be performed. Apart from this, three different inhibitor concentrations will be tested.

Sources

- Presentation of the PIPELHYNE project at the GERG 60th Anniversary Conference: https://t1p.de/qa1m1
- Article about the PIPELHYNE project at the GERG 60th Anniversary Conference: https://t1p.de/2vbom
- Article about the inauguration of GRTgaz's hydrogen test platform FenHYx: https://t1p.de/6d7r1

Hydrogen as Solution to Offshore Energy Storage - The DOSTA Project I NETHERLANDS



Impression of novel offshore energy storage technology; source: DOSTA project

The ambition of the Dutch government to greatly increase its offshore wind capacity by 2050 in pursuit of energy transition poses key challenges for energy transport and for coping with intermittency of electricity generation. Hydrogen and in particular offshore PtG options might be a facilitator for this. Therefore, a new research project, the DOSTA project, has recently been started in the Netherlands to examine offshore energy storage options (pumped storage of electricity and conversion to hydrogen) and alternative methods for transporting electricity and/or hydrogen onshore and their feasibility for implementation in the Dutch North Sea.

Project objectives and researchers

Four novel technologies for offshore energy storage and transport options are studied from a technical, system integration, regulatory and spatial perspective. Specifically, the DOSTA project includes the following four objectives:

1. Model and optimise energy harvesting, power production, onsite storage utilisation and balancing of collection cables in a hybrid offshore wind farm.
2. Identify the optimal design and operation of an offshore system for hydrogen production and transport using offshore wind.
3. Identify key legal obstacles and propose legal solutions to facilitate and govern the development of new offshore storage and transport infrastructure for hydrogen.
4. Identify the institutional innovations for marine spatial planning and associated (environmental) procedures for allocating offshore storage.

The researchers are joining forces to target interdisciplinary and explicit policy recommendations for industry practitioners and civil servants on the feasibility of the offshore storage and transport options analysed.

Larger consortium of academic, industrial and societal partners

The consortium consists of academic, industrial and societal partners and has received funding from the Dutch science organisation NWO under grant agreement No WIND.2019.002. Academic partners include the Dutch University of Groningen and the University of Utrecht. Amongst societal and industry partners feature EBN B.V., Loyens &

Loeff, Nederlandse Aardolie Maatschappij B.V., Nederlandse Vereniging voor Energierecht (NeVER), NOGEPA, New Energy Coalition (NEC), Noordgastransport B.V., NOGAT B.V., Ocean Grazer B.V., Siemens Gas and Power GmbH & Co. KG, SmartPort Rotterdam, TNO (Netherlands Organization for Applied Scientific Research), TenneT TSO B.V., Vattenfall.

Claudia Reinicke
c.reinicke@rug.nl
http://dosta-research.nl

Kiwa Hydrogen Experience Centre I NETHERLANDS

In 2021, Kiwa and Dutch network operator Alliander founded the Hydrogen Experience Centre, a demonstration and training location set up as a residential home. In the Hydrogen Experience Centre, Kiwa and Alliander demonstrate that hydrogen can be used as a fuel in the built environment. At the same time, the centre is intended to train technicians and installers and familiarise them with the transition from natural gas to hydrogen.

The Hydrogen House; source: KIWA

Kiwa and Alliander's Hydrogen Experience Center is located in Apeldoorn, the Netherlands. The centre 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. The use of hydrogen in the built environment is put into practice in the demo house. It functions as a knowledge centre where the latest insights into the energy transition and hydrogen applications are shared.

Promising energy source

Kiwa and Alliander are both convinced that hydrogen can drive the energy transition. Like natural gas, hydrogen can be used for heat purposes and stored in large quantities to compensate for seasonal fluctuations. It makes the electricity system more flexible, is a solution for heavy mobility and can serve as a raw material for industry. Only limited adjustments to procedures and measuring instruments are required for the safe management of the networks that transport hydrogen to end users.

Hydrogen in practice

The Dutch government has decided that all houses in the Netherlands must be natural gas-free by 2050. Hydrogen is one of the options to replace 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 home, Kiwa and Alliander enable homeowners, suppliers and policymakers to experience this for themselves.

Inside the demos site; source: KIWA

Training location

The Hydrogen Experience Centre is not only a demonstration site, but is primarily intended as a training location. Because most fitters and installers still have little experience in converting gas networks for hydrogen use, Alliander and Kiwa have joined forces to train professionals. Kiwa is the leading trainer in the field of hydrogen in the energy transition in the Netherlands and Kiwa's Apeldoorn site is equipped to work with hydrogen.

In-house knowledge

The need for professionals who 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 its climate goals. Kiwa has extensive in-house knowledge of all aspects of the hydrogen system: from production to transport, 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.

CO_2 reduction

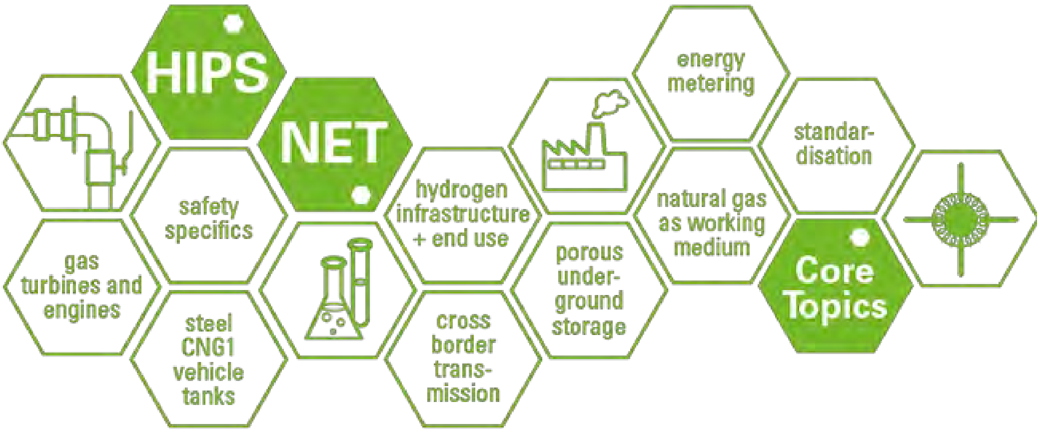
The use of hydrogen contributes to CO_2 reduction. A recent study by Kiwa shows that connecting part of the industry in the port of Amsterdam to hydrogen can lead to an annual CO_2 reduction of 396,000 tons on average. That is almost the amount of CO_2 emissions a city with 40 thousand inhabitants produces each year. If hydrogen can be produced on a larger scale in the coming years, there will be economies of scale and its use will become increasingly cheaper.

Virtual tour

Would you like to know what Kiwa and Alliander's Hydrogen Experience Centre looks like? Head over to the Kiwa website and take the virtual tour.

More information can be found at:

https://www.kiwa.com/nl/en/themes/renewable-energy-transition/hydrogen-house/



EVENTS AND PARTNERS

Selection of Appointments

April 2022

4-5 H2 Forum Berlin | Berlin & online, Germany, *https://www.h2-forum.eu/#h2forum22*

May 2022

9-11 World Hydrogen 2022 Summit & Exhibition | Rotterdam, Netherlands, *https://www.world-hydrogen-summit.com*

18-20 European Hydrogen Energy Conference (EHEC) | Madrid, Spain, *http://www.ehec.info*

31-1 FC³ - Fuel Cell Conference Chemnitz | Chemnitz, Germany, *https://hzwo.eu/veranstaltungen/fc3-2021*

June 2022

8-9 Handelsblatt Wasserstoff Gipfel 2022 | Essen + hybrid, Germany, *https://veranstaltungen.handelsblatt.com/wasserstoff/#*

15-16 9th HIPS-NET Workshop | Brussels, Belgium or online

21-23 E-world energy & water 2022 | Essen, Germany, *https://news.e-world-essen.com*

22-24 Greentech Festival | Berlin, Germany, *https://greentechfestival.com*

September 2022

13-15 Beyondgas | Oldenburg, Germany, *https://www.beyondgas.de/beyondgas2021*

6-9 SHK ESSEN | online, *https://www.shkessen.de/branchentreff*

Oktober 2022

11 HOC—Mission Hydrogen | online, *https://hydrogen-online-conference.com*

19-20 Hydrogen Technology European Expo | Bremen, Germany, *https://www.hydrogen-worldexpo.com*

Current Partners

Alliander AG, Cadent, DGC,
DNV GL, Elogen, Enagás,
Enbridge, Energinet.dk, ENGIE,
EWE Netz, Gas Connect Austria GmbH,
Gasnetz Hamburg, Gasum OY,
Gasunie, GRTgaz, GRZI e.V. (FIGAWA),
Infraserv GmbH & Co. Höchst KG,
INERIS, innogy SE, ITM Power,
Joint Research Centre (JRC), EC,
KOGAS, NAFTA a.s,
Naturgy, ONTRAS, ÖVGW,
Open Grid Europe GmbH,
Polymer Consult Buchner GmbH,
RAG Austria AG,
Shell, Solar Turbines Europe S.A.,
Storengy, SVGW,
Synergrid, Teréga, TNO,
Uniper Energy Storage GmbH,
Verband der Chemischen Industrie (VCI),
Wintershall Dea AG.

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Certified DIN EN ISO 9001:2015

HIPS-NET

“Establishing a pan-European understanding of admissible hydrogen concentration in the natural gas grid”

NEWSLETTER #38 **July, 2022**

Dear HIPS-NET members,

We have enjoyed this year´s workshop with you! Once again, we thank all participants for their interest in the presented projects and activities, the lively discussions, as well as for the fruitful exchange. A special thanks goes to Alexandra and Robert, who co-organised the workshop from GERG side, supported the moderation and helped making the event a success. All the presentations are available on the HIPS-NET website. For those who were not able to participate and have questions do not hesitate to get in contact with us. Please also save the date for the next workshop: 14th+15th of June 2023.

The current newsletter takes a look back at the workshop and summarises the main contents. In addition, two exciting projects are presented:

- Project H2SAREA I Spain
- Simulation of the hydrogen network 2050 | Germany

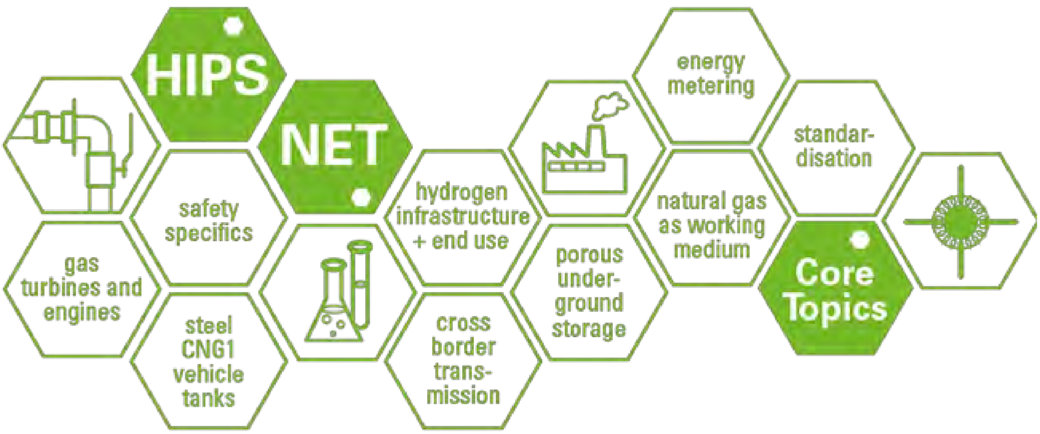
We hope that you enjoy reading the Newsletter.

Your HIPS-NET Team: Gert, Josephine, Charlotte and Ruven

CONTENT

CONTENT NEWSLETTER #38

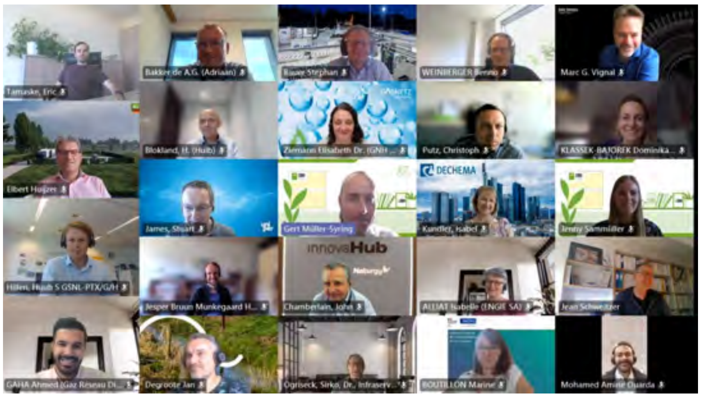
HIPS-NET CORE TOPICS



9TH HIPS-NET WORKSHOP SUMMARY

The 9th annual HIPS-NET workshop took place on the 15th and 16th of June. We were delighted and grateful for the participation and the engagement of the attendees. We would like to thank everyone for embracing the open exchange and extend this special gratitude to the presenters who shared valuable insights into their projects as well as an outlook for the hydrogen industry.

The first day started with welcoming the participants and introducing them to each other through the mural application.



The welcome was then followed by the first presentation titled “Changing course or changing pace?” presented by Mr. James Watson from Eurogas. The presentation focused on the RePowerEU and the gas package. Mr. Watson introduced the plan of REPowerEU as the additional efforts to transition from renewable to natural gases to Fit-for-55 by reducing gas consumption by an additional 194 bcm for a total of 250 bcm reduction by 2030. These adaptations would require €300 Bn cumulative investment from now until 2030 – beyond the FF55 proposals but would eventually help save on the costs of oil, gas and coal imports. The volumes projected required by 2030 are 35 bcm for biomethane and 20 Mt of hydrogen with 10 Mt from EU production, 6 Mt from import and the rest from import as ammonia. Mr. Watson would then conclude that the gas(es) will continue to play a crucial role in the energy transition to balance variable renewable power generation, for long-term seasonal storage and for cost-effective energy transition.

The second presentation was held by Dr. Isabel Kundler from Dechema titled “Hydrogen Flagship Project H2Giga: Serial Production of Electrolysers”. Dr. Kundler introduced H2Giga as an R&D initiative to support the industrialization and scale up of water electrolysis which is a precondition to make green hydrogen available on gigawatt scale. H2Giga consists of 27 joint projects and approximately 120 partners from the industry, universities and research institutes. It was launched in April of 2021 and will span for four years with a funding of around €450M. This flagship project is the amalgamation of three core topics that are synergized through a platform named Technology Platform Electrolysis from Dechema:

- Scale-up of electrolysis for established companies regarding electrolysis
- Next-generation scale-up for companies that recently switched to hydrogen
- Innovation pool in partnership with academia focusing on various topics such as material technology and re-design of components.

Dr. Kundler concluded by sharing the following email address: H2Giga@dechema.de to reach out for further details and information.

The wonder.me application was used in the breaks allowing the participants to break out into different groups to network and discuss their experiences.

The last presentation of the first day was then held by Mr. Philip Ginsberg from DVGW about the project H2vorOrt. This initiative consists of 50 partners working towards three main goals:

- Transformation of gas DSOs to climate neutrality
- Climate-neutral gases in all sectors
- Preservation and expansion of regional assets and values.

Mr. Ginsberg then stated the 3 pillars of the decarbonisation strategy which are the following:

- H_2 backbone for a transregional supply of hydrogen
- Decentralized H_2 production with a 140 TWh potential
- Bio- and RE-methane with a 169 TWh potential

Mr. Ginsberg then introduced the gas distribution transformation plan (GTP) that would make hydrogen available to all via the gas distribution networks, with four central building blocks: capacity, customer, injection and technical analysis.

Further information is available on the following link: https://www.dvgw.de/themen/forschung-und-innovation/forschungsprojekte/dvgw-forschungsprojekt-nachhaltiger-waermesektor

The first day was finished with feedback and an outlook for the next day.

The second day began with a summary of the previous day and welcoming the new attendees. The agenda was divided into two sessions with the participants choosing to participate between underground storage & transmission or distribution & end use.

Session 1 was led by Mrs. Jenny Sammüller and Mr. Gert Müller-Syring and with presentations from Mrs. Nazika Moeininia of DBI on Underground H2 Storages, Mrs. Manon Simon of Carbon Limits on Re-stream report and Mr. Eric Tamaske of Ontras on H_2-separation.

Session 2 was led by Mrs. Alexandra Kostereva and Mr. Mohamed Amine Ouarda with presentations from Mr. Elbert Huizer of Alliander on the H_2 grid in Lochem and Mr. Huib Blokland of TNO on the HyDeploy Program. Unfortunately, Dr. Botzem of BASF was held up to attend. The two sessions therefore regrouped for the H_2-separation presentation.

After a lunch break, Mr. Gert Müller-Syring from DBI shared the scope and status of the H_2-Database DVGW which will launch in Germany this upcoming fall. This database would allow assessing the hydrogen suitability of the gas infrastructure by providing requirements for new construction and the evaluation of reliability of existing infrastructure.

Mr. Müller-Syring followed his presentation to discuss organisational aspects of HIPS-NET. He reviewed the working plans for year 9 and year 10 as well as the status of HIPS-NET, the partners and core topics. It was agreed that while infrastructure remains our main focus, we will add information regarding hydrogen import.

The workshop concluded with a survey through the menti application for the participants in regards to this 9th edition of HIPS-NET. The survey showed the participants to be satisfied while suggesting discussion topics for the break out sessions in the networking part (wonder.me app) and opting for a potential field visit in the upcoming 10th HIPS-NET workshop.

Project H2SAREA I Spain

Nortegas, the second largest national gas distribution company in Spain, launched the H2SAREA project on the 2nd of May 2022. It is the first demonstration project in Spain where the injection of green hydrogen into the gas network is being tested.

H2SAREA focuses on analysing the limits of the current natural gas infrastructure and equipment in residential and industrial facilities where hydrogen is injected at different blending percentages. Currently, the existing gas infrastructure covers 90,000 kilometres in Spain that are available for injecting green hydrogen into the existing gas network. The project aims to prepare the ground for the transformation of the current gas network into the forthcoming hydrogen economy and to contribute to decarbonising the economy. The project results will serve to propose the next steps towards the transition to regulatory authorities, based on real experiments.

The project focuses on analysing the following aspects:

- the response of main materials, components, and systems which involves both the gas distribution network and the end-user's facilities and appliances such as pipes, flanges, valves and meters when being exposed to a hydrogen-natural gas mixture under different operating conditions.
- the hydrogen (H_2) injection capacity into the distribution network.
- design and construction of a research platform (H2Loop).
- research systems and methods to inject H_2 into the gas network
- response of the infrastructure after being in contact with hydrogen and natural gas-hydrogen mixtures.
- H_2 blending pilot project, by designing an injection system and 100% hydrogen residential gasification pilot project.
- Working together with project partners to identify the specific needs of each technical development to achieve joint solutions for the technological challenge of distributing H_2 blendings into the gas network.

H2SAREA is distributed in 8 phases, as shown in figure 1.

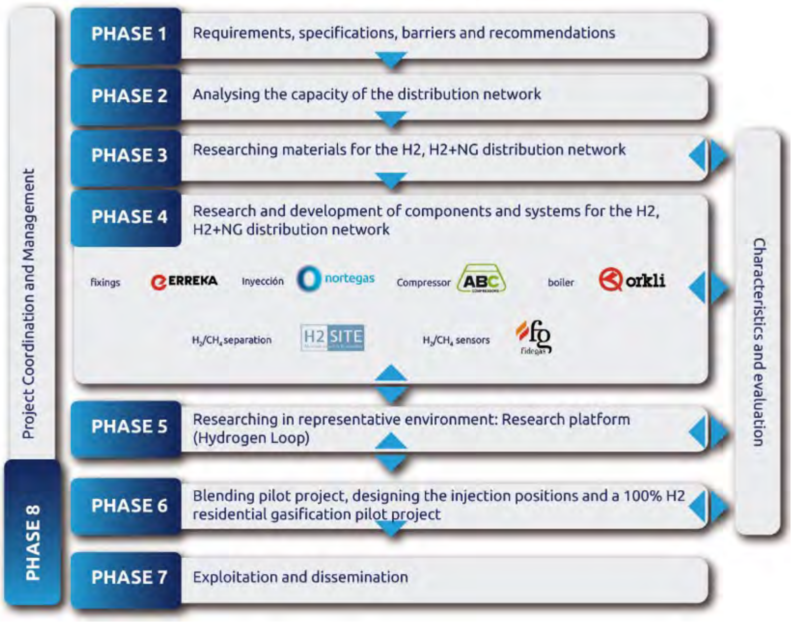


Figure 1: The 8 phases of the H2SAREA project
Source: https://www.h2sarea.com/en/h2sarea/

H2SAREA is part of the Basque Government's HAZITEK programme, which is led by Nortegas. The programme is run by a consortium of companies of the Basque industrial network, such as ABC Compressors, C.A.E., S.L., FIDEGAS, H2Site, Erreka Fastening Solutions and Orkli. Moreover, the project is endorsed by two of the main technological centres of the Basque Science, Technology and Innovation Network – Tecnalia and Ikerlan – and by the Spanish National Hydrogen Centre.

The Nortegas Group considers green hydrogen as a core area of its business model. The company is part of the

Basque Hydrogen Corridor and is working on the construction of the first hydrogen dedicated pipeline in Spain, which will become operational by the end of this year. The hydrogen will be generated at the Petronor refinery with a 2.5 MW electrolyser and will supply green hydrogen to the Abanto Technology Park.

Nortegas is involved in other green hydrogen projects as well, such as the BenorthH_2 project together with White Summit Capital, Castleton Commodities International (CCI), SENER and Bizkaia Energía. Moreover, Nortegas is involved together with Duro Felguera and Hunosa in the production, storage, transport and injection of H_2 into the natural gas network, as well as the use of H_2 in mobility.

Sources and more information:

- https://www.h2sarea.com/en/h2sarea/
- https://www.nortegas.es/en/press-note/nortegas-launches-h2sarea-the-first-national-demonstration-project-to-inject-green-hydrogen-in-the-current-natural-gas-network/
- https://energynews.biz/petronor-and-nortegas-to-introduce-first-green-hydrogen-distribution-network-in-spain/
- https://www.benorth2.com/en/
- https://www.nortegas.es/en/press-note/duro-felguera-hunosa-and-nortegas-sign-an-agreement-for-the-joint-development-of-green-hydrogen-projects-in-the-asturian-coalfields/

Contact: Paula Gata Gómez, Engineering and R&D Manager in Nortegas (paula.gata@nortegas.es)

Simulation of the Hydrogen Network 2050 | Germany

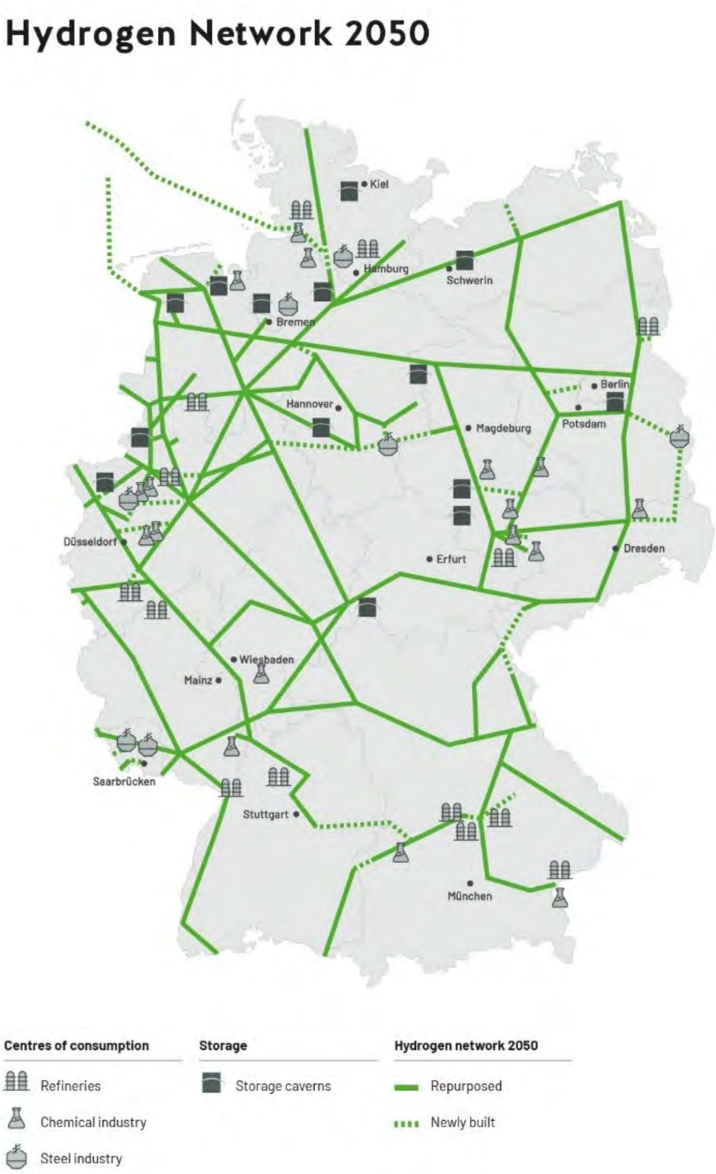
As the basis for a scenario of the hydrogen (H_2) network 2050 made by the German transmission system operators (TSO) was already shown in the NL25, the TSO developed their ideas to the next stage: a network simulation to calculate the needs of the future hydrogen transport.

The grid should help achieving climate-neutrality of Germany in 2050 and considers the transport requirements for this case. However, the needed H_2 pipelines could already exist in 2045, if the planning periods would be adjusted.

Keeping in mind the German hydrogen strategy and an increasing market demand, a dynamic development of the hydrogen economy in Germany was presumed. Especially steel and chemical industry need large amounts of hydrogen. For the transport sector, the use of H_2 increases slightly; for the electricity and heating sector the increase is moderate. At the distribution grid level, an admixture of hydrogen and, in the long term, also the conversion of entire grid areas to a supply of pure hydrogen was assumed.

In the considered scenario, there is a future demand of green methane in the same order of magnitude as hydrogen. In a scenario with minor use of methane, further potential for optimization could be realized through a higher proportion of converted lines.

The planned H_2 grid includes 13,300 km of pipelines, of which 11,000 km are converted pipelines. With an energy volume of 504 TWh and a power of 110 GWh/h (peak) the investment costs for interregional transport by 2050 are estimated at 18 billion euros. In addition, costs for offshore pipelines, storages, connection of individual H_2 generation plants and costs to individual customers were not taken into account. In this context, major investments in the electricity grid will also have to be made.



For the planning of the H_2 grid, the TSOs defined their entry and exit capacities for all of their entry and exit points. Existing industrial production capacities and locations helped to carry out a regionalization. For the regionalization of the consumption of the transport and heating sector the existing vehicle registrations and gas stations were used, and for the heating market the population figures in particular. A fluid mechanics grid simulation for different load scenarios was carried out depending on the availability of renewable energy and the existing connected cavern storages. The simulations consider that the German H_2 production will be too less for the foreseen demand, which leads to a high amount of import of H_2.

To sum it up, the new findings, that are the result of years of work on a simulation, provide important fundamentals to guide policy decisions for an efficient supraregional hydrogen transport infrastructure.

Source:
https://fnb-gas.de/en/hydrogen-network/hydrogen-network-2050-for-a-climate-neutral-germany/

EVENTS AND PARTNERS

Selection of Appointments

September 2022

6-9 SHK ESSEN | online, *https://www.shkessen.de/branchentreff*

13-15 Beyondgas | Oldenburg, Germany, *https://www.beyondgas.de/beyondgas2021*

14 H2.0-Konferenz 2022 | Husum, Germany, *https://www.wattzweipunktnull.de/h20-konferenz*

14-15 23. Forum der Energiewelt | Berlin, Germany, *https://www.forum-neue-energiewelt.de*

20-22 Energy Storage Europe (ESE) | Düsseldorf, Germany, *https://www.decarbxpo.de*

21-22 Hydrogen Dialogue | Nürnberg, Germany + online, *https://www.hydrogendialogue.com*

27-30 H_2 Expo and Conference | Hamburg, Germany, *https://www.h2expo.com*

Oktober 2022

4-5 f-cell | Stuttgart, Germany, *https://www.messe-stuttgart.de/f-cell*

5-7 eMove360° | Berlin, Germany, *https://www.emove360.com*

19-20 Hydrogen Technology European Expo | Bremen, Germany, *https://www.hydrogen-worldexpo.com*

November 2022

8 HOC - Mission Hydrogen | online, *https://hydrogen-online-conference.com*

11-12 REGWA Symposium | Stralsund, Germany, *https://www.hochschule-stralsund.de/regwa*

Dezember 2022

7-8 Berlin Electrolyser Conference | Berlin, Germany, *https://www.nextgen-electrolysers.com*

Current Partners

Alliander AG, Cadent, DGC,
DNV GL, Elogen, Enagás,
Enbridge, Energinet.dk, ENGIE,
EWE Netz, Gas Connect Austria GmbH,
Gasnetz Hamburg, Gasum OY,
Gasunie, GRTgaz, grzi e.V. (figawa),
Infraserv GmbH & Co. Höchst KG,
INERIS, innogy SE, ITM Power,
Joint Research Centre (JRC), EC,
KOGAS, NAFTA a.s,
Naturgy, Netze Südwest, ONTRAS, ÖVGW,
Open Grid Europe GmbH,
Polymer Consult Buchner GmbH,
RAG Austria AG,
Shell, Solar Turbines Europe S.A.,
Storengy, SVGW,
Synergrid, Teréga, TNO,
Uniper Energy Storage GmbH,
Verband der Chemischen Industrie (VCI),
Wintershall Dea AG.

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Certified DIN EN ISO 9001:2015

HIPS-NET

"ESTABLISHING A PAN-EUROPEAN UNDERSTANDING OF ADMISSIBLE HYDROGEN CONCENTRATION IN THE NATURAL GAS GRID"

NEWSLETTER #39 **OCTOBER, 2022**

Dear HIPS-Net partners,

we hope you all enjoyed a wonderful summer and are looking forward to the first sunny autumnal days that are coming. Today we send you the latests edition of the HIPS-Net-Newsletter-hot of the press. May be it sweetens one of the less sunny autumnal days.

It contains the following exciting topics:

- Global harmonisation of hydrogen certification
- New marks of conformity for fuel cell systems and H_2 system components
- Natural gas vs. hydrogen - characteristics of dispersion calculation and dimensioning of Ex-zones
- Effects of hydrogen on gas detection equipment

We also have news concerning the organisation. Josephine is back from her parental leave and will now take over the organisational management of HIPS-NET. Gert and Ruven will further develop the network and support where helpful.

Please mark the date for the 10th HIPS-NET workshop in your calendars now. We hope to meet in Brussels on 15 June 2023 with an informal meeting the evening before. If the date is not convenient, please contact us ideally by email (josephine.glandien@dbi-gruppe.de).

Have fun reading!

Your HIPS-NET Team, Gert, Josephine and Ruven

CONTENT

CONTENT NEWSLETTER #39

Global harmonisation of hydrogen certification - Overview of global regulations and standards for renewable hydrogen | Worldwide

In February 2022, the German Energy Agency (dena) and the World Energy Council Germany published the study "Global Harmonisation of Hydrogen Certification - Overview of global regulations and standards for renewable hydrogen", which examines whether a globally uniform certification system for renewable hydrogen is feasible. The following eleven hydrogen regulations and standards are assessed in the report:

Schemes:

- ISCC PLUS (EU)
- CertyHy (EU)
- Dena Biogas Register (DE)
- TÜV Süd CMS 70 (DE)
- China Hydrogen Alliance's Standard (CN)
- Certification Scheme (JP)
- Zero Carbon Certification Scheme (AU)

Support programmes:

- H2Global (DE)

Regulations:

- Californian Low Carbon Fuel Standard (LCFS) (US/CA)
- Renewable Energy Directive (RED) II (EU)
- Renewable Transport Fuel Obligation (RTFO) (UK)

The assessment of these criteria leads to the conclusion that the development of a global certification scheme will be challenging. The main reason is that some markets (such as the EU) would have to abandon their ambitious criteria in order to follow a globally harmonised system.

The study proposes the system concept shown in the figure as a thought experiment that takes into account the regulations and standards assessed.

Due to the high production costs, the study presents other plant concepts that are suitable for different standards and regulations.

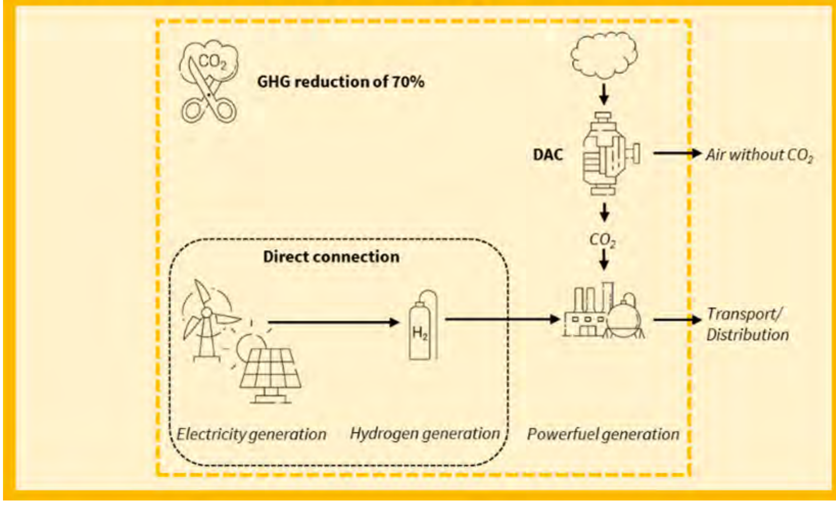
The EU has the potential to be a consumer of large quantities of renewable hydrogen. Renewable Fuels of Non-Biological Origin (RFNBOs) are part of the EU's Fit for 55 package for transport and industry and create a market for hydrogen production. Therefore, documentation and certification requirements in line with sustainability requirements are important for RFNBOs. On the other hand, the EU market could lose its attractiveness in the long run if the regulations are too strict. This would run counter to the objective of the EU Hydrogen Strategy to strengthen leadership in technical standards, regulations and definitions for hydrogen.

https://t1p.de/0hxcq
(World Energy Council)

A plant concept addressing the largest global offtake market*:

1. **Direct connection** between the renewable power source and the electrolyser
2. **GHG reduction of 70%** (target value: 28.2 gCO_{2equ}/MJ) compared to a fossil baseline of 94,1 gCO_{2equ}/MJ
3. Carbon source: Atmospheric (**DAC**)

*Proof for mass balance needs to be provided along the value chain



Hydrogen plant concept addressing the largest global offtake market
(Source: https://t1p.de/0hxcq p.39)

New test marks for fuel cell systems and H_2 system components | Germany

We already reported on the "GreenHydrogen" certification of TÜV Süd in Newsletter 26. Since May 2022, the company has been awarding a new test mark for the certification of "fuel cell systems" and "hydrogen system components".

Sample of the fuel cell system test mark (Source: TÜV Süd)

Sample of the hydrogen system component TÜV-approval mark (Source: TÜV Süd)

The "fuel cell systems" test mark covers systems that generate electricity electrochemically, are stationary and are manufactured at a factory. Hydrogen system components are hydrogen-carrying components such as valves, tank nipples, refuelling couplings or hoses. They can be found, for example, on hydrogen filling stations or vehicles.

The test marks ensure that the national and international standards for technical safety are complied with.

The inspection and monitoring of the production facilities is carried out by TÜV Süd at regular intervals, if required.

TÜV Süd tests components and systems for their H_2 suitability, compatibility and performance in its hydrogen testing laboratory in Garching near Munich. The test mark thus supports manufacturers in strengthening confidence in the safety and performance of their products.

In most cases, the certification of fuel cells and hydrogen system components is not required by law. However, this could change in the medium term with the revision of the Alternative Fuels Infrastructure Regulation (AFIR).

For example, customers of steel mills are already increasingly willing to pay higher prices if the CO_2 balance of the energy carrier improves.

With its voluntary certification, TÜV Süd already wants to set a visible sign for more sustainability.

https://www.tuvsud.com/de-de/presse-und-medien/2022/juni/neue-pruefzeichen-fuer-brennstoffzellensysteme-und-h2-systemkomponenten

Natural gas vs. hydrogen - Characteristics of dispersion calculation and dimensioning of Ex zones | Germany

Hydrogen can contribute significantly to reducing greenhouse gas emissions in the future energy system. For the use and establishment of hydrogen, the safety assessment must be completed in addition to the technological suitability. In particular, the behaviour of hydrogen and natural gas in the event of a gas leakage must be analysed and calculated for risk assessment. The calculation is carried out with so-called dispersion calculations. The gas properties of hydrogen and natural gas are different. Therefore, explosion zones of different sizes can occur, for example. Several mathematical models and calculation programmes exist to determine the safety-relevant explosion protection zones. These programmes are mainly used in connection with natural gas. The transferability of the models and programs for hydrogen and hydrogen-rich gases is only partially given. For hydrogen additions in the single-digit percentage range, the current regulations remain valid. For a hydrogen quantity above 10 % by volume, there is currently no normative basis for the calculation and design of Ex zones for hydrogen or hydrogen-rich gases.

Background

In plants where flammable gases are handled under pressure, gas leakage in the form of a free jet can occur in the following cases:

- in the event of a failure of the containment (e.g. leakage or damage to piping),
- in the event of leakage of detachable connections (e.g. seals, flange connections) or
- at outlet openings when pressure relief devices (e.g. safety valves or bursting discs) respond, or in general at ventilation, exhaust and expansion lines.

With suitable models, the propagation of the free jet and the concentration limit can be calculated. Several models are known from the literature that can be used with reasonable computational effort under certain boundary conditions.

Explosion zone

The decisive parameter for the dispersion behaviour of a flammable gas is the explosion zone, or Ex zone for short. This defines the concentration range in which a fuel gas-air mixture can be ignited if sufficient energy is supplied. Ex zones are characterised by the upper explosion limit (UEL) and the lower explosion limit (LEL). If the concentration of the fuel-air mixture exceeds a minimum value (LEL), an explosive atmosphere is present.

Calculation of dispersion

In a dispersion calculation, a fuel gas is released into the atmosphere under defined conditions (pressure, temperature) via an expeller. During the release, the fuel gas mixes with the ambient air under expansion and forms a combustible fuel gas-air mixture. The LEL marks the outer limit of the explosion range.

To determine the Ex zone, which is dimensioned as a cylinder with maximum height and radius, the largest possible dispersion consideration is examined. The maximum height results from a vertical free jet arising in a stationary environment without consideration of crosswinds. The horizontal extent of the Ex zone (radius) is calculated under the influence of crosswinds with a wind speed of 15 m/s. DVGW Code of Practice G 442 specifies 15 m/s as the maximum wind speed. However, experience shows that this limit value does not always lead to the maximum expansion of the Ex zone.

Natural gas vs. hydrogen

For further consideration, the dispersion behaviour of natural gas and hydrogen or hydrogen-natural gas mixtures is investigated with the software ProNuSs® Version 9. This is a programme for numerical accident simulation. It is carried out according to the specifications of VDI Guideline 3783, Sheet 2 and in compliance with DVGW Code of Practice G 442.

Figure 1 shows an example of the calculation of natural gas and hydrogen under identical conditions (pressure, temperature and pipeline geometry). It can be seen that hydrogen (blue) spreads significantly more in the vertical direction than natural gas (orange). The reason for this is the lower density of hydrogen compared to natural gas, which leads to a higher exit velocity despite the same conditions. In addition, due to

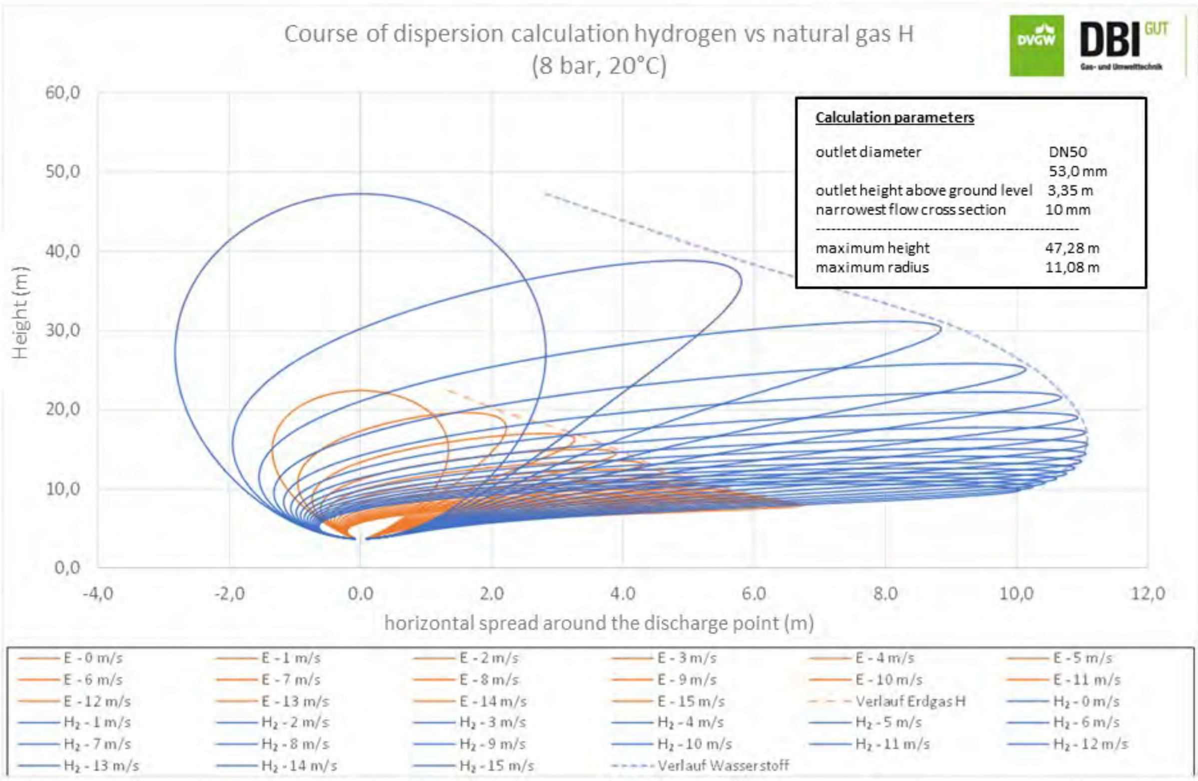


FIGURE 1: COMPARISON OF THE DISPERSION CALCULATION HYDROGEN VS. NATURAL GAS, 8 BAR, 20°C (SOURCE: DBI GRUPPE)

its density, hydrogen travels a longer distance until it has mixed sufficiently with atmospheric oxygen. This phenomenon is also evident if one takes the crosswind into account.

As the wind speed increases, the radius of the danger zone of natural gas steadily increases. The height decreases and the cloud becomes flatter. For hydrogen, too, the radius of the ex-zone initially increases with increasing wind speed. From a wind speed of in this case approx. 7 m/s, the jet length decreases and the radius of the gas cloud decreases. This effect is due to the favourable mixing of the fuel gas with the ambient air through the effect of turbulence at high wind speeds.

In most cases, a larger ex-zone is achieved with the release of hydrogen than with natural gas. However, research results from the DBI have shown that this statement is not true under certain conditions. The calculation of a vertical blowout with DN 500 and 200 bar shows that the Ex-zone of natural gas is significantly larger than that of hydrogen in this case. The results are shown in Figure 2. The reason for this is the combination of high pressure, the different density and the associated high outlet velocities.

Conclusion

The programmes presented here, especially the calculation programme used, provide a good basis for performing dispersion calculations for hydrogen and hydrogen-containing gases. For a reliable application of the methodology, the next step is to validate the knowledge gained through practical experiments and then to transfer it to codes and standards eg. DVGW rules.

The calculations carried out assume that hydrogen basically volatilises more quickly due to its specific properties and that other Ex zones therefore arise than with methane. Depending on the general conditions, these can also be smaller than for natural gas. This means that for safety reasons, the dispersion of a fuel gas must always be calculated individually in order to be able to make a reliable statement about the expansion of Ex zones.

ThaiSon.Bui@dbi-gruppe.de

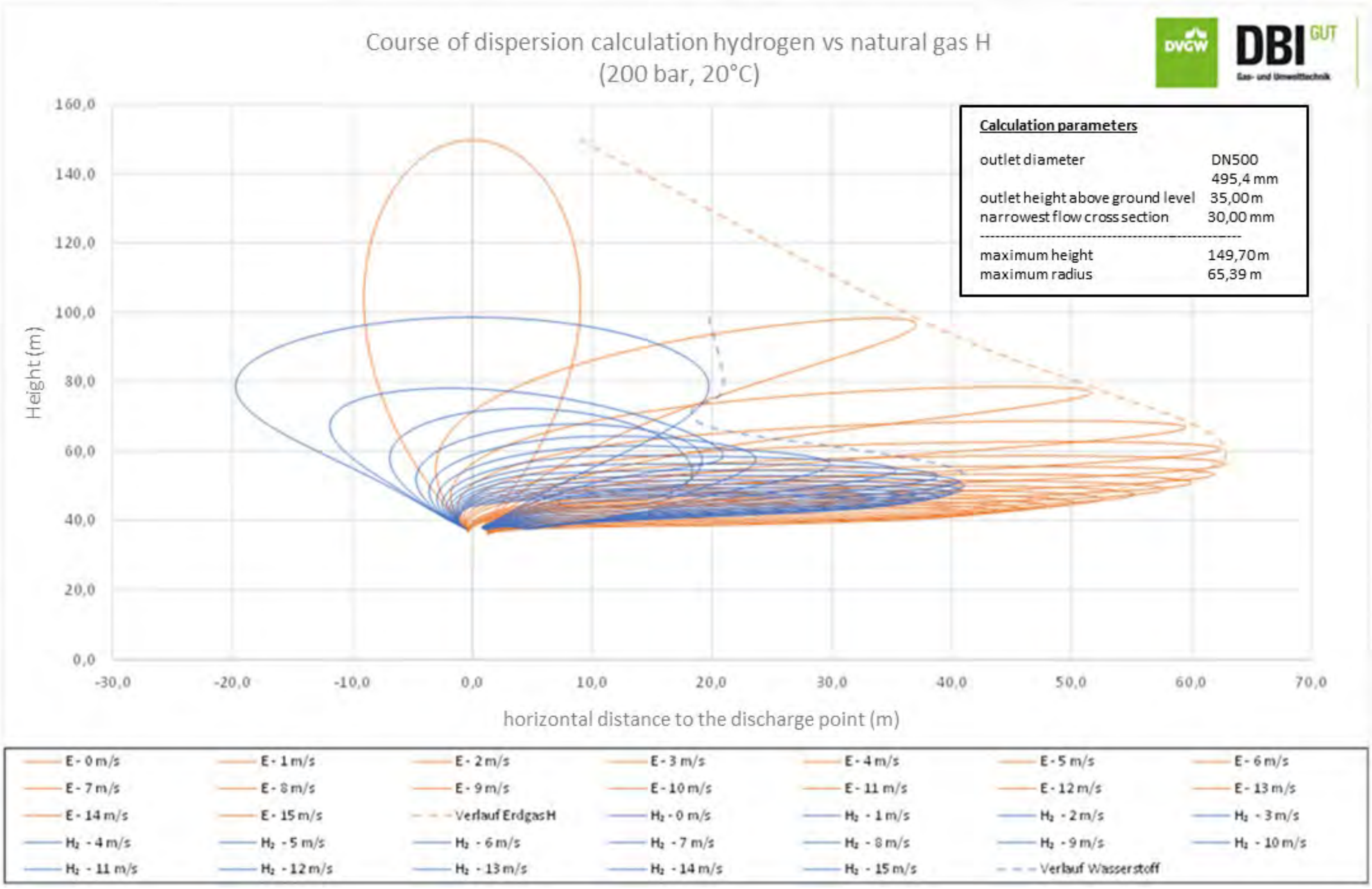


FIGURE 2: DISPERSION CALCULATION COMPARISON HYDROGEN VS. NATURAL GAS, 200 BAR, 20°C (SOURCE: DBI GRUPPE)

Effects of H_2 on gas measuring instruments | Germany

In May 2022, the DVGW published a final report on the analysis of the leakage behaviour of underground pipelines with hydrogen-containing and hydrogen-rich gases. Gas measuring devices according to DVGW Code of Practice G 465-1 were used for the above-ground location of H2 leaks.

In the "H2-BoMess" project, three different gas measuring devices available on the German market were analysed that have at least one sensitive semiconductor detector for the detection of H2 and CH4. In the theoretical part of the analysis, the measuring principles used were described and the manufacturers' specifications were summarised. In the experimental part, laboratory tests were carried out on the sensitivity, cross-sensitivity and handling of the measuring devices. In addition, field tests were carried out on OGE test fields by simulating different leakages. The aim of the analysis was to use the findings to expand or revise the existing set of regulations and to use them for operational practice.

Of the three gas detectors examined, one was intended for measuring hydrogen. As expected, this device had a high sensitivity to hydrogen and a high safety level. Above-ground testing of hydrogen-bearing buried pipelines according to DVGW Code of Practice G 465-1 is possible with this device. The other two gas detectors have been specified for the measurement of methane or gas mixtures. They can be used for above-ground testing of gas pipelines with a hydrogen volume content of up to 30 percent by volume.

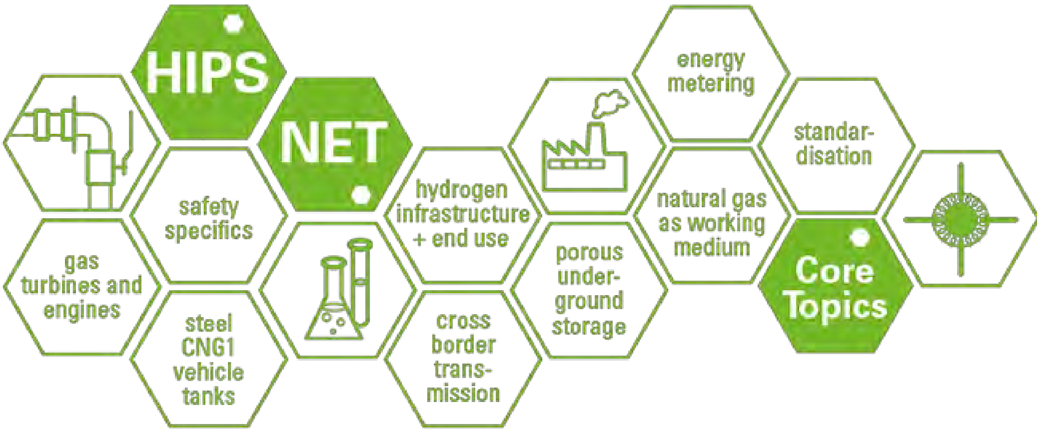
project partners: DVGW Research Centre at the Engler-Bunte Institute of the Karlsruhe Institute of Technology and Open Grid Europe (OGE) GmbH.

project duration: 03.2021-05.2022

Project H2-BoMess (Source: DVGW)

https://www.dvgw.de/themen/forschung-und-innovation/forschungsprojekte/dvgw-forschungsprojekt-h2-detektion-h2bomess

HIPS-NET CORE TOPICS



EVENTS AND PARTNERS

Selection of Appointments

October 2022

4-5 f-cell | Stuttgart, Germany, *https://www.messe-stuttgart.de/f-cell*

5-7 eMove360° | Berlin, Germany, *https://www.emove360.com*

18-19 gat | wat 2022 | Berlin, Germany, *https://www.gat-wat.de*

19-20 Hydrogen Technology European Expo | Bremen, Germany, *https://www.hydrogen-worldexpo.com*

November 2022

8 HOC - Mission Hydrogen | online, *https://hydrogen-online-conference.com*

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December 2022

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Current Partners

Alliander AG, Cadent, DGC, DNV GL, Elogen, Enagás,
Enbridge, Energinet.dk, ENGIE,
EWE Netz, Gas Connect Austria GmbH,
Gasnetz Hamburg, Gasum OY,
Gasunie, GRTgaz, grzi e.V. (figawa),
Infraserv GmbH & Co. Höchst KG,
INERIS, innogy SE, ITM Power,
Joint Research Centre (JRC), EC,
KOGAS, NAFTA a.s, Naturgy, Netze Südwest, ONTRAS,
ÖVGW, Open Grid Europe GmbH,
Polymer Consult Buchner GmbH,
RAG Austria AG,
Shell, Solar Turbines Europe S.A.,
Storengy, SVGW,
Synergrid, Teréga, TNO,
Uniper Energy Storage GmbH,
Verband der Chemischen Industrie (VCI),
Wintershall Dea AG.

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DBI Gas- und Umwelttechnik GmbH
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04229 Leipzig
GERMANY
www.dbi-gruppe.de

CEO: Dr.-Ing. Jörg Nitzsche, Dipl.-Ing. (FH) Gert Müller-Syring

Certified DIN EN ISO 9001:2015

HIPS-NET

“Establishing a pan-European understanding of admissible hydrogen concentration in the natural gas grid”

NEWSLETTER #40 — **November, 2022**

Dear HIPS-Net Partner,

we are pleased to present today the 40th issue of the HIPS-NET newsletter! The understanding of the importance of hydrogen as well as the existing gas infrastructure in the future energy system has developed very positively since the foundation of HIPS-NET and is in principle consensus. When it comes to the concrete design, there are still partly very different perspectives. We see an enormous number of exciting developments that are worth informing about. We are pleased to report on some of these developments in this anniversary issue:

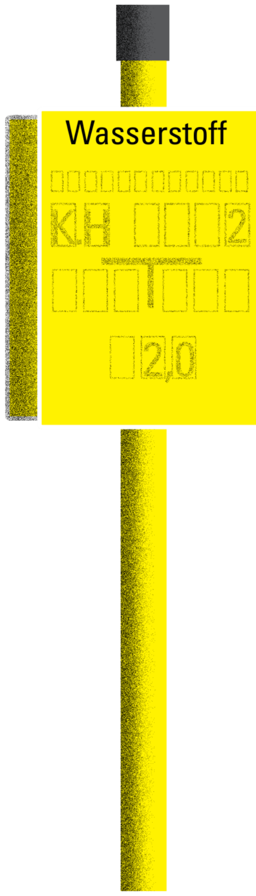
- H2vorOrt and the Gas Grid Area Transformation Plan | Germany
- Nel ASA opens fully automated electrolyser production plant in Herøya | Norway
- HyCavMobil: Leak test of the hydrogen supply line to a salt cavern | Germany
- Draft for the introduction of a guarantee of origin register law for hydrogen | Germany
- Decarbonisation of heavy industry via green hydrogen | China
- PtG map | HIPS-NET internal

If you have interesting topics in your country or company that we may report on, we are always happy to receive a message and even more so a draft article.

Enjoy reading!

Your HIPS-NET Team

Gert, Josephine and Ruven



CONTENT

content NEWSLETTER #40

H2vorOrt and the Gas Grid Area Transformation Plan | Germany

In September, the H2vorOrt initiative published the results report of the Gas Grid Area Transformation Plan (GTP) for 2022. The GTP is part of a multi-year planning process to transform the German gas distribution grids towards climate neutrality.

Procedure of the GTP

As part of the H2vorOrt project, 33 companies from the gas industry exchanged ideas with the DVGW on the design of a climate-neutral and secure gas supply in October 2020. In March 2022, the GTP planning process of the now 45 partner companies of H2vorOrt started with the publication of the guideline for the GTP individual planning. The first results report was presented in September. An investment-ready plan is to be produced by 2025 at the latest. In the first planning run (as part of the 2022 results report), 180 distribution network operators participated throughout Germany.

The path to climate neutrality is defined by four phases (see figure below). Today we are in the initial situation (I. Phase) with the supply of natural gas, partly biogas feed-in. In the initial phase (II. Phase), which begins immediately, the proportion of pipelines that are H_2-ready is increasing, based on available R&D results. There are initial areas with regional hydrogen production and admixture of up to 20 vol.-%. Phase III, the expansion phase, begins from 2030. The number of grids with regional H_2-generation as well as H_2-ready lines is increasing. The first grids are part of the H_2 backbone. The last, IV. phase, is the target state by 2045 at the latest. The majority of distribution grids will supply customers with 100 vol.-% H□. Smaller network areas distribute 80 vol.-% biomethane and 20 vol.-% H□ or 100 vol.-% renewable methane.

The company's internal GTP

The company's internal GTP 2022 contains four central building blocks consisting of analysis paths and two results. The four analysis paths comprise the feed-in, capacity, customer and technical analysis. On the one hand, the results consist of the feedback for 2022, which is incorporated into the overall GTP 2022. On the other hand, the result is an ongoing internal process which is relevant for the next GTP 2023.

In the feed-in analysis, the distribution system operators (DSOs) consider the secured feed-in of biomethane, synthetic natural gas (SNG) or hydrogen (H_2) into the existing network. The analysis takes into account the feed-in suitability as well as the gas quality.

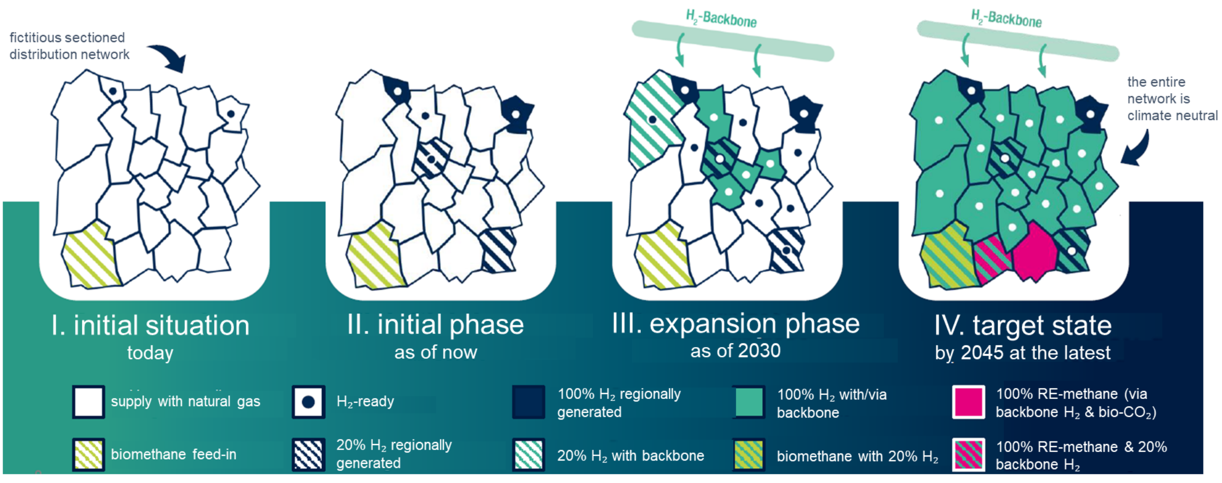
The capacity and customer analyses are close to each other in terms of content. In the capacity analysis, the gas grids are classified into conversion zones, which results in a conversion sequence for the transformation of the DSO. Network customers and municipalities provide input for the conversion zones and sequence as part of the customer analysis. The DSO formulates the results as requirements for the transmission system operators (TSOs), i.e. how much capacity it needs at which time at which network interconnection point or exit zone.

The technical analysis includes the analysis of the network components, the examination of a sectioning of the changeover zones into sub-networks as well as the network hydraulic analysis. The H_2-Readyness planning is to be completed by 2025.

Results of the 2022 Results Report

180 DSOs submitted their GTP, 10 others notified the start of the planning process.

The DSOs are planning to convert their grids to hydrogen on a large scale. DSOs see the first regular use of hydrogen in their grids soon, in large parts of Germany already by 2030. First 100 vol.-% H_2 grids are expected in many parts of Germany by 2030. Large-scale conversions will take place in the 2030s. The majority of



The path to climate neutrality in four phases (Source: GTP Guideline p. 6, translated) hydrogen purchases will be made via the TSOs. Only a few DSOs are expected to purchase methane after 2045. Depending on the region, a long-term and extensive supply of local biomethane is assumed. Many network operators expect energy efficiency gains. The customer analysis shows relevant amounts of early defossilisation demand in industry, power plants and CHP.

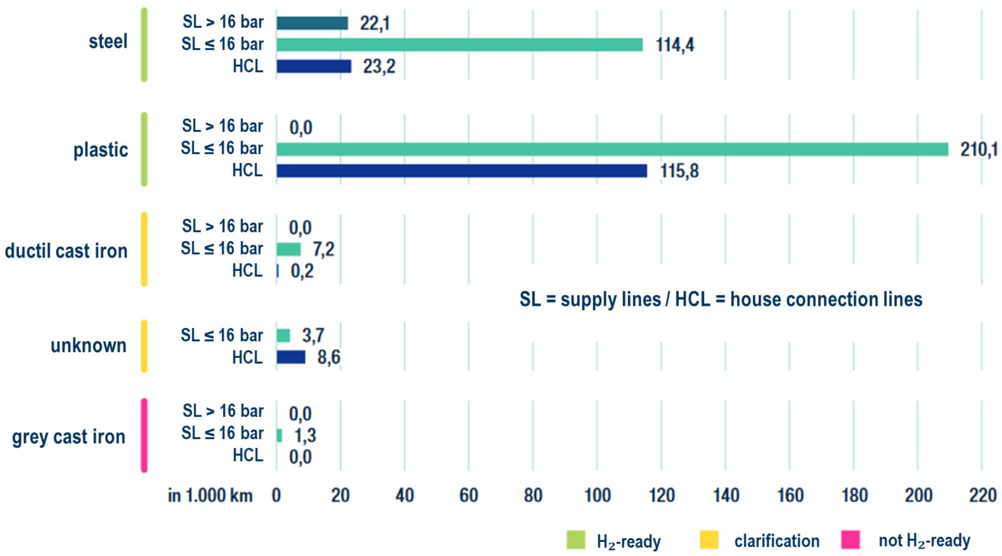
The first GTP found that 95.9 % of the pipelines are made of steel and plastic, which are H_2-suitable (see figure below). 0.2 % of the pipelines are made of grey cast iron, which is classified as unsuitable due to a lack of investigations. Further clarification is necessary for 3.9 %. These include pipes made of ductile cast iron (1.5 %). No final statement can yet be made on ductile cast iron, but initial trials in the UK showed positive results regarding H_2 suitability. The share of unknown piping materials is 2.4 %. Current and future construction sites will be used to complete the documentation.

Gas systems that are designed for the 2nd gas family according to DVGW G 260 require adaptations for operation with hydrogen. The adaptation requirement is individual for each system. The assessment is carried out by the responsible network operator. In addition, it must be checked whether the design parameters correspond to the future demand. If they are not powerful enough, they must be dimensioned larger. These analyses will be performed by the DSOs in the next steps.

Conclusion

From today's perspective, the transformation of the gas distribution network to 100 vol.-% hydrogen is possible and Germany's distribution network is basically suitable for the operation of 100 vol.-% hydrogen. More than 180 DSOs are actively supporting the transformation.

GTP Guide (only German)
GTP Results Report 2022 (only German)



PIPELINE MATERIALS GAS ACCORDING TO GAS-WATER STATISTICS G 410
(SOURCE: GTP RESULTS REPORT 2022 P. 22, TRANSLATED)

NEL ASA OPENS FULLY AUTOMATED ELECTROLYSER PRODUCTION PLANT IN HERØYA | NORWAY

On 04/20/2022, the company Nel ASA opened the first fully automated production plant of alkaline electrolysers in Herøya, an industrial site in southern Norway. Nel ASA is an European company with production sites in Norway, Denmark and the USA and serves the hydrogen sector with technologies for the production, storage and distribution of hydrogen from renewable energy. The newly built plant will produce alkaline electrolysers with a total capacity of 500 MW per year. As demand increases, the site's capacity can be expanded to 2 GW. In total, Nel aims to reach a production capacity of 10 GW by 2025.

AUTOMATED PRODUCTION OF ELECTROLYSERS
(SOURCE: NEL ASA)

So far, green hydrogen only accounts for 1 % of the worldwide consumption of hydrogen in industry and mobility. As costs fall, further fields of application could be opened up in which green hydrogen is the best or only option for decarbonisation. Nel's goal is to make green hydrogen as cheap to produce as conventional hydrogen made from natural gas and aims to achieve this by scaling up and automating the production of electrolysers. Further plans are directed at the industrial production of PEM (proton exchange membrane) electrolysers in the USA: based on 20, 100 and 200 MW units, capacities of up to 800 MW are to be built.

https://nelhydrogen.com/articles/in-depth/official-opening-of-the-heroya-facility/ (including video of the opening)

HyCavMobil: Leak test of the hydrogen supply line to a salt cavern | Germany

In Rüdersdorf, EWE Gasspeicher GmbH is building the first pure hydrogen cavern in a salt dome as part of the HyCavMobil (Hydrogen Cavern for Mobility) research project. The aim of this project is to test the operation of the facility and the quality of the hydrogen that is fed out. If the hydrogen is 100% pure even after it has been stored, it can be used for future applications (especially in the field of fuel cell mobility).

Construction of the hydrogen test cavern at a depth of 1000 m (Source: EWE Gasspeicher GmbH)

The first milestone of the project was the leak test of the supply line to the planned cavity at a depth of 1000 meters. The cemented connection between the pipe-in-pipe system and the salt rock was filled with hydrogen and compressed to different pressure levels. The result was that the **tightness tests were successfully passed**, so that the next milestone can be started.

In November 2022, construction of the hydrogen test cavern will begin by leaching out a house-sized cavity in the salt caverne (500 cubic metres). This process will take about 3 months. Up to six tonnes of hydrogen can be stored in the finished test cavern, which is sufficient to fuel around 1000 hydrogen cars.

Pipe-in-pipe system (Source: Andreas Prinz)

Hydrogen storage is scheduled to start in spring 2023 with tests of various storage and retrieval scenarios. The project partner German Aerospace Center (DLR), Institute for Networked Energy Systems, is responsible for investigating the hydrogen quality and other important parameters as well as material tests. For this purpose, EWE Gasspeicher GmbH is installing a monitoring system with fibre optic technology in the supply line. During underground storage, the hydrogen absorbs moisture. As this is problematic, a special drying facility is also planned.

Quality tests of the weld seams between the steel pipes (Source: Andreas Prinz)

Important findings are expected for the optimisation of the technical processes and the applicability in existing natural gas cavern storage facilities. Likewise, it will be evaluated which systems and controls are necessary to feed hydrogen into and out of a salt cavern and requirements and operating concepts for the best possible integration of the hydrogen cavern into the existing energy system will be determined.

The results of the test with a small research cavern can be transferred to larger caverns without any problems. This can create large capacities for hydrogen storage and make a further contribution to security of supply with renewable energies. EWE Gasspeicher GmbH has 37 salt caverns in Germany, accounting for 15 % of all German cavern storage facilities.

Project partners: EWE Gasspeicher GmbH and Institute for Networked Energy Systems at the German Aerospace Center (DLR)

Project budget: around 10 million euros

Duration: 06/2019 until 05/2023

Nationales Innovationsprogramm Wasserstoff- und Brennstoffzellentechnologie
nip

Gefördert durch: Bundesministerium für Verkehr und digitale Infrastruktur

Koordiniert durch: NOW NOW-GMBH.DE

Hydrogen storage: Tightness proven | EWE AG

DLR - Institute for Networked Energy Systems - HyCavMobil research project

Draft for the introduction of a guarantee of origin register law for hydrogen | Germany

At the beginning of August 2022, the Federal Cabinet in Germany presented a draft law on guarantees of origin for gas, hydrogen, heating and cooling from renewable energy sources. The Act transposes the EU requirements from the Renewable Energy Directive (EU) 2018/2001 (RED II) into national law. Now that there is already a register of guarantees of origin for electricity from renewable energy sources at the Federal Environment Agency, such registers are to be established for gaseous energy sources (gas, hydrogen) and heating and cooling from renewable energy sources.

"Guarantees of origin serve to document to an end customer that a certain proportion or quantity of energy was produced from renewable sources. Guarantees of origin thus make the origin of the energy source from renewable energies transparent. The issuance, recognition, transfer and cancellation of guarantees of origin are registered in a database. At the same time, the guarantee of origin ensures that this quality can only be taken into account once for the same energy from renewable sources. Guarantees of origin are an instrument of consumer information and thus also serve to protect consumers." (Source: BMWK)

Unbureaucratic and non-discriminatory access to guarantees of origin for green gases can provide positive market impulses for the use of green gases and stimulate innovative sector coupling. Guarantees of origin increase the opportunity for the development of liquid cross-border trade in hydrogen.

Bundesrat **Drucksache** **462/22**

16.09.22

Wi - U

Gesetzentwurf
der Bundesregierung

Entwurf eines Gesetzes zu Herkunftsnachweisen für Gas, Wasserstoff, Wärme oder Kälte aus erneuerbaren Energien und zur Änderung der Fernwärme- oder Fernkälte-Verbrauchserfassungs- und -Abrechnungsverordnung

Comments on the draft law

21 German associations took a stand on the draft law at short notice and voiced criticism. These include, for example, the German Association of Energy and Water Industries (BDEW), the Association of Municipal Companies (VKU) and the German Energy Agency (dena). Overall, the picture that emerges is that the implementation of the measures planned in the draft law is still inadequately designed in many cases.

Concerns about implementation in the hydrogen sector include the following:

"Gaseous energy carriers" are used as a generic term under which hydrogen and other gases are grouped and nevertheless separate guarantees of origin are to be issued for hydrogen and gas. This hinders the joint trade of green gases and impedes the conversion of the current natural gas system into a hydrogen system.

The current draft legislation hinders the blending of hydrogen into natural gas networks, as guarantees of origin for hydrogen are only to be permitted for trading in pure hydrogen networks. If the regulation were to remain as it is, it would hinder the development prospects of hydrogen. There would be no incentive for investments in blending and the conversion of existing gas infrastructures.

The draft also stipulates that only unsubsidised electricity from renewable energies may be consumed for the production of hydrogen. This ban on double marketing is already hindering the ramp-up of the hydrogen economy and the development of a liquid market in hydrogen guarantees of origin. The generation of guarantees of origin should depend on the form in which the hydrogen is used by the end customer, thus ensuring that the green energy generated is only credited once.

Guarantees of origin should not only be issued to plant operators, but also to service providers who manage a majority of plants, because otherwise small plants will not be able to obtain their guarantees.

The enabling legislation must clearly state the extent to which renewable energy previously stored in a shared storage facility is still considered renewable after withdrawal.

Draft law (only German)
Comments (only Geman)

First study on the use of clean hydrogen as a solution for China's heavy industry and heavy transport | China

Background

China has committed to reducing its emissions before 2030 and to be emissions neutral by 2060, but is by far the largest producer of iron, steel and building materials. In contrast to Western economies, China has the peculiarity that the share of heavy industry in emissions is much larger and the share of private motorised transport and energy consumption in buildings is much smaller.

Until now, there has been no study on the role of clean hydrogen in China's net-zero future. A new study by Xi Yang, Chris P. Nielsen, Shaojie Song and Michael B. McElroy has now been published in *Nature Energy* (29 September 2022). This study is the first of its kind to evaluate the use of green hydrogen in China's energy system and economy. Filling this research gap will help provide a clearer roadmap for China's CO_2 emissions reductions, enable an assessment of the feasibility of its 2030 and 2060 decarbonisation promises, and provide guidance to other growing developing countries with large heavy industrial sectors.

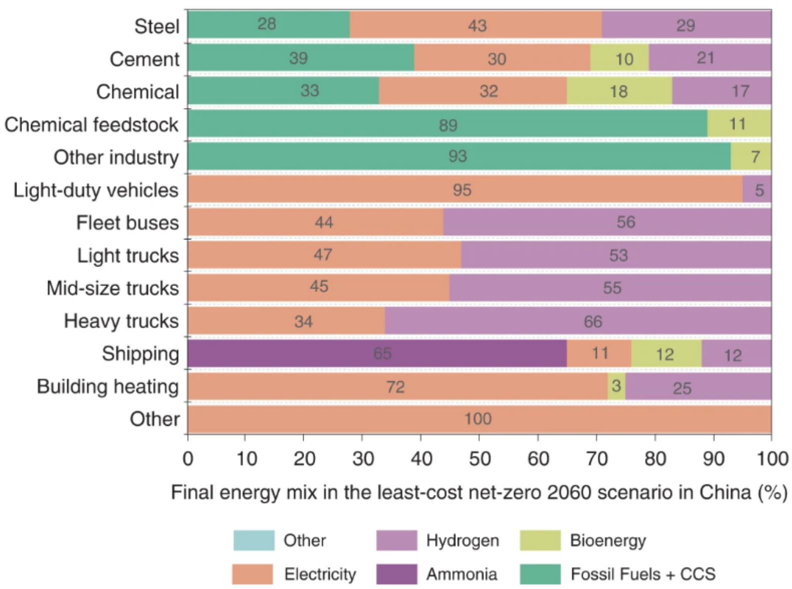
Results of the study

In the study, a least-cost optimisation of mitigation pathways to carbon neutrality for China in 2060 was conducted. Three main results were obtained:

1. Clean hydrogen can help China reduce emissions from heavy industry and achieve net-zero targets.
2. By 2060, clean hydrogen can power up to 50% of China's truck and bus fleets and a large share of shipping.
3. A realistic clean hydrogen scenario that reaches a production of 65.7 million tonnes in 2060 could avoid US$1.72 trillion in new investments compared to a scenario without hydrogen.

Green vs. blue hydrogen

China has rich unused resources of solar and wind energy, both on land and at sea. These resources give China an advantage in developing green hydrogen for use in industry and transportation.



Final energy mix in the scenario with the lowest H_2 costs (2060) (Source: Yang et al.)

As part of the study, the researchers also investigated whether green or blue hydrogen would be more cost-effective. The study leans towards green hydrogen, indicating that the average cost of green hydrogen in China can be reduced to $2/kg by 2037. By 2050, the cost could be reduced even further to $1.2/kg. This is cheaper than blue hydrogen, which would cost $1.9/kg.

Evaluation of the results

China's carbon-neutral future will be characterised by the dominance of renewables and the gradual phase-out of coal in primary energy consumption. Non-fossil fuels account for 88% of the primary energy mix in 2050 and 93% in 2060. Wind and solar will cover half of primary energy consumption in 2060. On a national average, the share of clean hydrogen in total final energy consumption could reach 13 % in 2060.

The use of clean hydrogen in the heavy industry and heavy transport sectors to achieve carbon neutrality in China by 2060 is feasible, but requires effective policy implementation at both national and sectoral levels.

The study did not consider hydrogen pipelines.

Yang, X., Nielsen, C.P., Song, S. et al. Breaking the hard-to-abate bottleneck in China's path to carbon neutrality with clean hydrogen. Nat Energy 7, 955–965 (2022). https://doi.org/10.1038/s41560-022-01114-6

PtG map | HIPS-NET internal

In the last workshop, we asked for feedback on our worldwide PtG map. The background is that the effort to keep this map up to date is increasing with the growing number of PtG projects. In addition, there is already a very extensive database of the IEA on worldwide PtG projects and some very similar maps for Germany could be found online.

Since the majority of participants consider the PtG map merely "nice to have" or "unimportant", the PtG map will no longer be updated. However, we will regularly research external sources of suitable overviews and make the links available in HIPS-NET.

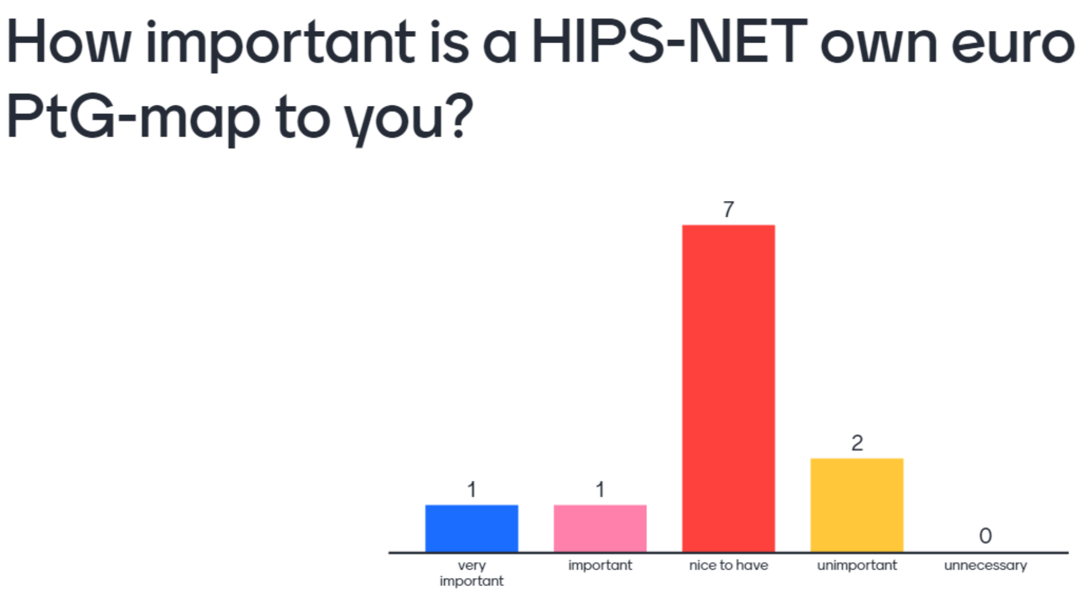
Here you can find the current overviews of PtG projects worldwide:

- IEA Hydrogen Projects Database (Hydrogen Projects Database - Data product - IEA - free registration required)

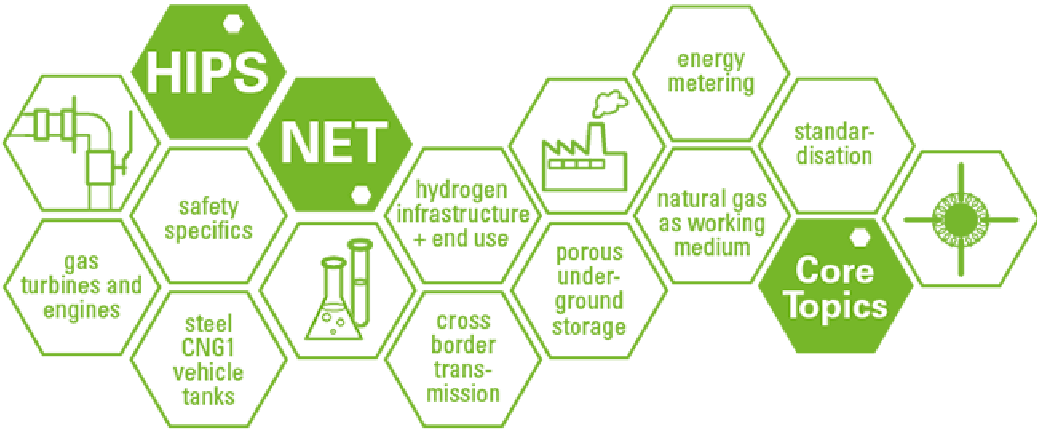
Here you can find the current overviews of PtG projects in Germany:

- Interactive Power to Gas Map Germany of the DVGW (DVGW e.V.: Interactive Power to Gas Map)
- dena project map (Project Map - H2 Dialogue)
- Norddeutsche Wasserstofflandkarte (North German Hydrogen Map - IHK Nord (ihk-nord.de))

Result of the vote on the PtG map
(Source: Workshop 2022 via Mentimeter)



HIPS-NET CORE TOPICS



EVENTS AND PARTNER

Selection of Appointments

December 2022

1-3 f-Cell China | Shanghai, China, *https://www.messe-stuttgart.de/f-cell/aussteller/f-cell-weltweit*

7-8 Berlin Electrolyser Conference | Berlin, Germany, *https://www.nextgen-electrolysers.com*

January 2023

23-24 20. International congress renewable mobility | Berlin, Germany, *https://www.kraftstoffe-der-zukunft.com*

February 2023

1-2 HyVolution 2023 | Paris, France, *https://paris.hyvolution.com/en/event*

Partner

Alliander AG, Cadent, DGC, DNV GL, Elogen, Enagás,
Enbridge, Energinet.dk, ENGIE,
EWE Netz, Gas Connect Austria GmbH,
Gasnetz Hamburg, Gasum OY,
Gasunie, GRTgaz, grzi e.V. (figawa),
Infraserv GmbH & Co. Höchst KG,
INERIS, innogy SE, ITM Power,
Joint Research Centre (JRC), EC,
KOGAS, NAFTA a.s, Naturgy, Netze Südwest, ONTRAS, ÖVGW, Open Grid Europe GmbH,
Polymer Consult Buchner GmbH,
RAG Austria AG,
Shell, Solar Turbines Europe S.A.,
Storengy, SVGW,
Synergrid, Teréga, TNO,
Uniper Energy Storage GmbH,
Verband der Chemischen Industrie (VCI),
Wintershall Dea AG.

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Certified DIN EN ISO 9001:2015

HIPS-NET

"ESTABLISHING A PAN-EUROPEAN UNDERSTANDING OF ADMISSIBLE HYDROGEN CONCENTRATION IN THE NATURAL GAS GRID"

NEWSLETTER #41 **DECEMBER, 2022**

Dear HIPS-Net Partner,

in the last issue of 2022, we want to think outside the box and, in addition to the core topics of HIPS-NET, deal with the currently very exciting developments in hydrogen mobility, the "rush" approval of a pipeline that is already H2ready, and the qualification of skilled personnel for the hydrogen industry.

The 41st Newsletter contains the following exciting topics:

- Northern Green Crane Project - pan-European hydrogen infrastructure for import and export | Sweden, Germany, Netherlands
- Innovation Award of the German Gas Industry | Germany
- GREATER4H Project | Europe
- Qualification / training / skilled workers in the hydrogen sector | Germany, France, Brazil
- Construction and approval of the connection line "WAL" | Germany
- Alstom's record drive over 1175 km | Germany
- H_2-powered dredging demonstration plant | Germany

We wish you all a reflective and merry Christmas, a good start into the new year and lots of fun reading the newsletter!

Your HIPS-NET Team

Gert, Josephine and Ruven

CONTENT

content NEWSLETTER #41

Northern Green Crane Project - pan-European hydrogen infrastructure for import and export | Sweden, Germany, Netherlands

Northern Green Crane is a lighthouse project for the development of a Europe-wide infrastructure for hydrogen transport using LOHC technology (Liquid Organic Hydrogen Carrier). The aim is to transport the green hydrogen produced in Sweden on an industrial scale (up to 8000 tonnes of H2 per year) to demand centres in Germany and the Netherlands by 2026.

The Northern Green Crane will be one of the first large-scale projects to import green hydrogen to Germany and the Netherlands, which is needed to increase energy security in Europe and to contribute to the ambitious plans of the European Commission.

With the production of green hydrogen in Sweden, the project gains access to new green hydrogen sources and strengthens the landing sites in Germany and the Netherlands. As a producer country, Sweden is characterised by its large renewable energy potential, including hydro and wind power, as well as excellent infrastructure and corresponding industry players.

The project will be realised by storing green hydrogen in LOHC (benzyl toluene carrier) in Sweden with a hydrogenation plant from Hydrogenious LOHC Technologies with a capacity of 24 tonnes of hydrogen per day. The LOHC loaded with hydrogen will be transported from Sweden to the Netherlands via about 40 shiploads per year.

In Rotterdam, half of the hydrogen gas is released in a new Hydrogenious LOHC dehydrogenation plant with a capacity of 12 tonnes of hydrogen per day to reach industry in the port and inland. The other half of the hydrogen-loaded LOHC is transported by barge via the river Ems to Lingen/Germany. After dehydration, the 12 tonnes of hydrogen per day will be used by local industry as well as fed into a hydrogen pipeline as part of the GET H2 initiative.

The project creates a unique hydrogen network that connects low-cost sources of green hydrogen with industrial demand across Europe, accelerating import activities and supporting Europe's ambitious defossilisation goals.

The project is funded by the Ministry of Economy and Climate Protection and was also preselected as a hydrogen IPCEI (Important Projects of Common European Interest) in 2021 (or Green Crane before that, see info box).

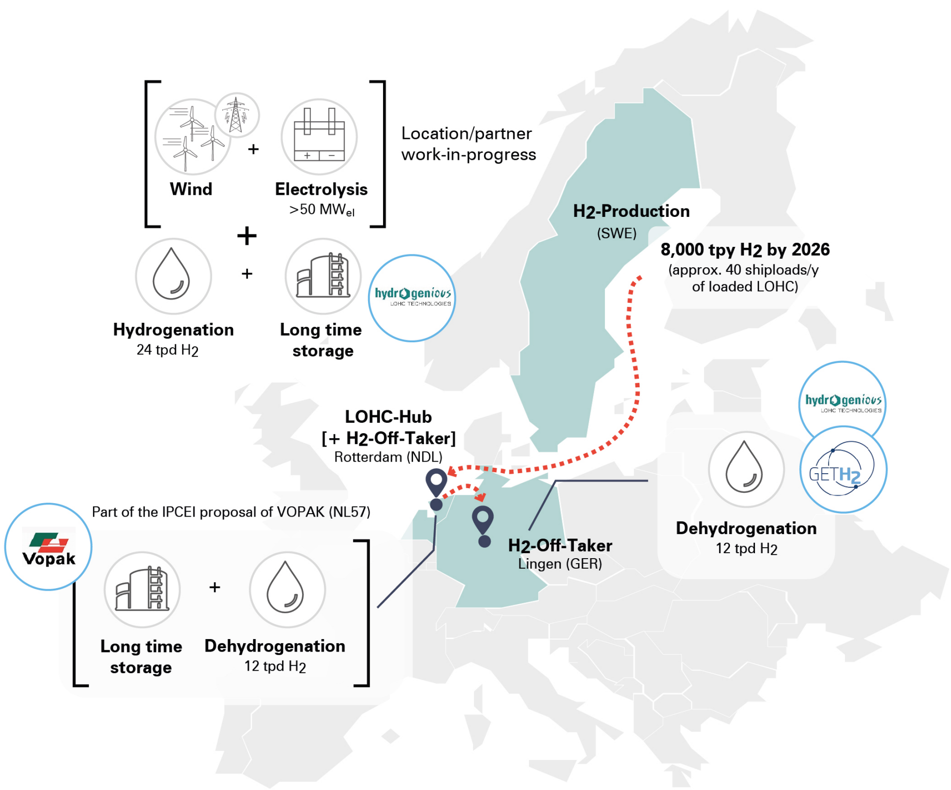
Partner: Hydrogenious LOHC Technologies GmbH, Vopak, Project GETH2

Background information:

Hydrogenious LOHC Technologies announced at the beginning of October that the hydrogen production site will be moved from Spain to Sweden. The background to this is that Spain has decided to use the hydrogen produced for the time being in its own country to cover its hydrogen demand. As a result, the name of the project was changed from "Green Crane" to "Northern Green Crane".

Hydrogenious LOHC Technologies

NORTHERN GREEN CRANE



Northern Green Crane (Source: Hydrogenious LOHC Technologies)

Innovation Award of the German Gas Industry | Germany

The associations of the German gas industry have now awarded the Innovation Prize for the 22nd time in the four categories "Application-oriented Research", "Sustainable Generation", "Intelligent Infrastructure" and "Efficient Application Technology". This way, inventors, visionaries and developers are given a stage to present groundbreaking concepts and projects that effectively contribute to the transformation of our energy system. From more than 50 applications, four projects were awarded the Innovation Prize of the German Gas Industry 2022 this year. Here are the four winners:

1) H_2-network and H_2-infra in the hydrogen village Bitterfeld-Wolfen

Since 2019, the transport, distribution and application of hydrogen has been tested on an experimental field at the Bitterfeld-Wolfen Chemical Park.

Within the project "H_2-Infrastructure - Efficient and Safe Operation of Hydrogen Distribution Networks (H2-Infra)", which is funded by the German Federal Ministry of Economics and Climate Protection, the application of hydrogen in households and businesses is tested under realistic conditions.

In Newsletter#33 we already reported on the project results of the HYPOS project "H_2-Netz", whose research infrastructure is also located at the Chemiepark Bitterfeld-Wolfen.

In Newsletter#36 we informed about the project goals of the HYPOS project "H_2-Infra", which will run until the end of 2024.

2) Negative emissions with CO_2 from biogas and fuel cell

The project partners developed an efficient and economical closed-loop technology for the CO_2-negative production of biogas, electricity and hydrogen. A bidirectionally running solid oxide fuel cell system was integrated into the conventional biogas upgrading process. This reversibly produces electricity from biogas or hydrogen from electricity depending on demand. The project partners are Landwärme GmbH and Reverion GmbH.

3) PSIcontrol / Green gas: Energy security through precise modelling

With the help of this software solution, hydrogen compatibility requirements and states are visualised for the grid infrastructure. Simulations of the feed-ins of hydrogen, biomethane or LNG are possible. The automatic driving mode suggestions enable an optimal operation of the gas grids even with the feed-in of gases of different properties. The software solution was developed by PSI Software AG.

4) H_2-Micro-Mix burner: H_2 combustion system for gas turbines.

With the Micro-Mix fuel chamber, it is now possible to operate gas turbines with 100% hydrogen by volume! This innovative combustion system burns hydrogen CO_2-free and achieves significantly lower NO_x emissions than conventional combustion systems without the need for additional water or steam.

Winning team of the hydrogen village Bitterfeld-Wolfen: MITNETZ Gas, DBI, HTWK (Source: Innovation Award of the German Gas Industry)

Winner - Innovation Award of the German Gas Industry

GREATER4H - The STRING Megaregion's hydrogen infrastructure project for zero-emission mobility in Northern Europe | Europe

STRING hydrogen corridor (Source: Hynion)

With green hydrogen from Hamburg to Oslo

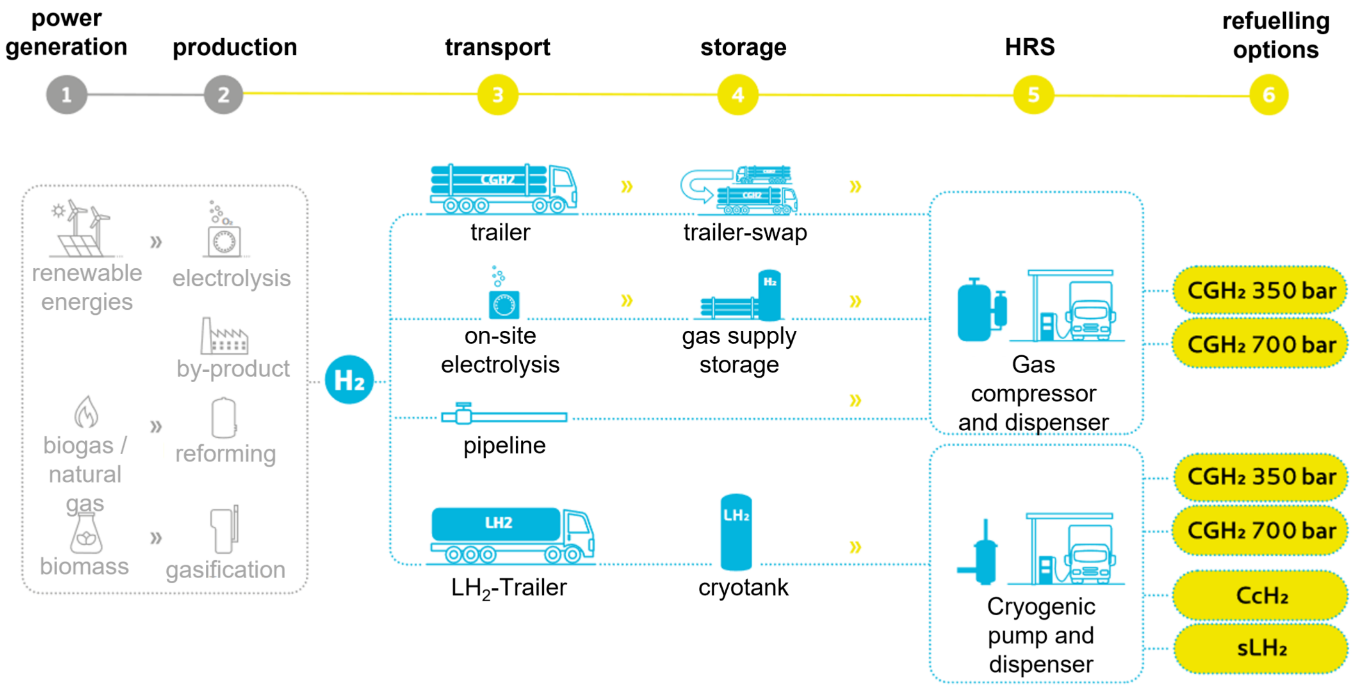
The hydrogen infrastructure project GREATER4H aims to convert heavy goods transport between Germany, Denmark, Sweden and Norway from diesel propulsion to hydrogen fuel cell technology. To this end, the EU has pledged funding from the EU's Connecting Europe Facility (CEF) programme and is supporting the construction of at least 12 hydrogen filling stations along the route from Hamburg to Oslo to the tune of 12 million euros. The new hydrogen infrastructure can help to leave diesel trucks behind beginning by 2025 and also enable other hydrogen-powered vehicles to refuel throughout the country. The project was developed in 2020/2021 under the STRING chairmanship of the state of Schleswig-Holstein. STRING (South Western Baltic Sea Transregional Area - Implementing New Geography) is a membership organisation linking local and regional governments from Germany, Denmark, Sweden and Norway. It serves to cooperate on cross-border infrastructure development, support the green transition in the transport sector and accelerate innovation and export of green industrial technology.

Hydrogen as an emission-free drive variant

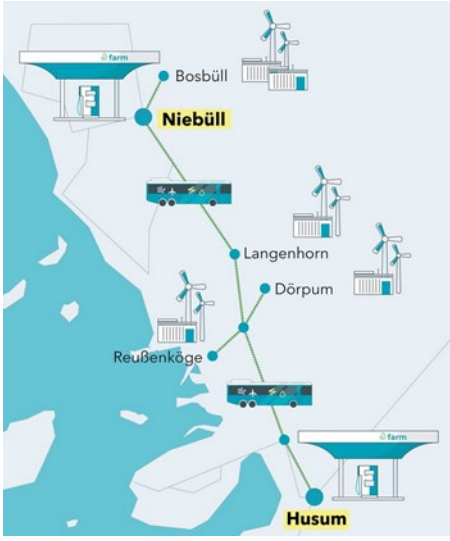
Hydrogen fuel cell technology has the potential to make the transport sector climate neutral. A hydrogen vehicle can be refuelled within 3 to 12 minutes, eliminating the logistical challenges of prolonged refuelling and thus idle times when recharging battery-powered alternatives. In addition, hydrogen vehicles have a long range, only minor payload losses, are silent and their only by-product is water. Thus, hydrogen offers a viable alternative to diesel and petrol for the transport of goods and people, and the fastest to implement. There are various refuelling technologies, whereby the delivery of hydrogen by trailer in gaseous or liquid form as well as **pipeline transport** for commercial use are seen as promising for the future, as is on-site **generation by electrolysis** (see figure below). In order to establish a nationwide refuelling infrastructure, further efforts and investments are necessary, especially with regard to the availability of green hydrogen and on-site refuelling facilities.

Cross-border teamwork

To solve the problem of refuelling infrastructure, STRING members and six private companies have initiated a transnational public-private partnership to support the development of hydrogen refuelling infrastructure. The hydrogen refuelling



Hydrogen value chain and refuelling technologies (Source: H_2 Mobility)



eFarm joint project (Source: eFarm)

stations between Hamburg and Oslo, funded by the CEF EU programme, are built and operated by the private partners Everfuel (DK), Hynion (NO) and GP JOULE (DE).

Everfuel has already built two filling stations in Oslo, with 8 more to follow - one in Germany, two in Sweden and five in Denmark. The stations will be equipped with 350 and 700 bar dispensers and will enable the refuelling of passenger cars and heavy commercial vehicles. For zero-emission mobility in Europe, the Danish company wants to **produce green hydrogen on the basis of electrolysis** and distribute it to the filling stations with its own hydrogen trailers. Everfuel already sells locally produced hydrogen from wind power, which comes from the **pilot project "Brande Hydrogen"** in cooperation with Siemens Gamesa. "Brande Hydrogen", implemented in the Danish town of Brande, is the world's first project in which a wind turbine is connected to an electrolyser and operated in "island mode" without a connection to an electricity grid.

GP JOULE will build two filling stations in the Schleswig region as part of the project. Commissioning is planned for the end of 2024 and the beginning of 2025. The planned delivery volume is at least one tonne of hydrogen per day. GP Joule will supply the green hydrogen itself. This is because with the **"eFarm"** project - Germany's largest hydrogen mobility project - the service provider for renewable energies in North Friesland already produces **green hydrogen from wind power at five locations via electrolysis** and operates two filling stations in Niebüll and Husum with it. The green hydrogen is transported to the filling stations in mobile hydrogen storage containers (see illustration beside).

Hynion will also build two hydrogen refuelling stations in Malmö and Gothenburg as part of GREATER4H. Hynion is also planning a station in Oslo, the end of the corridor from Hamburg via Denmark and western Sweden to Norway. In addition, Hynion is pursuing the ambitious goal of building more than 100 hydrogen filling stations across Europe by 2030. Starting with smaller electrolysers for green hydrogen production on site, Hynion plans to **build a centralised system for hydrogen production** in cooperation with the company HydrogenPro. In the future, the green hydrogen produced there in large-scale electrolysis plants will be distributed to the filling station network with hydrogen trailers.

Quantron (DE) is a system provider of battery and hydrogen-powered e-mobility for commercial vehicles. As Work Package Leader in the GREATER4H project, Quantron will supply hydrogen vehicles in different weight classes.

Ørsted (DK) and **RENOVA** (SE) have also joined the GREATER4H project as associated partners, supplying green hydrogen and operating hydrogen trucks respectively. The project is further supported by the 13 public STRING members by harmonising their regulations regarding the delivery of hydrogen infrastructure as much as possible.

The commitment of the STRING organisation and its partners also takes into account the regulations on the development of infrastructure for alternative fuels adopted by the European Parliament in October 2022. According to this, **hydrogen refuelling stations are to be installed every 100 kilometres on the EU's main roads by 2028**.

eFarm plant in Bosbüll (Source: eFarm)

- https://stringmegaregion.org/
- https://www.hynion.com/
- https://www.everfuel.com/
- https://www.gp-joule.de/
- https://www.efarm.nf/efarm-nordfriesland/
- https://www.siemensgamesa.com/en-int/products-and-services/hybrid-and-storage/green-hydrogen/unlocked-brande-hydrogen-project
- https://www.europarl.europa.eu/news/de/press-room/20221014IPR43206/europaabgeordnete-fordern-ladestationen-fur-e-autos-alle-60-km
- https://h2-mobility.de/wp-content/uploads/sites/2/2021/10/H2M_Ueberblick_BetankungsoptionenLNFSNF_TankRast_2021-10-21.pdf

Qualification / Training / Skilled workers in the hydrogen sector | Germany, France, Brazil

"When previous niche technologies come into widespread use, new skills and possibly new job profiles are needed, which sometimes have the potential to disruptively change or at least question previous professions. The integration of hydrogen into our existing infrastructure systems triggers such a chain reaction." (VDE/DVGW 2022)

VDE/DVGW Impulse Paper Knowledge Transfer Hydrogen | Germany

The topic of further education in the hydrogen industry is gaining momentum in Germany. This is illustrated, for example, by an impulse paper by the VDE and DVGW entitled "Hydrogen knowledge transfer - the hydrogen market ramp-up needs skilled workers today". This paper predicts a great need for retraining and further education for technical qualifications and competences as well as legal (licensing, regulation), business (economic feasibility) and planning competences. Based on the individual areas of the hydrogen value chain, the impulse paper identifies training needs and takes a closer look at them under the aspects of "involved occupational groups" and "cross-cutting issues" and lists them in tabular form.

VDE/DVGW 2022 online at impuls-papier-wissensvermittlung-wasserstoff--2--data.pdf (vde.com)

Learning Lab - H2Skills | Germany

The H2Skills project focuses on how to find and close local skills gaps in the northern German hydrogen economy. It was launched in 2021 and is being implemented with funding from the European Social Fund (ESF). To determine the actual market needs, data was collected through online surveys and expert interviews, and companies were surveyed. Based on this data analysis, a targeted curriculum was developed that reflects the actual needs of the local industry. A series of courses, certifications and training modules will now be introduced from October 2022.

H2Skills 2022 Learning Lab - H2Skills (unesco.org)

"Hydrogen Competence Hub" - Practical seminar in the Hydrogen Village | Germany

In the hydrogen village in Bitterfeld Wolfen, DBI, together with the project partners of MITNETZ GAS, transferred the results gained from the completed HYPOS H2-Netz project and the existing competences into a 2-day practical seminar. The training course has been arranged by the DVGW within the framework of vocational training as a certificate course in H_2 expertise - Module 5: Practice - Basics for pipeline-based supply with hydrogenous gases and hydrogen. The aim of the seminar is to teach participants the basics of the hydrogen value chain on a theoretical basis and to familiarise them with the handling of hydrogen in practice. Being able to get hands-on is the major added value for the participants.

The first day of the training will take place at DBI-Gastechnologisches Institut gGmbH Freiberg. There, content on hydrogen production, transformation of the gas infrastructure to hydrogen and possibilities of hydrogen end-uses in industry, commerce and households will be presented. Furthermore, there will be a first practical demonstration on the flammability of hydrogen and how to extinguish a hydrogen fire.

The second day takes place on the premises of the hydrogen village in the Bitterfeld-Wolfen Chemical Park. There, MITNETZ GAS will carry out work with the participants on a gas pressure control system, shutting down and starting up a pipeline section, using a hydrogen flare and shut-off procedures by means of squeezing and bubble setting.

The aim of the practical seminar is to sensitise participants as best as possible in the field of pipeline-based hydrogen supply, to inform them about the potentials for a sustainable energy infrastructure and to provide them with practical training while taking safety requirements into account. The training is aimed at employees of all fields of action with a technical background and basic gas knowledge who want to build up or deepen their expertise on the topic of hydrogen.

https://www.dvgw-veranstaltungen.de/veranstaltungen/direktsuche/60005 (further information and registration for the training)

Practical seminar in the hydrogen village (Source: DVGW)

In addition, a scientific study by HYPOS e.V. on behalf of the Centre for Digital Work on job profiles and skills in the hydrogen economy with a focus on the new federal states and Berlin was published on 5 October 2022.

HYPOS 2022 online under Vocational Qualification in the Hydrogen Industry (hypos-eastgermany.de)

DVGW Vocational Training | Germany

In response to the expansion of the DVGW rules and regulations to include climate-neutral gases such as hydrogen, the DVGW's vocational education and training department is offering modular courses that can be booked individually to acquire basic hydrogen expertise. The courses are aimed at employees from all fields of activity with a technical background and basic knowledge of gases who would like to build up their technical competence in the field of hydrogen.

- Certificate course "Professional competence H_2" - Module 1 (Basics of hydrogen-containing gases and H_2)
- Certificate course "Technical Competence H_2" - Module 2 (Hydrogen-specific requirements of the DVGW Code of Practice)

DVGW website Vocational Training: Direct search (dvgw-veranstaltungen.de)

Study on skills and professions in the hydrogen sector | France

In France, France Hydrogène has highlighted in detail why knowledge transfer is so important in the hydrogen economy and for its development, and has gathered much needed competences.

The National Strategy for the Development of Hydrogen declares the hydrogen sector a strategic industry for France. By 2030, more than 100 000 jobs will be created in the hydrogen technology sector. Capacity building in the industry and in the regions with regard to hydrogen technology is therefore of great importance.

France Hydrogène has created a reference system listing the skills and professions in the hydrogen sector. This reference system lists 84 professions. The first observation is that the hydrogen sector needs existing professions with a greater or lesser degree of specialisation:

- 27 professions require expertise in hydrogen,
- 41 professions require basic knowledge,
- 16 occupations do not require specific knowledge about hydrogen.

The identification of 17 already strained occupations indicates a lack of availability of the relevant skills and occupational profiles in the short term. These occupations are subject to competition between several industries. Fast measures need to be taken to address the low attractiveness of the industries and to create the relevant know-how.

Engineers, technicians and operators are currently trained in the majority of companies on the specifics of hydrogen that their profession requires. As the supply of initial hydrogen-specific training is currently very low, some industrial companies are engaging at the local level to develop training modules in partnership with institutions.

In order to match the strategic challenges with the realities of the professional world, efforts must be immediately directed towards the development of training opportunities to avoid the risk of a shortage of know-how.

STUDY ON SKILLS AND PROFESSIONS IN THE HYDROGEN SECTOR (SOURCE: FRANCE HYDROGÈNE 2021)

GIZ 2022 online under Promoting Green Hydrogen in Brazil (H2Brazil) (giz.de)

Hydrogen curricula of the "H2Brasil" initiative | Brazil

In Brazil, too, it was recognised how urgent the topic is. Therefore, within the framework of the "H2Brasil" initiative, a hydrogen curriculum was developed that addresses the needs of a hydrogen economy in Brazil with new occupational profiles. These job profiles are, for example, "gas transport logistician", "technical specialist for the operation of plants for the production of green hydrogen" and "specialist for green hydrogen systems".

France Hydrogène 2021 "Compétences-métiers de la filière Hydrogène. Anticiper pour réussir le déploiement d'une industrie stratégique" online at France_20Hydrog_C3_A8ne_Livre_20blanc_20Comp_C3_A9tences-m_C3_A9tiers_Final.pdf (france-hydrogene.org) (only in French)

Construction and approval of the connection line "WAL" in best time | Germany

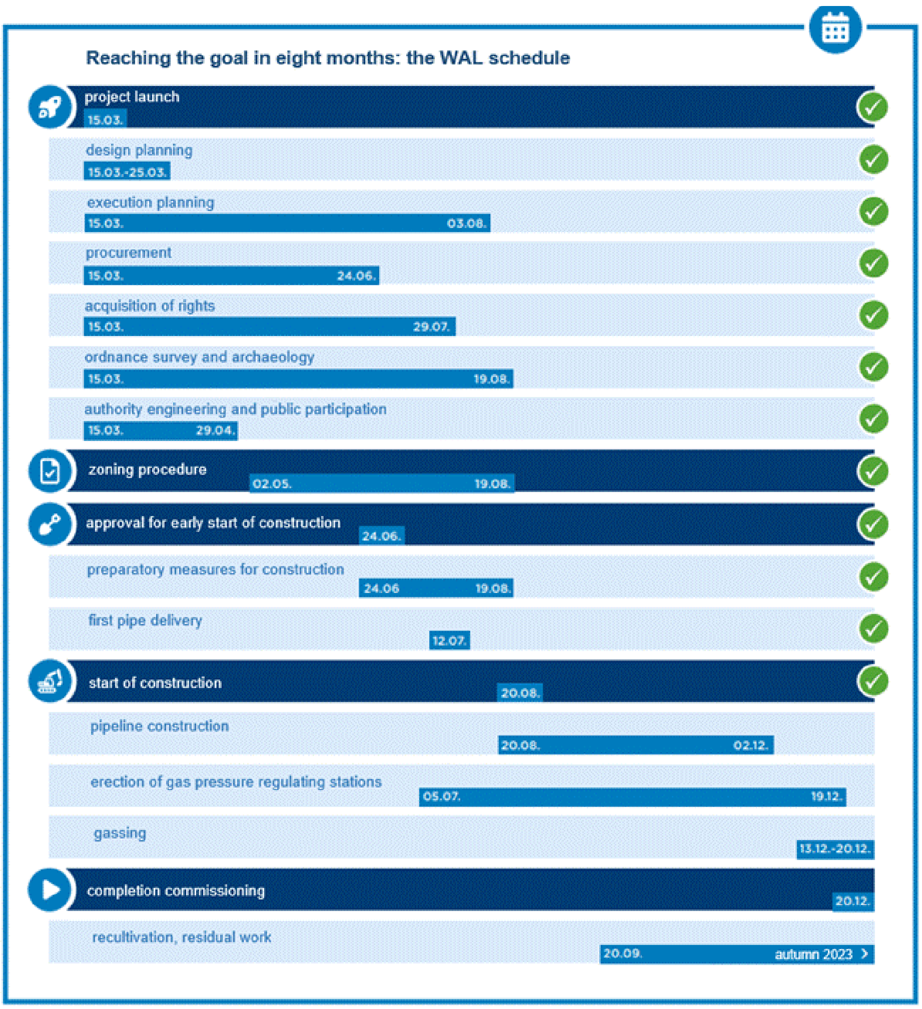
The hydrogen-capable Wilhelmshaven connection line "WAL" has been completed and commissioned in December 2022. The construction phase started in August 2022 after a particularly speedy approval process - for which there was close cooperation between politics, authorities, society and Open Grid Europe (OGE).

The pipeline will start at a new LNG terminal on the North Sea coast and run for about 27 km to the Norddeutsche Erdgas-Transversale (NETRA) pipeline at the Etzel natural gas storage facility (see figure beside). It will have a diameter of about one metre (DN 1000), an operating pressure of up to 100 bar and an initial capacity of 10 billion m³.

In addition to the pipeline, special structures are also being built, such as gas pressure regulating systems and a pipeline shut-off device, the Schortens-Heidmühle LSE station. This self-sufficient station enables the gas pipeline to be quickly and specifically secured in the event of an operational fault by closing sections using remote-controlled section shut-off valves. In addition, data on the voltage supply and the cathodic corrosion protection of the pipeline are regularly recorded.

Planned route of the WAL pipeline (Source: OGE)

Another special feature: the State Office for Mining, Energy and Geology (LBEG) approved the project with a high staff input in record speed; for similar projects, the approval time was almost 8 times longer. Within 3.5 months, the authority carried out the planning approval procedure to approve the project (see figure beside). The new LNG Acceleration Act also made a significant contribution, enabling individual procedural steps to be shortened by several weeks.



The WAL-Scedule on Permitting and Construction (Source: OGE)

Wilhelmshaven connection line | OGE and WAL Brief Nr. 7 (Newsletter subscription required)

Liquefied gas: Pipeline construction in record time | Made in Germany | DW | 02.11.2022 (Video in German)

Alstom's record drive over 1175 km | Germany

First emission-free hydrogen trains in regular service and record journey over 1175 km

After successful test operation (HIPS-NET reported in Newsletter#21), 14 hydrogen fuel cell-powered Coradia iLint trains from the manufacturer Alstom have been in regular service since August 2022. They connect the cities of Bremervörde, Bremerhaven, Cuxhaven and Buxtehude in the Weser-Elbe triangle and replace 15 diesel trains that were previously operated on these non-electrified routes. The project involves the Landesnahverkehrsgesellschaft Niedersachsen mbH (LNVG), the rail vehicle manufacturer Alstom, the Eisenbahnen und Verkehrsbetriebe Elbe-Weser (evb) and the gas and engineering company Linde (project volume: 93 million euros).

With a tank filling of 250 kg of hydrogen, the trains can travel over 1000 km. This was demonstrated on 15.09.2022 by a record-breaking journey from Bremervörde via Frankfurt am Main to Munich: A total of 1175 km was covered in 19 hours without refuelling.

In the future, not only the drive itself, but also the production of the hydrogen should be free of CO_2 emissions: The operators are relying on green hydrogen from electrolysis with renewable energy.

Emission-free fuel cell train Coradia iLint in operation (Source: © evb / Sabrina Adeline Nagel)

https://www.alstom.com/alstom-coradia-ilint-distance-run

https://www.alstom.com/de/press-releases-news/2022/8/weltpremiere-erstes-netz-mit-14-wasserstoffzuegen-nimmt-niedersachsen

Ceremonial commissioning of the first hydrogen-powered dredging demonstration plant | Germany

On 1 December 2022, Germany's first hydrogen-powered dredging damage demonstration facility (H2-BSDA) was ceremonially commissioned at the DBI in Freiberg. Previously, the training facility was operated with natural gas. Now it has been modernised and expanded to include hydrogen as an energy source.

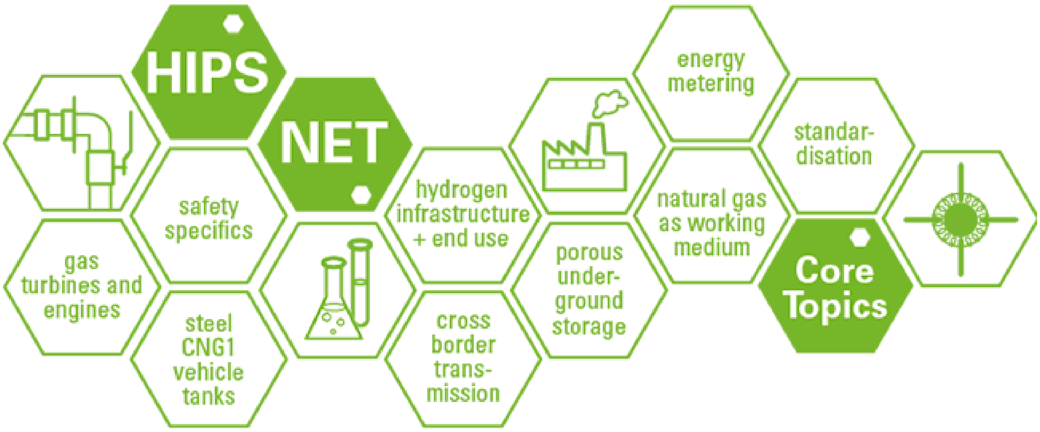
The H2-BSDA was opened with a big bang and the hydrogen operation was demonstrated live. The DBI Group also presented the new hydrogen training course. Employees of energy companies, pipeline and construction firms as well as firefighters can be trained for accident scenarios with the help of this training facility.

Realistic scenarios can be run through in several prepared high-pressure pits to train participants in handling natural gas/hydrogen mixtures and hydrogen and to prepare them for emergency situations.

Opening of the H2-BSDA in Freiberg (Source: DBI Group)

Hydrogen training - DBI - Gastechnologisches Institut gGmbH Freiberg (dbi-gti.de)

HIPS-NET CORE TOPICS



EVENTS AND PARTNER

EVENTS (SELECTION)

January 2023

23 3Minutes2Talk: Building a global hydrogen economy | Hannover, Germany, *Hydrogen & Fuel Cells: 3MINUTES2TALK: Building a global hydrogen economy (hannovermesse.de)*

23-24 20th International Congress on Renewable Mobility | Berlin, Germany, *https://www.kraftstoffe-der-zukunft.com*

24-26 Crash course: Hydrogen expertise in 3 days Does the energy transition stand a chance without hydrogen? | online, *https://www.dvgw-kongress.de/veranstaltungen/gas/crashkurs-wasserstoff*

February 2023

1-2 HyVolution 2023 | Paris, France, *https://paris.hyvolution.com/en/event*

March 2023

22-23 Hydrogen Cross Border Conference + Excursion Weser-Ems | Emmen, Netherlands + Weser-Ems-Region, Germany, *Hydrogen Cross Border Conference - Anmeldung (aanmelder.nl)*

Partner

Alliander AG, Cadent, DGC, DNV GL, Elogen, Enagás,
Enbridge, Energinet.dk, ENGIE,
EWE Netz, Gas Connect Austria GmbH,
Gasnetz Hamburg, Gasum OY,
Gasunie, GRTgaz, GRZI e.V. (FIGAWA),
Infraserv GmbH & Co. Höchst KG,
INERIS, innogy SE, ITM Power,
Joint Research Centre (JRC), EC,
KOGAS, NAFTA a.s, Naturgy, Netze Südwest, ONTRAS, ÖVGW, Open Grid Europe GmbH,
Polymer Consult Buchner GmbH,
RAG Austria AG,
Shell, Solar Turbines Europe S.A.,
Storengy, SVGW,
Synergrid, Teréga, TNO,
Uniper Energy Storage GmbH,
Verband der Chemischen Industrie (VCI),
Wintershall Dea AG.

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Certified DIN EN ISO 9001:2015

HIPS-NET

"ESTABLISHING A PAN-EUROPEAN UNDERSTANDING OF ADMISSIBLE HYDROGEN CONCENTRATION IN THE NATURAL GAS GRID"

NEWSLETTER #42 **FEBRUARY, 2023**

Dear HIPS-Net Partner,

we hope you all had a good start into the new year 2023 and wish you all the best!

The 42nd Newsletter contains the following exciting topics:

- Africa's Green Hydrogen Revolution | Africa
- Underground storage of green hydrogen in caverns - limits for compressor systems | Germany
- MéthyCentre project - catalytic methanation | France
- Australia's first large-scale hydrogen plant Yuri | Australia
- Hydrogen in industry: steel production, paint shop and glass melting | Germany, Sweden
- "Hydrogen Infrastructure Map Europe" | Europe

We hope you enjoy reading!

Please mark your calendars for the 10th HIPS-NET workshop. We are very optimistic that we can finally meet again in Brussels on 15 June 2023 (there will be a casual dinner together the evening before). If there is interest from your side to give a presentation, please feel free to contact Josephine. We are really looking forward to it!

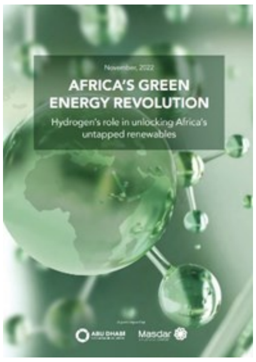
Your HIPS-NET Team

Gert, Josephine and Ruven

CONTENT

content NEWSLETTER #42

Africa's Green Hydrogen Revolution | Africa



In November 2022, the report "Africa's Green Energy Revolution - Hydrogen's role in unlocking Africa's untapped renewables" was published. This report was produced by Masdar (Abu Dhabi Future Energy Company) and ADSW (Abu Dhabi Sustainability Week) with analytical support from McKinsey & Company.

Background

The African continent is suitable for producing low-cost, renewable hydrogen for export and domestic use, as several regions in the northern and southern parts of Africa have very favourable wind and solar resources. National and international actors are increasingly recognising this potential, and hydrogen activity on the African continent is growing. African countries now account for about 3 % of the hydrogen projects announced worldwide. While this is still a small share, the announced capacity doubled last year alone.

North Africa is uniquely positioned to serve European demand centres and can supply hydrogen directly due to the short distances (e.g. about 3,300 km from Algeria to Germany). Companies can convert existing natural gas export infrastructure to hydrogen pipelines (e.g. in Algeria, Tunisia and Libya). Parts of Northwest Africa (such as Morocco or Mauritania) are competitive on a global scale due to attractive solar and wind resources and proximity to Europe and the export of pure hydrogen via pipelines.

A look into the crystal ball

Africa could achieve hydrogen production of 30 to 60 million tonnes per year by 2050, requiring investments of USD 680 to 1,300 billion. Such a hydrogen industry would likely create 1.9 to 3.7 million jobs in the African economy and have a positive impact on GDP of USD 60 to 120 billion in 2050. Other socio-economic benefits include broader economic development and electrification of African societies, the creation of a cleaner energy system and reduced dependence on imported fossil fuels.

Africa has a theoretical potential capacity of about 850 terawatts (TW) of solar and wind energy. If only 2% of this, i.e. 17 TW of renewables, were used for the production of green hydrogen, about 900 million tonnes per year could be produced, which is about 1.5 times the total global demand of 610 million tonnes per year in 2050.

Benefits of green hydrogen for Africa

Green hydrogen can accelerate and expand the use of renewable energy in Africa in three ways:

1. Green hydrogen serves as an anchor for the integration of renewable energies into the energy system.
2. Green hydrogen production plants act as a grid buffer, enabling better integration of renewables into the system.
3. Green hydrogen projects create an ecosystem and infrastructure for renewable energy, local jobs, access to new technologies, co-finance infrastructure and open the door for new foreign investors.

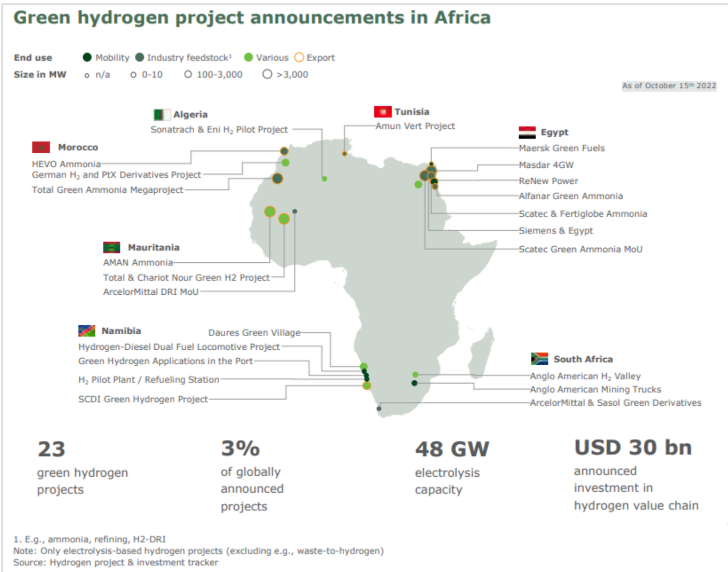
Six crucial implementation steps

To implement this, both governments and the private sector need to act. Six critical issues have been analysed that can facilitate necessary investments:

1. Integrated vision and master plan for energy from renewable sources and hydrogen (guideline)
2. Steering, (international) coordination and mobilisation
3. National legal framework for hydrogen exports and international alignment
4. Extensive infrastructure investments (grid capacities, roads, ports, water desalination)
5. Innovation and workforce qualification
6. Mechanisms to reduce project risk

Status Quo H_2-Project Announcements

African governments and companies, international investors and global energy companies are increasingly recognising the opportunities that hydrogen offers. In the last three years, more than 20 projects have developed across Africa (see figure) with an electrolyser capacity of about 48 gigawatts (GW).



Announcements of green hydrogen projects in Africa (Source: Report, p. 12)

More than 90 % of these volumes are focused on exports (mainly ammonia), while the remainder target domestic demand in the transport sector, chemical and fertiliser sectors. About 15 % of the investments are in feasibility or front-end engineering or FEED (front-end engineering design) studies, while about 85 % are at an early stage of announcement.

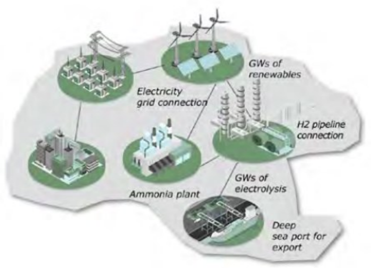
Study on project types

Three project types are examined in the study: Grid-connected exports, export island and green hydrogen for on-site demand. The first two project types are briefly presented here.

A) Project type "Grid-connected exports“

This project type includes large-scale hydrogen projects with several GW of renewable energy and electrolysis connected to the grid. The grid-connected export project type mainly aims to produce either pure hydrogen (for pipeline injection) or derivatives such as ammonia or synthetic fuels for export. The project is connected to the grid for all or part of the energy and can draw electricity from the grid - or feed energy into the grid to meet local demand. Such projects can be implemented in export locations where there is also significant potential local energy demand, such as near Cairo in Egypt. In order to integrate the new energy, upgrades to the existing transmission grid (e.g. higher line capacities) may be required.

Grid-connected export project



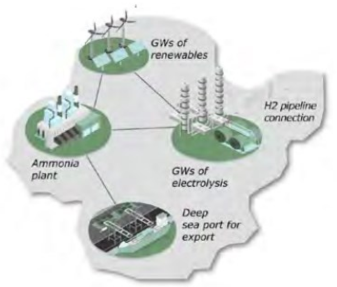
Infrastructure connection	Full/partial grid connection, hydrogen pipeline connection possible
Project size	RES and electrolysis capacity in GWs
Production focus	Pure hydrogen, derivatives (e.g., ammonia, synfuels)
Target use	Export (primary), local use (secondary)
Involved stakeholders	Investors (foreign), transmission system operators (local), government entities (local/foreign)

PROJECT TYPE „GRID-CONNECTED EXPORTS“ (SOURCE: REPORT, P. 16)

B) Project type "Export island“

The second project type, the export island, is similar to the grid-connected export project type in terms of size and end use. However, these projects are completely isolated energy islands that use unused renewable resources for energy export without a physical connection to the entire domestic energy system or grid. The project developers and owners are usually predominantly foreign companies. Such projects can be carried out in remote desert locations, for example in southern Namibia, far from major cities. The autonomous energy system developed in such a project could be connected to the power grid (or even to other projects) at a later stage, gradually moving to an integrated energy system. In addition, connections could be made to provide low-cost

Export island project



Infrastructure connection	No grid connection, hydrogen pipeline connection possible
Project size	RES and electrolysis capacity in GWs
Production focus	Pure hydrogen, derivatives (e.g., ammonia, synfuels)
Target use	Export
Involved stakeholders	Investors (foreign) government entities (local/foreign)

PROJECT TYPE „EXPORT ISLAND“ (SOURCE: REPORT, P. 16)

electricity to nearby communities, which would have a direct positive impact on them.

Regulatory considerations

Regulation should be predictable and allow for effective business planning. This includes predictable tax regimes and contract certainty overseen by effective courts and institutions, but there are also specific regulatory considerations for large-scale renewable energy and hydrogen projects:

- Ensure conformity with international standards for green hydrogen so that importers can claim the full effect of decarbonisation. This could include setting standards such as life-cycle carbon content thresholds in line with the EU.
- Effective treatment of transmission and distribution fees for hydrogen producers. For example, if hydrogen serves as a complementary balancing service for the grid, regulators can waive these fees.
- Clear and transparent access to land and licensing procedures for renewable energy plus hydrogen, ensuring that both investors and the local population receive fair treatment and compensation.

Infrastructure considerations

The production and transport of hydrogen and hydrogen derivatives will require significant new infrastructure. This includes export ports, pipelines for hydrogen transport, water desalination plants, grid expansion and roads in large areas that are being redeveloped for renewable energy. While it is unlikely that public finances will allow countries to make all of these infrastructure investments from public funds, countries should have a strategic discussion about how to enable such investments and which assets governments should (co)invest in to attract investment. For example, if the electricity grid is public, there could either be a legal exemption for private investment in additional transmission capacity, or public funds could be invested through an adjusted transmission fee for the hydrogen project developer using the interconnection.

Background information on Masdar

The Masdar company has recently been working with other energy companies and governments to advance the development of green hydrogen as a future energy source. Masdar's multi-billion dollar clean energy investments include a major collaboration to produce green hydrogen and related sustainable synthetic fuels in Abu Dhabi, called Project Green Falcon.

In April 2022, Masdar and Egypt's Hassan Allam Utilities agreed to collaborate on the development of green hydrogen production facilities in the Suez Canal Economic Zone and on the Mediterranean coast. A strategic platform will be established for the development of green hydrogen production facilities on Egypt's Mediterranean coast. The project aims to achieve an electrolyser capacity of 4 GW and a production of up to 480,000 tonnes of green hydrogen per year by 2030.

Two project examples from Namibia

The conditions in Namibia are particularly good: in the Namib Desert, solar radiation reaches global peaks, strong winds blow on the southwest African coast and the proximity to the ports of Walvis Bay and Lüderitz facilitate exports. A national hydrogen strategy is still being worked on, but the first projects are already on their way to implementation. Project promoters are mostly consortia of Namibian and international companies and institutions.

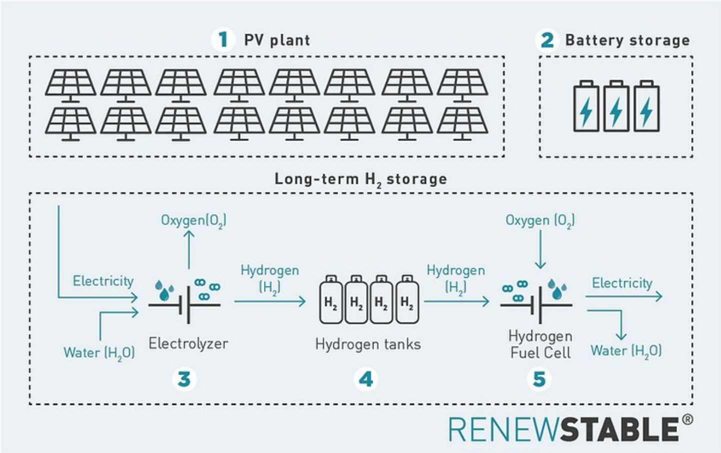
A) Tsau ǁKhaeb National Park Project of the Hyphen Hydrogen Energy Consortium

The investment company Nicholas Holdings and the German energy company Enertrag are involved in this project. In the Tsau ǁKhaeb National Park, on an area of 4000 km², the former diamond restricted area near the town of Lüderitz, 5 GW of generation capacities for solar and wind power are to be built and the electricity generated is to be converted into hydrogen by means of electrolysis. The water required will be treated by means of seawater desalination. In this way, around 300,000 tonnes of H_2 are to be produced per year.

HYPHEN HYDROGEN ENERGY (SOURCE: GH2 NAMIBIA)

B) Renewstable Swakopmund

The French company Hydrogène de France (HDF) is developing a project near Swakopmund that aims at a continuous power supply based on solar energy. Hydrogen is used as a storage medium for a solar power plant with 85 MW. When the sun is not shining, the energy stored in fuel cells can be converted back into electricity.



RENEWSTABLE SWAKOPMUND (SOURCE: HDF ENERGY NAMIBIA)

Source report: report_africas_green_energy_revolution.pdf (energycentral.com)

Source Namibia: Großprojekte machen Namibia zum Zentrum der Wasserstoffwirtschaft | Branchen | Namibia | Wasserstoff (gtai.de)

Underground storage of green hydrogen in caverns - limits for compressor systems | Germany

The German Aerospace Center published a study in August 2022 about the requirements of compressor systems for cavern storage facilities to store green hydrogen.

With the transition of the energy system from fossil fuels to renewable energy, green hydrogen can be produced from renewable electricity via electrolysis. Due to the mismatch between the timing of hydrogen production and demand, hydrogen needs to be stored. Salt caverns are suitable for the storage of hydrogen.

Within the study they exemplarily analysed a cavern from Lower Saxony in the north of Germany due to the availability of renewable energies and cavern gas storages. A hydrogen storage demand profile of one year was developed in hourly resolution from feed-in time series of renewable energy sources. The injection profile relevant for compressor operation was compared to current natural gas injection operation modes.

The aim of the study was to design and model concepts for technically feasible and energy-efficient underground storage of green hydrogen. At first, boundary conditions of the cavern were defined, with the balance sheet limits, pressure in the transmission network, hydrogen storage demand (forecast for 2050) and required cavern size.

Finally, the required storage conditions for hydrogen were compared with the natural gas parameters (see figure beside and table below). The comparison is based on the amount of annually stored hydrogen energy.

	Hydrogen	Natural Gas (Type H)
Annual stored energy [TWh]	6.08	6.08
Gross calorific value [kWh/m³] [51]	3.54	11.449
Required standard working gas volume [Mm³]	580.3	360.9
Required geometric volume [Mm³]	6.80	2.78
Energy storage capacity of caverns (single filling) [TWh]	2.05	4.13
Average number of cycles (stored energy/capacity) [a^{-1}]	2.96	1.47

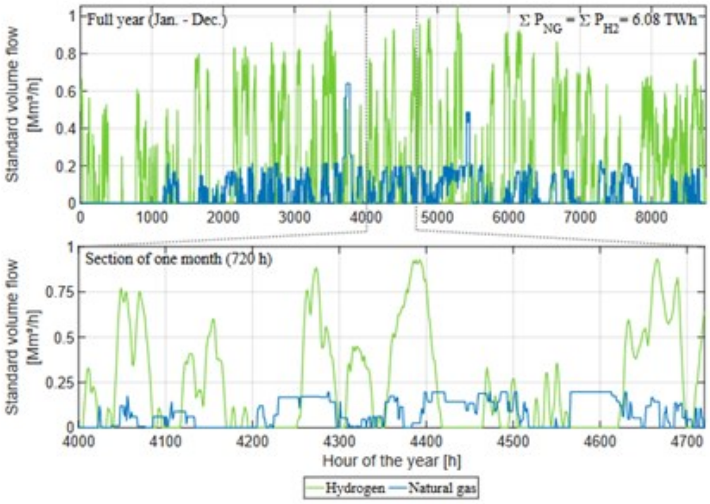
Comparison of the required storage conditions for hydrogen and natural gas storage parameters (Source: DLR)

In this scenario an amount of 6.08 TWh of stored energy per year was calculated. For the comparison, this was considered for both hydrogen and natural gas.

The results of the study show significant differences between the storage of natural gas and hydrogen. Hydrogen has a smaller gross calorific value than natural gas. Therefore, hydrogen requires a working gas volume that is about 3.2 times larger than the one for natural gas.

The hydrogen demand profile (see figure beside) is highly dynamic. It shows an increased injection during the summer and an increased withdrawal in the winter. The storage profile depends strongly on the availability of renewable energy as well as on the hydrogen demand, the geographical location and the regional energy system.

The different compressibility factors of the gases lead to an about 4.4-fold larger geometric cavern volume for hydrogen. But natural gas storage is more seasonal than green hydrogen, therefore only about 2.4 times the geometric cavern size is needed.



Comparison of the standard volume flows of injection between natural gas (blue) and hydrogen (green) storage with balanced annual energy quantities, over the course of a calendar year (top) and for the period of one month in summer (bottom) (Source: DLR)

With an increasing share of locally generated hydrogen quantities, gas storage facilities will increasingly take on the role of pressure stabilisation in the gas grid to avoid shutdowns of generation plants.

Regarding the compressor system for hydrogen storage facility, the following aspects should be considered compared to a natural gas storage facility:

- Three to four times higher standard volume flows require larger compressor capacities. Volume flows that cannot be processed would lead to a change in pressure in the upstream transport network, a shutdown of hydrogen production and upstream renewable energy production.
- The compressors should be placed on fast response and should have a wide-range controllability.
- Another solution might be buffer storage systems for the compensation of high dynamic but small capacities.
- A larger share of storage with a duration shorter than a year can be expected, which leads to doubling of the number of storage cycles.
- The more even distribution of injection phases over the year is relevant e.g., for compressor maintenance planning and reinforces the role of redundancy of compressor systems in gas storage operations.

Source: Underground Storage of Green Hydrogen—Boundary Conditions for Compressor Systems (dlr.de)

MéthyCentre Project—innovative linking of hydrogen mobility, synthetic and bio-methane | France

MéthyCentre is an innovative power-to-gas project in France for the production of renewable gases for green mobility applications and for storage or grid injection. The project combines and tests the interaction of electrolysis, methanisation and gas purification under the leadership of Storengy (energy storage specialist). The main objective of the project is to demonstrate and evaluate the technical and economic feasibility of the process in order to accelerate the industrialisation of methanisation.

The concept - coupling anaerobic digestion and power-to-gas

The hydrogen required for methanation is generated from green electricity in an on-site electrolyser, and some of the green hydrogen can be used for hydrogen filling stations. The other part of the hydrogen is combined in a methanisation process with carbon dioxide (CO_2), which is a by-product of the purification of biogas. Both the synthetic methane and the biomethane are fed into the gas grid and used for green mobility.

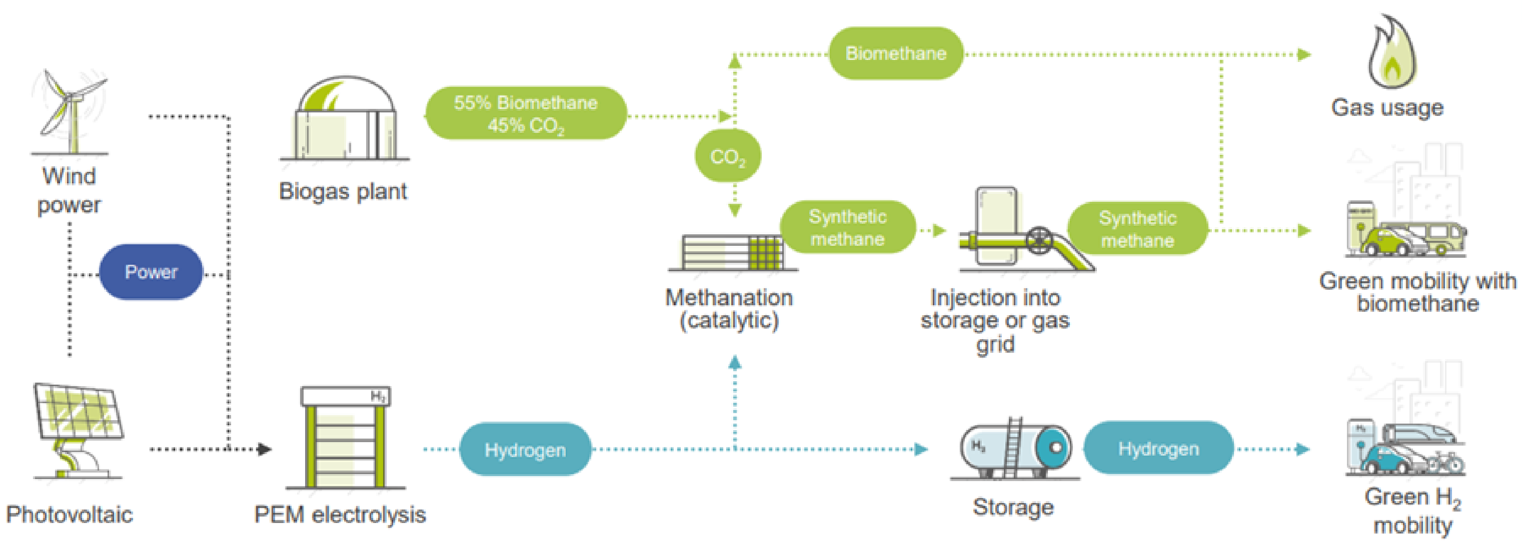
MéthyCentre - catalytic mathanation

The MéthyCentre project is the first project in the field of power-to-gas that couples biogas production, hydrogen electrolysis and *catalytic* methanation. It is being realised by Storengy and its partners KHIMOD (methanisation plant), PRODEVAL (specialist in the upgrading and recovery of biogas from the methanisation of organic waste), CEA and ELOGEN (design and assembly of electrolysers) on a 2 ha site in the Centre-Val de Loire region. Construction began in June 2021 and commissioning is scheduled for 2023.

In a biogas plant, organic material from farms in the surrounding area is converted into biomethane, CO_2 and organic fertiliser that can be used in agriculture. The resulting CO_2 is further used for *catalytic* methanation. The hydrogen required for this is obtained by using a 250 kW PEM electrolyser. The hydrogen production corresponds to about 50 kg/day and covers the demand of 20 light vehicles. In the process, MéthyCentre consumes about 1 GWh of renewable electricity from the grid per year, as well as 400 m³ of water. Using membrane separation, both the biogas and the synthesis gas are purified and upgraded according to green gas specifications. In this way, around 50 m³ of methane is produced every hour.

Sources:

- Methycentre | MéthyCentre
- MéthyCentre - Gas Infrastructure EuropeGas Infrastructure Europe (gie.eu)

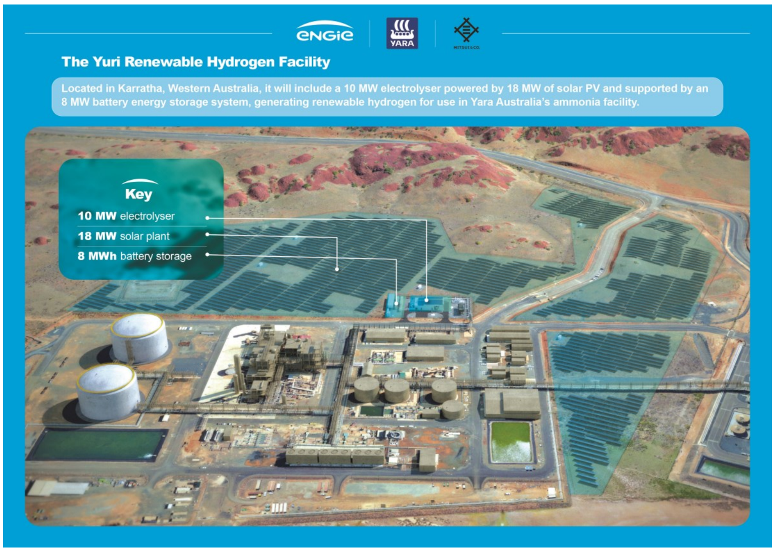


Systematic illustration of the MéthyCentre project (Source: Methycentre | MéthyCentre)

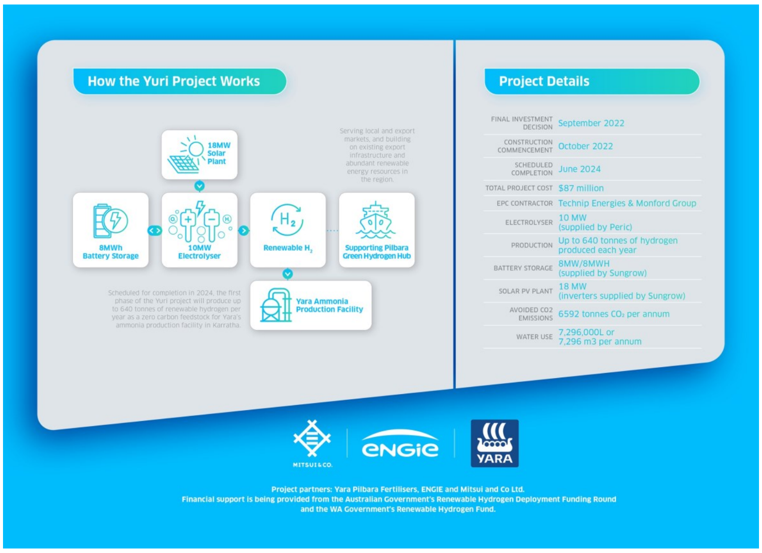
Australia's first large-scale hydrogen plant Yuri in the Pilbara region | Australia

One of the world's largest renewable hydrogen plants is to be built in the Pilbara region to supply hydrogen and electricity to Yara Pilbara Fertilisers' (Yara) existing ammonia plant near Karratha in Western Australia. The permitting process has been completed, a 100 per cent off-take agreement has been signed with Yara, and construction of the project started in November 2022 and is expected to be completed by mid-2024. When completed, this will be Australia's largest electrolyser, capable of producing up to 640 tonnes of renewable hydrogen per year in the first phase of the project. This will be key to the development of a green hydrogen hub in Pilbara, serving local and export markets and building on the existing export infrastructure and abundant renewable energy resources in the region. The project will also share knowledge and experience in community engagement, permitting processes and industry participation.

The project is funded by ENGIE and Mitsui, the Australian Renewable Energy Agency (ARENA) ($47.5 million) and the Western Australian Government's Renewable Hydrogen Fund ($2 million) under the Western Australian Government's Renewable Hydrogen Strategy.



Yuri project overview (Source: ENGIE)



Yuri Factsheet (Source: ENGIE)

The $87 million project includes:

- a 10 MW electrolyser for the production of renewable hydrogen
- an 18 MW photovoltaic system to supply power to the electrolyser
- 8 MW / 8 MWh lithium-ion battery for storage
- Avoided CO_2 emissions: 6592 tonnes CO_2 per year
- Water consumption: 7,296,000 l or 7,296 m^3 per year

"We have a strong pipeline of renewable energy, storage and hydrogen projects in Australia. With each of these projects reaching financial close, construction and commissioning, we move closer to decarbonising our economy and achieving our ambitious net zero targets," said Andrew Hyland, Chief Executive Officer of ENGIE Australia and New Zealand.

Source: Yuri Renewable Hydrogen to Ammonia Project | ENGIE

Contact: Carlos Trench, Head of Hydrogen Projects via E-Mail carlos.trench@engie.com

Hydrogen in industry: steel production, paint shop and glass melting | Germany, Sweden

Salzgitter AG steel production with green hydrogen

Salzgitter is characterised by strong industry from the steel, electronics and mobility sectors and aims to develop as a model region for the successful transformation of industry and society towards climate neutrality. With its SALCOS® programme, Salzgitter AG is implementing the complete transformation of the steelworks to green steel production by 2033. SALCOS stands for **SA**lzgitter **L**ow **CO_2** **S**teelmaking and aims to completely convert steel production in Salzgitter to low CO_2 crude steel production in three stages. As part of the transformation process, two direct reduction plants and three electric furnaces will be built, replacing the previous coking coal-based steel production with a new hydrogen-based route. A saving of 8 million tonnes of CO_2 emissions achieved in this way will prevent around 1 % of Germany's CO_2 emissions.

GrInHy2.0 Sunfire high-temperature electrolyser in Salzgitter (Source: Salzgitter AG)

In Salzgitter, the world's largest high-temperature electrolyser from Sunfire is already being used to produce green hydrogen for green steel production. This was developed and tested as part of the GrInHy2.0 (Green Industrial Hydrogen) project, which was successfully completed after 4 years. Since 2019, the electrolyser with an electrical connected load of 720 kW has been operating on the premises of Salzgitter Flachstahl and has achieved a record production of almost 100 tonnes of green hydrogen for the climate-neutral production of green steel. The hydrogen produced is fed directly into Salzgitter Flachstahl's hydrogen network and then used in the annealing processes and galvanising plants for steel refinement. The plant now achieves an electrical efficiency of 84 % $el_{,LHV}$ - which corresponds to an energy requirement of only 39.7 kWh/kgH_2 - and produces up to 200 Nm^3 of green hydrogen per hour. The high-temperature electrolyser is based on SOEC (solid oxide electrolysis cell) technology and runs at operating temperatures of 850 °C. The plant uses available steam from industrial waste heat and splits it into its components hydrogen and oxygen with the help of renewable electricity.

Dr Alexander Redenius from Salzgitter Mannesmann Forschung takes stock: *"GrInHy2.0 is an important building block for our SALCOS project for CO_2 -reduced steel production. Green hydrogen is indispensable for the production of low-CO_2 steel, as it can be used very efficiently to reduce CO_2 emissions from steel production. With GrInHy2.0 we have gained a lot of valuable knowledge on how to integrate electrolysis into our production processes."*

Source: GrInHy2.0: Grüner Wasserstoff für grüne Stahlproduktion | Salzgitter AG (salzgitter-ag.com)

Ardagh Group and Absolut Vodka use hydrogen-powered glass smelter

Ardagh Group S.A. and Absolut Vodka are jointly developing a partially hydrogen-fired glass furnace for the large-scale production of the iconic bottles. This hydrogen initiative is a crucial step for Absolut Vodka to become completely CO_2-neutral by 2030.

Ardagh Glass Packaging, a subsidiary of Ardagh Group, has signed an agreement with Absolut Vodka to use this partially hydrogen-fuelled glass vat from mid-2023. This innovative collaboration will accelerate the transition of the global glass manufacturing process to a more sustainable future. In the pilot project, 20 % of natural gas will be substituted by green hydrogen. The hydrogen used will be produced on site in Ardagh using electricity from renewable energy sources. The use of hydrogen can reduce Absolut Vodka's CO_2 footprint in glass production by 20 %.

Bo Nilsson, Managing Director of Ardagh Glass Limmared AB, says: *"Our industry needs to be less dependent on fossil fuels and move faster towards more green energy. By investing in this new technology, we are embarking on a journey to reduce the carbon footprint of our glass packaging. Such innovation has challenges, but we are determined to lead the way in securing the future of our global glass production."*

Low-CO_2 production of glass bottles (Source: Absolut Vodka)

Source: Ardagh Group & Absolut Vodka co-invest in hydrogen-fired glass furnace

Hydrogen in industry: steel production, paint shop and glass melting | Germany, Sweden

Special glass manufacturer Schott tests use of hydrogen for glass production | Germany

The company Schott wants to become climate-neutral by 2030 and therefore also relies on the use of green hydrogen. Hydrogen and natural gas are mixed in a container on the factory premises and fed into the heart of the plant, where the gas mixture is used to heat the melting tanks. Constant temperatures of 1700 degrees Celsius are needed for glass production. In the first phase, 10 % hydrogen by volume was added, but now there is 35 % H_2 by volume in the natural gas. The first results of the tests are promising: sufficiently high temperatures are achieved for the glass melt. Now it is to be investigated whether the use of hydrogen has an effect on the glass quality. A test with 100 % hydrogen in the laboratory is planned for 2023.

The only problem that still exists is the availability of green hydrogen. Currently, grey hydrogen is still being used, as there is still no possibility of connecting to a hydrogen pipeline.

Schott CEO Frank Heinricht says: *"We are still in an experimental phase with our hydrogen project. But if we really want to use hydrogen on an industrial scale, we need the necessary infrastructure."*

Hydrogen for glass production at Schott (Source: tagesschau.de)

Source: Produktion mit Wasserstoff: Geht Industrie ohne Erdgas? | tagesschau.de

BMW plant replaces natural gas with hydrogen in paint shop

At the Leipzig plant, the carmaker has now used hydrogen burners in the paint shop for the first time worldwide. This means that green hydrogen from electrolysis can be used instead of natural gas to dry the vehicle paint. In addition, hydrogen is to be used more for transport in the future.

Flexible hydrogen burners in the paint shop (Source: BMW Group)

The burner can burn hydrogen and methane alone or in a mixture. The changeover of fuels can take place during operation. A total of 68 burner systems are to be converted in the next few years, which were developed together with a Bremen company. The Fraunhofer Institute IFF has developed a safety concept for BMW and is supporting integration. In order to reduce carbon emissions in production by 80 percent by 2030 compared to 2019, BMW wants to use other renewable energy sources besides hydrogen.

A prerequisite for the continuous hydrogen operation of the burners is the sufficient pipeline-based availability of green hydrogen. In this context, it is advantageous that a water network is being built in the region and BMW can connect its production site to a pure hydrogen network. There are plans with other companies in the region to connect to the long-distance gas pipeline about two kilometres from the plant. This is the second longest hydrogen pipeline in Germany, with a length of 150 km, and is operated by the chemical companies Linde and Dow Chemical. In the future, more green hydrogen is to be fed into this pipeline.

Chief Production Officer Milan Nedeljković: *"This technological breakthrough underlines our innovative strength and our will to continuously improve the sustainability of our production."*

Source: Wasserstoffbrenner Lackiererei (bmwgroup-werke.com)

Hydrogen Infrastructure Map Europe

In a joint initiative of ENTSOG, GIE, EUROGAS, CEDEC, GD4S and GEODE in cooperation with the European Hydrogen Backbone, a bottom-up process was launched to map all relevant hydrogen infrastructure projects and subsequently publish this data in a publicly accessible map.

The interactive hydrogen infrastructure map includes the projects and perspectives of transmission system operators, distribution system operators, storage operators and LNG system operators as well as third-party project sponsors along the entire value chain.

It includes:

> **220** hydrogen projects in total

> **120** hydrogen transport and distribution projects

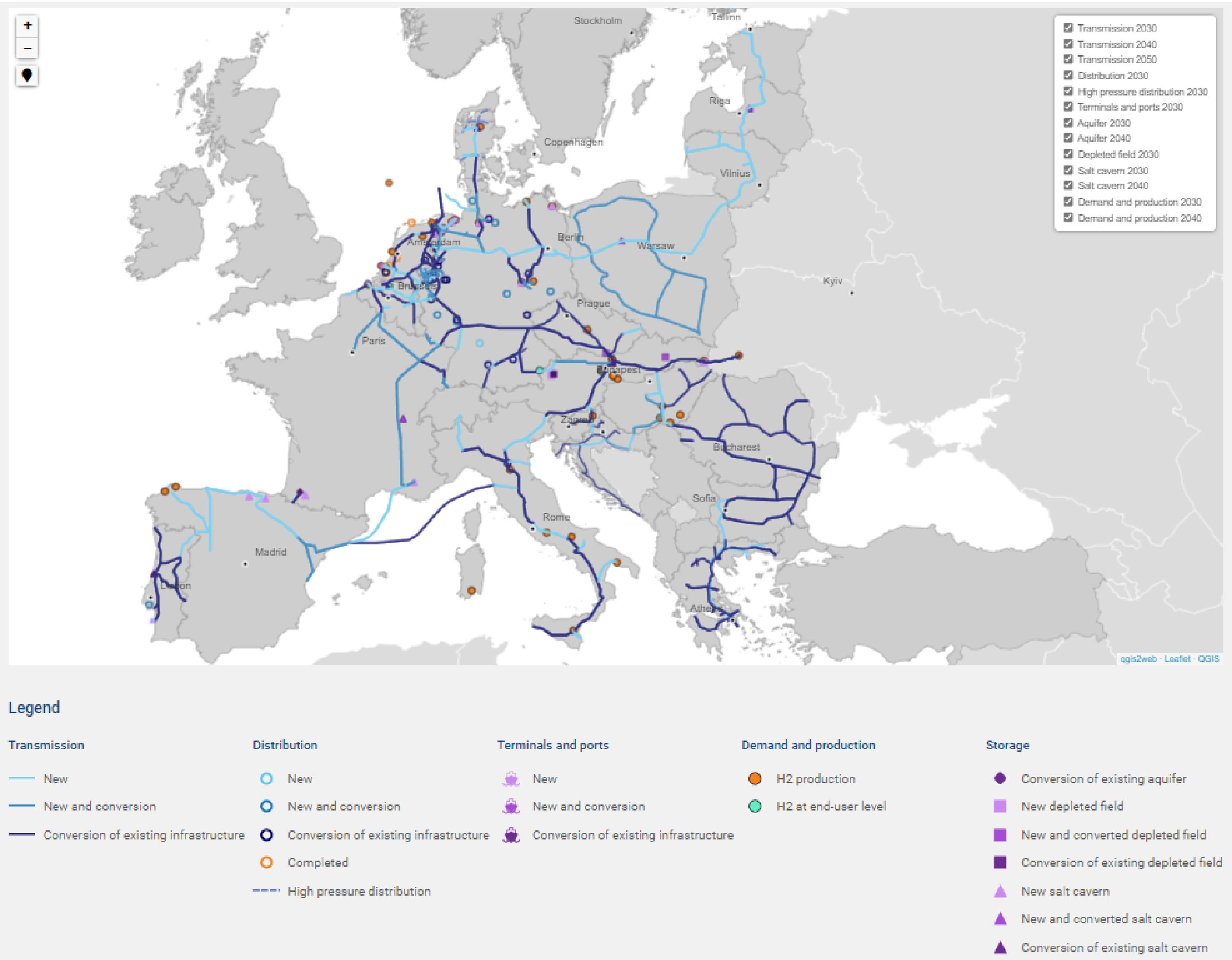
> **40** hydrogen storage projects

> **10** hydrogen terminal and port projects

> **40** hydrogen demand and production projects

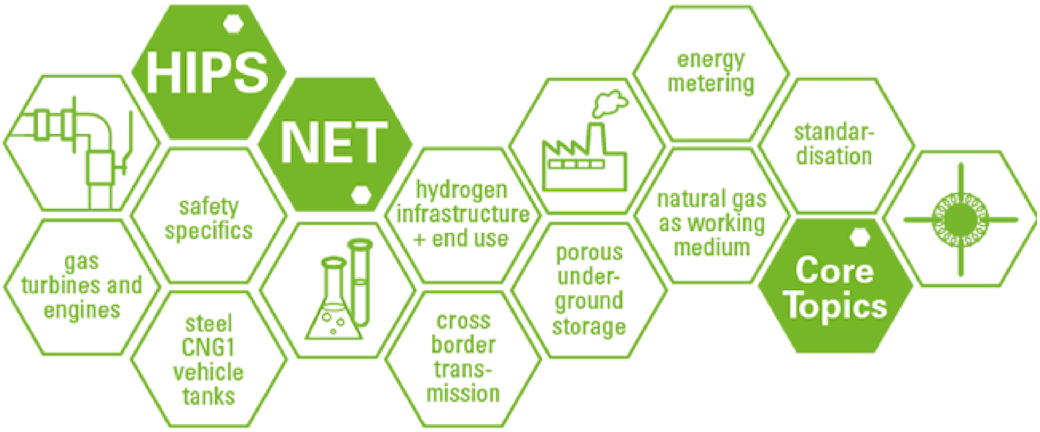
Click here for the interactive map:

H2 Infrastructure Map Europe (h2inframap.eu)



Interactive hydrogen infrastructure map (Source: H2 Infrastructure Map Europe (h2inframap.eu))

HIPS-NET CORE TOPICS



EVENTS AND PARTNER

EVENTS (SELECTION)

February 2023

22 Regional conference of the H2-Well project market ramp-up with focus on decentralised hydrogen economy Weimar, Germany, *Aktuelle Informationen – SolarInput*

March 2023

6-7 Hydrogen and Fuel Cells - Fuelling the Future Now Birmingham, UK, *Hydrogen and Fuel Cells – Fuelling the Future NOW – Climate Change Solutions (climate-change-solutions.co.uk)*

22-23 Hydrogen Cross Border Conference + Excursion Weser-Ems | Emmen, Netherlands + Weser-Ems-Region, Germany, *Hydrogen Cross Border Conference - Anmeldung (aanmelder.nl)*

24 H2 View's Renewables & Ecosystem Snap Summit: Making Hydrogen Hyppen | digital event, *H2 View Events (h2-viewevents.com)*

29-31 Hydrogen Days 2023 - 13th International Conference on Hydrogen Technologies | Prague, Czech Republic, *Hydrogen Days 2023*

PARTNER

Alliander AG, Cadent, DGC, DNV GL, Elogen, Enagás,
Enbridge, Energinet.dk, ENGIE,
EWE Netz, Gas Connect Austria GmbH,
Gasnetz Hamburg, Gasum OY,
Gasunie, GRTgaz, grzi e.V. (figawa),
Infraserv GmbH & Co. Höchst KG,
INERIS, innogy SE, ITM Power,
Joint Research Centre (JRC), EC,
KOGAS, NAFTA a.s, Naturgy, Netze Südwest, ONTRAS, ÖVGW, Open Grid Europe GmbH,
Polymer Consult Buchner GmbH,
RAG Austria AG,
Shell, Solar Turbines Europe S.A.,
Storengy, SVGW,
Synergrid, Teréga, TNO,
Uniper Energy Storage GmbH,
Verband der Chemischen Industrie (VCI),
Wintershall Dea AG.

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Certified DIN EN ISO 9001:2015

HIPS-NET

“Establishing a pan-European understanding of admissible hydrogen concentration in the natural gas grid”

NEWSLETTER #43 **April, 2023**

Dear HIPS-Net Partner,

The 43rd newsletter contains the following exciting topics:

- Green hydrogen picks up speed | Latin America
- Green Octopus | Europe
- Building the German hydrogen economy | Germany and Europe
- Hydrogen network project mosaHYc | Germany, France
- HyGreen Provence Project | France
- Technical regulations for hydrogen infrastructure | Austria
- Cooperation between Alstom and Air Products for the introduction of H_2 trains | Czech Republic

We hope you enjoy reading!

We are pleased to welcome **VNG AG** as a **new HIPS-NET partner**! VNG AG, headquartered in Leipzig, is a gas and gas infrastructure group with more than 20 companies in Germany and Europe.

Please mark your calendar for the **10th HIPS-NET workshop**. We are optimistic that we can finally meet again in Brussels on 15 June 2023 (there will be a casual dinner together the evening before). We will get back to you soon with more information!

If there is interest from your side to give a presentation, please feel free to contact Josephine. We are really looking forward to it!

Your HIPS-NET Team

Gert, Josephine and Ruven

Content

Content NEWSLETTER #43

Green hydrogen picks up speed | Latin America

In reducing their greenhouse gas emissions, more and more countries in Latin America are also turning to green hydrogen. Chile, Colombia, Brazil, Panama and Costa Rica have already published national hydrogen strategies (see figure below). Such strategies are also in the making in Ecuador and Peru. In Bolivia, Argentina, Mexico and French Guyana, discussions on hydrogen are still at the early stages. Chile, for example, wants to achieve 24% of its greenhouse gas reduction targets by 2050 with the production and use of green hydrogen. The country has set itself the ambitious goal of producing the cheapest hydrogen in the world by 2030: A kilogram of green hydrogen should cost less than 1.50 US dollars.

"Lighthouse projects" in Latin America (Source: Facundo Da Roza / Diálogo Chino)

On the continent, 13 (partly pilot) plants are already in operation, and more than 70 further plants are planned. One of these is operated by the company Unigel at the Camaçari site in the Brazilian state of Bahia. Unigel, a large chemical company and manufacturer of nitrogen fertiliser, has invested 120 million US dollars and built the first production facility for green hydrogen that operates at an industrial scale. It consists of three standard electrolysers with 20 MW each from the German company thyssenkrupp nucera. These will initially be able to produce 10,000 tonnes of green hydrogen and 60,000 tonnes of green ammonia per year, which can be further processed into fertiliser. In the course of further investment steps, the capacity is to be increased to up to 40,000 tonnes of H_2 per year.

Until green hydrogen can contribute to climate goals throughout Latin America, the continent still faces structural challenges: In some countries and regions, problems of electrification and energy efficiency should be solved first. When planning new projects, effective interaction between political and industrial actors in line with national energy strategies and decarbonisation targets is necessary. Furthermore, the capacities for generating renewable energy from wind, solar and hydropower must be massively expanded. Access to investment funds is also fundamental to this. Risks for investors can be reduced if projects are built in locations where there are several industrial consumers, such as in industrial parks.

Conclusion: There are already many countries in Latin America where a lot is currently happening in the field of hydrogen and there will be a lot more developments to report in the near future.

Status of hydrogen strategies in Latin American countries (Source: IDB Invest)

Sources:

https://dialogochino.net/en/climate-energy/60802-green-hydrogen-latin-america-makes-moves-on-fuel-of-the-future/

Unigel setzt bei der ersten Produktionsstätte für grünen Wasserstoff im Industriemaßstab in Brasilien auf die thyssenkrupp nucera-Technologie

Green Hydrogen Is Picking Up Speed in Latin America and the Caribbean | IDB Invest

Green Octopus - Hydrogen backbone between Belgium, the Netherlands and Germany | Europe

Green Octopus IPCEI projects (Source: WaterstofNet)

The aim of the Green Octopus project (IPCEI project) is to create a hydrogen backbone between Belgium, the Netherlands and Germany with connections to France and Denmark (see figure above), serving the supply and demand for clean hydrogen. Green Octopus stands for close cooperation between major green hydrogen producers, ports, gas companies and large hydrogen customers.

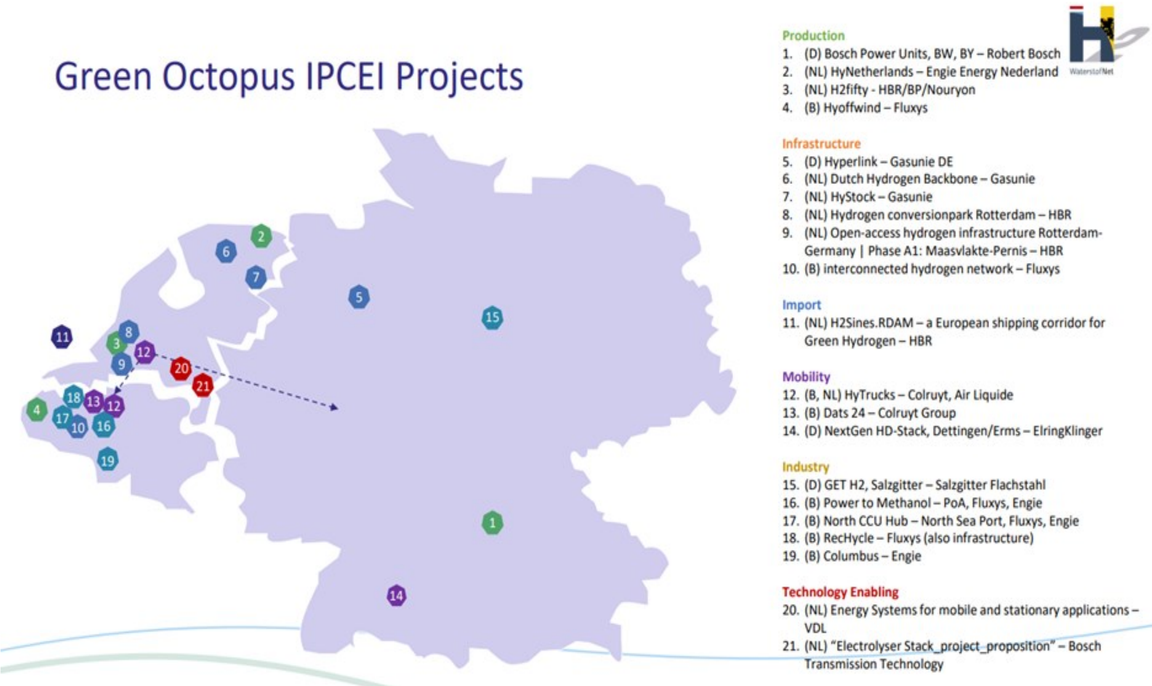
The entire hydrogen value chain is to be covered. It is planned to use electricity from PV solar plants and offshore wind energy. The hydrogen will be produced by alkaline electrolysis, polymer electrolyte membrane electrolysis and steam reforming with CC(U)S. The hydrogen will be transported via pipeline and it is possible to store hydrogen temporarily in salt caverns. The connected uses are mobility (trucks), stationary fuel cells for decentralised production and industry (supply to the chemical industry (e.g. fertiliser production), supply to refineries, the steel industry, etc.).

The project was initiated by WaterstofNet in 2019 and is carried out in association with 12 project partners from Belgium, the Netherlands and Germany. In September 2022, the project entered the next phase: Green Octopus 2.0 aims to create and stimulate an integrated hydrogen market in Northwest Europe. Through a bottom-up approach, the project aims to align regional strengths by creating a platform for flexible responses to dynamic hydrogen market developments at EU level. The partners exchange best practices and lessons learned and develop roadmaps and policy recommendations. Another objective is to develop an efficient form of cross-border cooperation, a common legal framework and harmonisation of policies and standards.

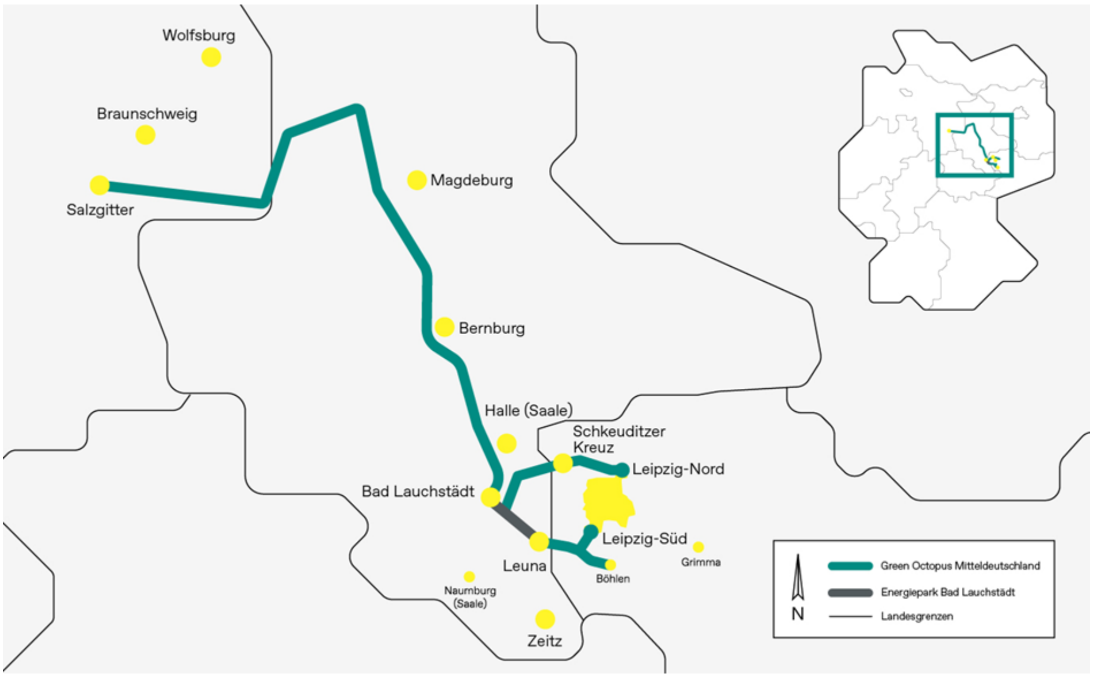
The 5 countries in the project have recently been joined by Luxembourg and Ireland in the second phase and more North West European countries are being sought to further expand Green Octopus 2.0 and attract representatives from the whole value chain and from all regions. So far, more than 21 IPCEI projects have been submitted by Green Octopus partners, some of which have already been notified by the European Commission (see figure below).

Netherlands

Flanders and the Netherlands are located ideally and equipped for the large-scale conversion of offshore wind into green gas in the form of hydrogen. In addition to local production of hydrogen, it will also be necessary to import hydrogen from abroad. Ports in Flanders and the Netherlands, which currently rely mainly on the use of fossil fuels, will play an important role in this. First, by using hydrogen to make their port activities and those of the industry more sustainable, and second, by transporting the hydrogen. To make the transport of hydrogen as efficient as possible, a 'hydrogen corridor' will



Generation and transport of hydrogen (Source: WaterstofNet) be established: a connection between Zeebrugge and Eemshaven. This corridor uses both existing natural gas pipelines and new, yet to be built, hydrogen pipelines and will become the backbone of a hydrogen economy. Flanders and the Netherlands have a number of strong technology companies that, by working together, form a unique value chain for hydrogen technology in Europe.



Green Octopus Central Germany (GO!) (Source: ONTRAS)

Belgium

Fluxys, Advario Stolthaven Antwerp (a 50:50 joint venture with Stolthaven Terminals) and Advario Gas Terminal aim to find the optimal solution for ammonia terminals in Northwest Europe by combining their strengths and expertise in logistics, terminals and pipeline transport. The first green ammonia import terminal is scheduled to be operational in the port of Antwerp-Bruges in 2027. The terminal will also be connected to Fluxys' open-access hydrogen network to ensure supply throughout Northwest Europe.

Germany

Green Octopus Central Germany (GO!) is the future transport route and storage facility for green hydrogen for the Central German chemical triangle, the industries in Saxony-Anhalt and the steel region in Salzgitter. One storage option for hydrogen is the future hydrogen storage facility in Bad Lauchstädt. This cavern storage facility, owned by VNG Gasspeicher GmbH, has a working gas volume of 50 million cubic metres and ensures a balance between supply and demand. The pipeline length will be around 305 kilometres, of which 190 kilometres will come from the conversion of existing pipelines and 115 kilometres from the construction of new pipelines.

Heading north, GO! will reach as far as the industrial region of Salzgitter in Lower Saxony, where it can be connected to the planned pipeline infrastructure towards the North Sea and Benelux (see figure above). GO! will use existing natural gas pipelines wherever possible. They will be thoroughly checked beforehand, upgraded if necessary and then converted to hydrogen operation. This reduces significantly the overall costs of the project and shortens the time until hydrogen operation. Time-consuming planning and approval procedures as well as waiting times for materials and services are significantly reduced. Also, existing pipelines already follow an optimised route to the main consumers.

Partners Green Octopus: WaterstofNet (project management), Fluxys, Gasunie, Port of Rotterdam, Port of Antwerp, Port of Zeebrugge, North Sea Port, Colruyt Group, VDL, Engie, Salzgitter AG, Bosch, EKPO Fuel Cell Technologies GmbH

Partners Green Octopus 2.0: Fluxys (BE), OGE (D), Inovyn (BE), Bosch (D), the Port of Antwerp-Bruges (BE), the Port of Rotterdam (NL) and the North Sea Port (NL/BE)

Sources:

Hydrogen valleys | Green Octopus (h2v.eu)

Hydrogen Pipeline Costs (waterstofnet.eu)

Ambitious collaboration between Belgium-the Netherlands-Germany on the development of the hydrogen value chain(Green Octopus) (waterstofnet.eu)

Hydrogen Economy - Green Octopus 2.0 Consortium and Programme Launched - Hydrogen Central (hydrogen-central.com)

Driving Europe's hydrogen strategy: Fluxys and Advario join forces to develop a green ammonia import terminal at the Port of Antwerp-Bruges

Green Octopus Central Germany | ONTRAS Gastransport GmbH

Building the German hydrogen economy | Germany and Europe

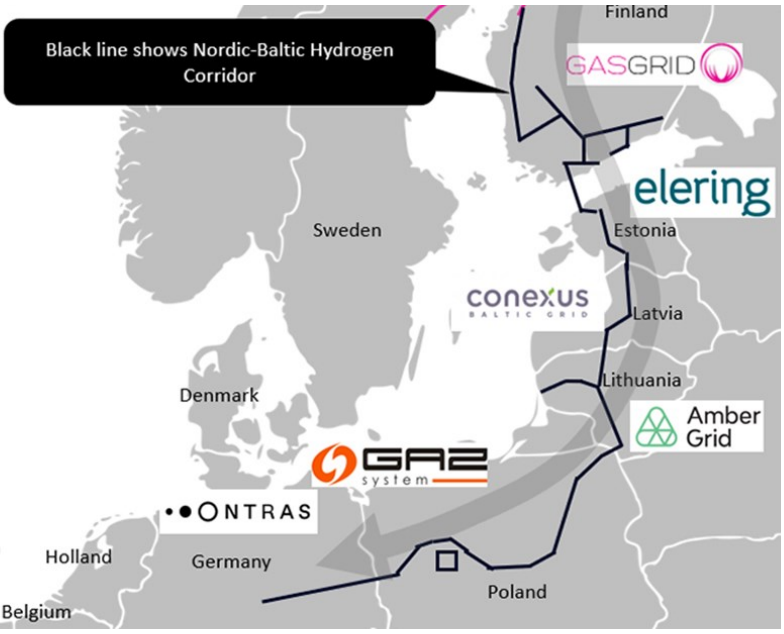
In Germany, numerous projects are working on the development of a hydrogen economy. In the following, the projects "Nordic-Baltic Hydrogen Corridor", "Flow" and "Doing Hydrogen" are presented to shine a light on recent developments.

Nordic-Baltic Hydrogen Corridor

On 14.12.22, the European long-distance network operators (TSOs) Gasgrid Finland (Finland), Elering (Estonia), Conexus Baltic Grid (Latvia), Amber Grid (Lithuania), GAZ-SYSTEM (Poland) and ONTRAS (Germany) signed a cooperation agreement for the Nordic-Baltic Hydrogen Corridor project.

The Nordic-Baltic Hydrogen Corridor aims to ensure the region's energy security, reduce dependence on fossil energy imports and promote decarbonisation along the corridor. The project aims to achieve this by substituting fossil energies with green hydrogen. Green hydrogen will be produced in the Baltic Sea region and transported via the corridor towards Central Europe, as well as supplying consumption clusters along the corridor (see figure below). The development of hydrogen infrastructure should create a strong market for hydrogen and access to existing renewable energy resources. The Nordic-Baltic Hydrogen Corridor supports the EU Hydrogen Strategy, the RePowerEU plan and regional and Europe-wide climate goals, such as the European Green Deal and Fit for 55.

The first phase of the project will start in 2023, during which the project partners will conduct preliminary feasibility studies. Based on this, a decision will be made on the continuation of the project development. Subsequently, the engineering and approval phases as well as construction and commissioning will take place.



Nordic-Baltic Hydrogen Corridor (Source: ONTRAS)

Flow - Making Hydrogen Happen

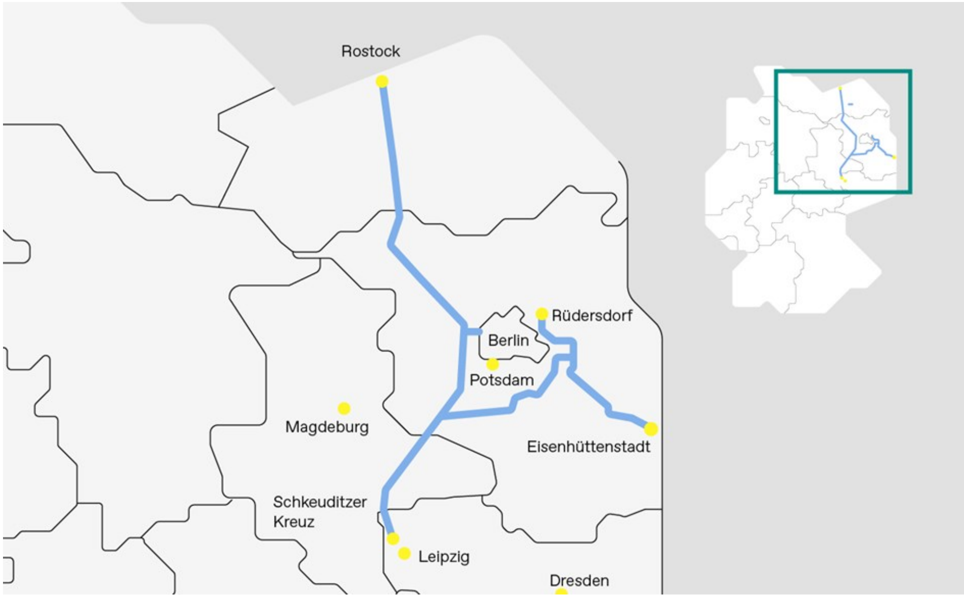
The German transmission system operators Gascade Gastransport GmbH, terranets bw GmbH and ONTRAS Gastransport GmbH are working on the "Flow - Making Hydrogen Happen" project to transport hydrogen from the Baltic Sea to

Hydrogen network of the "Flow" project (source: Flow)

southwest Germany from 2025. In the future, five neighbouring European countries are to be connected with this corridor; associated partners are already part of the project.

The project partners see the north of Germany as the future centre of hydrogen imports and production (onshore and offshore) as well as for transport to meet demand in the south. The expansion of the transport network for hydrogen is to take place in steps. The project aims to convert large-scale pipelines to hydrogen by 2025, for transport from Mecklenburg-Western Pomerania to Thuringia (see figure above). For 2028, the conversion is to take place in Hesse and Rhineland -Palatine From 2030, hydrogen is to be transported to Baden-Wurttemberg and Bavaria. The project partners are relying primarily on the conversion of natural gas pipelines for rapid feasibility as well as a large transport capacity. At the beginning, the pipeline network will have a length of more than 1,100 km and a feed-in capacity of up to 20 GW, which will be expanded in the future. The aim is to link it to the IPCEI projects (Important Projects of Common European Interest) "doing hydrogen" and "Green Octopus Mitteldeutschland" (see article 2) as well as to the projects "Hydrogen for Baden-Württemberg", "HyPipe Bavaria" and "MosaHYc".

Flow has a European orientation and offers connecting points for Germany's neighbouring countries. Therefore, the project partners applied for Project of Common Interest (PCI) status with the EU. The partners see imports from the Scandinavian countries for transits to the south as an important part of the European infrastructure. Therefore, the Danish "Energy Island" Bornholm is to be connected in 2027. From 2030 onwards, connections will be made to Austria, the Czech Republic, Poland and France.



PLANNED DOING HYDROGEN PIPELINE (SOURCE: ONTRAS)

Doing hydrogen - The East German hydrogen hub

Doing hydrogen is a platform for the hydrogen economy in East Germany. The hub connects companies and sub-projects in the area of the entire hydrogen value chain, from production, transport and storage to application. Numerous hydrogen projects in East Germany are part of Doing hydrogen. Doing hydrogen 2021 was initiated by the two transmission system operators GASCADE Gastransport GmbH (participation until 12/2022) and ONTRAS Gastransport GmbH. The aim is to establish a European hub for a green hydrogen economy in East Germany. Investments of €1.3 billion are to be made by 2030, a hydrogen network of 616 km is to be created, 207,000 tonnes of hydrogen per year are to be transported from 2030 and 2.03 million tonnes of CO_2 savings are to be achieved annually.

Doing hydrogen consists of several project partners and sub-projects. In December 2022, Doing hydrogen received approval from the Federal Ministry of Economics and Climate Protection (BMWK) for the early start of measures in the course of funding as an IPCEI project.

Doing hydrogen transport network

The Doing hydrogen transport network of ONTRAS Gastransport GmbH is to be extended from Rostock to Leipzig, Rüdersdorf (east of Berlin) and Eisenhüttenstadt (see figure above). Construction is scheduled to start in 2025 and commissioning is planned for 2027/2028. It is planned to convert 354 km of existing natural gas pipelines to 100 % hydrogen and to build a further 262 km of new pipelines suitable for hydrogen. In addition, the connection of hydrogen producers, consumers and storage facilities and the connection to other hydrogen networks is planned.

Electrolysis Corridor East Germany

Enertrag's Electrolysis Corridor East Germany project aims to commission electrolysers on a large scale. The electrolysers are to be located at four sites in Mecklenburg-Western Pomerania, Brandenburg and Saxony-Anhalt, along the hydrogen pipeline of **Doing hydrogen**. The commissioning of a total of 210 MW electrolysers with a production of 16,500 tonnes of hydrogen per year is scheduled for 2027. An annual CO_2 saving of 135,000 tonnes is expected. Other elements of the project are wind power and photovoltaic plants to supply green electricity for electrolysis and four hydrogen filling stations to use the hydrogen in the mobility sector. The most important consumer of the hydrogen is the Concrete Chemicals sub-project.

Concrete Chemicals

The Concrete Chemicals project of the companies CEMEX Zement GmbH, Enertrag and Sasol Eco FT at the Rüdersdorf site aims to decarbonise cement production through CO2 capture. The captured CO_2 is to be further processed with hydrogen from the Doing hydrogen pipeline in catalytic reactors to produce synthetic fuels. From 2027 onwards, 35 t/a of green synthetic hydrocarbons (eCrude or sustainable aviation fuels) are to be produced annually. The project will start in 2023, commissioning is planned for 2027 and the expansion will take place until 2050. Concrete Chemicals is expected to achieve CO_2 savings of 125,000 t/a in 2027 and 450,000 t/a in 2030.

Green hydrogen from Rostock

The "Green Hydrogen from Rostock" project of the company Apex Energy Teterow GmbH started in February 2023. The goal is to commission a 100 MW electrolysis plant for the production of green hydrogen in Rostock-Laage at the end of 2026. From 2027, more than 7,500 tonnes of hydrogen are to be produced annually and transported via a hydrogen pipeline from the Rostock overseas port via Berlin to Leipzig/Leuna. An annual CO_2 saving of at least 70,000 tonnes is expected.

HyTechHarbour Rostock

The "HyTechHafen Rostock" project of Rostock EnergyPort cooperation GmbH, founded in July 2022, is committed to the establishment and expansion of a sustainable green production and distribution structure for hydrogen (see figure below). The goal is to build an electrolysis plant in the Rostock seaport for the production of (green) hydrogen. The hydrogen will be fed into a supra-regional distribution network, but will also be available to local consumers. The consortium consists of 4 companies, each holding 25 %, namely EnBW Neue Energien GmbH, RheinEnergie AG, RWE Generation SE and the port operator ROSTOCK PORT GmbH. The 100 MW electrolyser is to be built on the site of the Rostock hard coal-fired power plant by the end of 2026 to produce 6,500 tonnes of green hydrogen per year. The electricity is to be generated with numerous onshore and offshore wind turbines as well as with photovoltaic systems in the region.

Future Network Northwest

The Zukunftnetz Nordwest project of Vattenfall Wärme Berlin AG at the Berlin Nordwest site (Reuter West CHP plant) aims at the development of a regional, hydrogen-capable transport network for hydrogen-based urban heat and power generation in CHP plants for combined heat and power. Commissioning is planned for 2030 and the expansion of Berlin's urban heating to climate neutrality is to take place in 2040.

Sources:

Nordic Baltic Hydrogen Corridor: https://www.ontras.com/de/aktuelles/newsroom/nordic-baltic-hydrogen-corridor

Flow: https://www.ontras.com/de/aktuelles/newsroom/flow-medieninformation

https://www.flow-hydrogen.com/

Doing Hydrogen: https://www.doinghydrogen.com/partner/ontras/

https://www.ontras.com/de/infrastruktur/innovationsprojekte/doing-hydrogen

https://www.ontras.com/de/aktuelles/newsroom/vorzeitiger-massnahmenbeginn

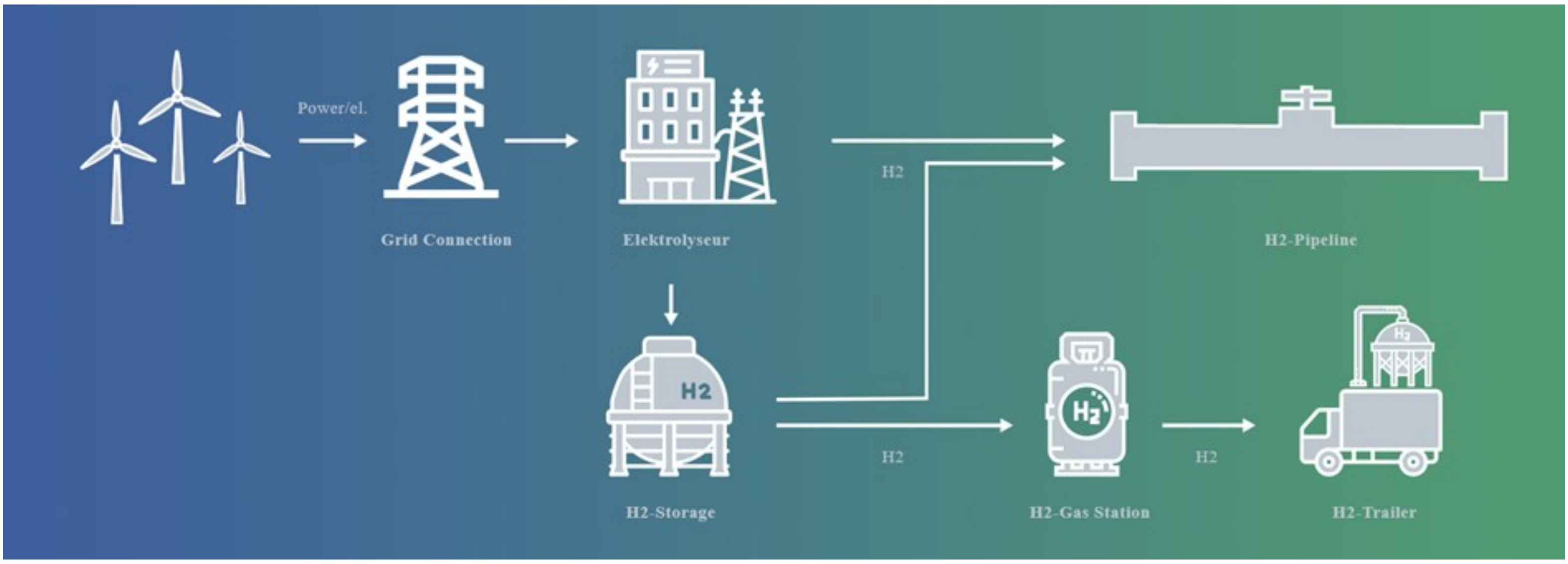
Elektrolysekorridor Ostdeutschland: https://www.doinghydrogen.com/partner/enertrag-ag/

Concrete Chemicals: https://www.doinghydrogen.com/partner/concrete-chemicals-scale-up/

Grüner Wasserstoff aus Rostock: https://www.doinghydrogen.com/partner/apex-energy-teterow-gmbh/

HyTechHafen Rostock: https://energyport-rostock.de/

Zukunftsnetz Nordwest: https://www.doinghydrogen.com/partner/vattenfall-waerme-berlin-ag/



PROCESS CHAIN OF THE "HYTECHHAFEN ROSTOCK" PROJECT (SOURCE:HTTPS://ENERGYPORT-ROSTOCK.DE/)

Hydrogen network project mosaHYc | France, Germany

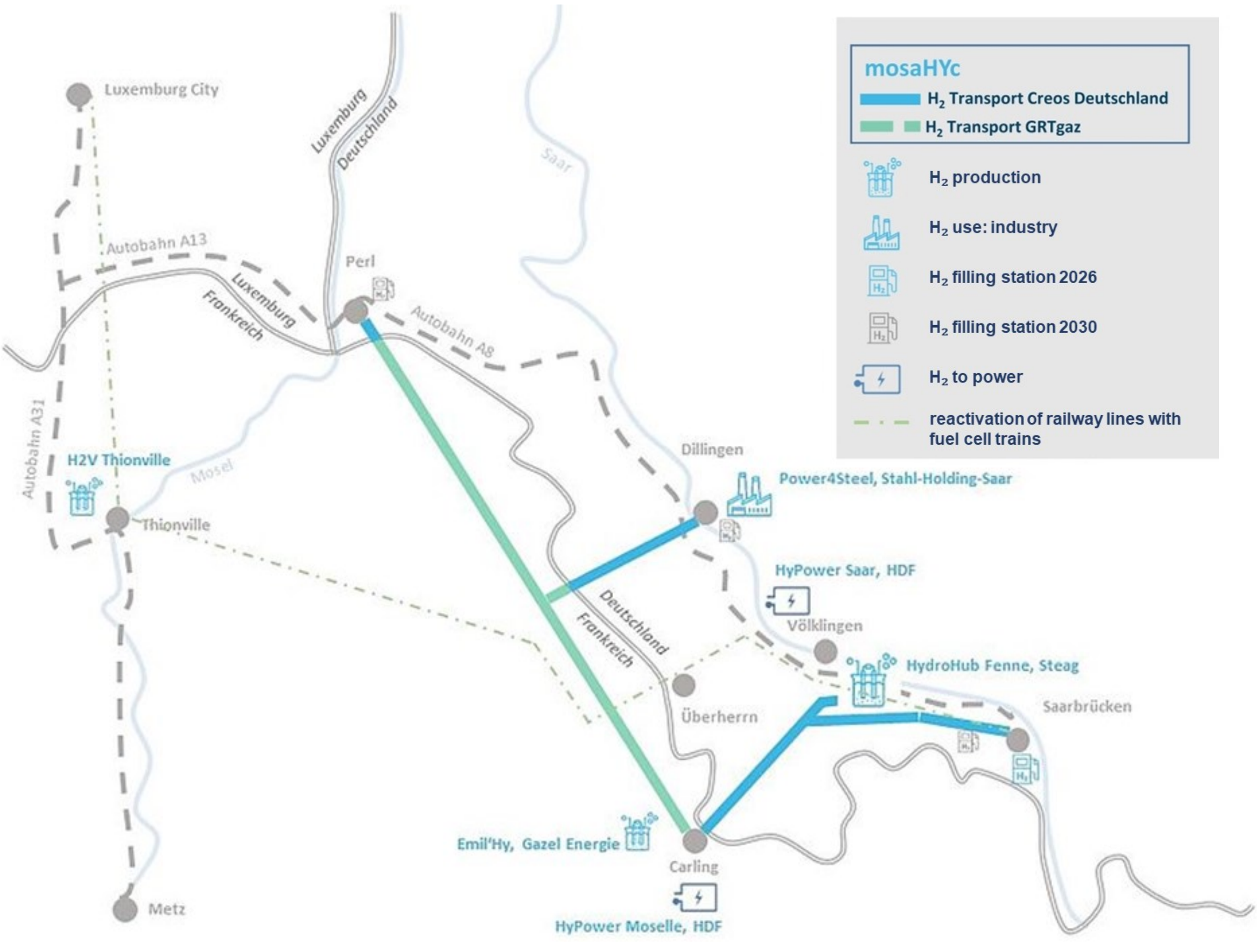
A first step towards the European hydrogen network

The infrastructure project mosaHYc (moselle-saar-hydrogen-conversion) of the network operators Creos (Germany) and GRTgaz (France) in cooperation with the energy company Encevo (Luxembourg) aims to build a cross-border high-pressure network for the transport of hydrogen in the Grande Région. The goal is to create a 100-kilometre-long infrastructure that can supply the Saarland, the Grand Est region in France and Luxembourg with hydrogen. To this end, around 70 kilometres of existing and partially decommissioned gas infrastructure will be converted to hydrogen in France and 30 kilometres of new gas infrastructure will be built in Saarland. This first island network will initially supply the Saarland steel industry with climate-neutral hydrogen from 2027 and in the future provide hydrogen as a fuel and energy carrier for industry, mobility, reverse power generation and heat in the greater region. In addition, mosaHYc offers the opportunity for a future connection of the region to the European hydrogen transport system.

Although the final funding decision is not yet available, the Federal Ministry of Economics and Climate Protection (BMWK) has approved the so-called "early start of measures" within the framework of the IPCEI on Hydrogen (Important Project of Common European Interest).

Outlook - Hydrogen from the North for the Southwest of Germany

In addition, Creos Deutschland entered into a partnership with the hydrogen network flow as part of the mosaHYc project (more information in the previous article). With the conversion of further gas pipelines in Saarland and Rhineland-Palatinate, Creos Deutschland then wants to realise the connection of the two hydrogen island networks and thus the connection of flow to the French hydrogen network in the 2030s. The long-term goal is to connect the large production and import capacities for climate-neutral hydrogen in the north with the consumers in southwest Germany.



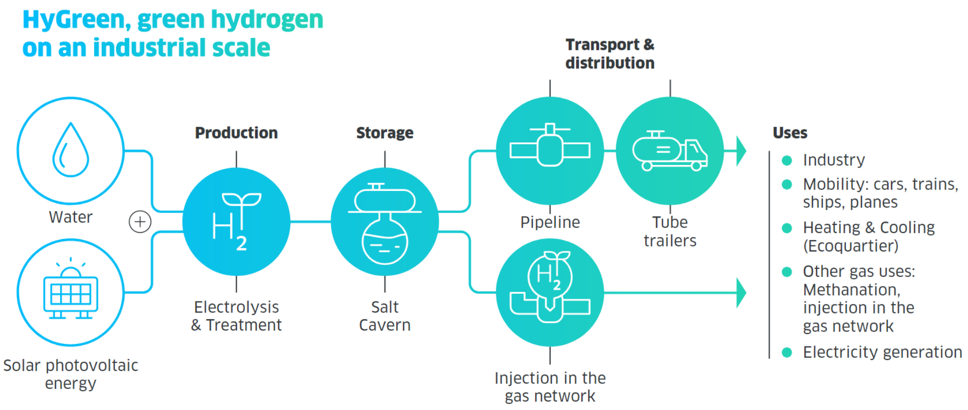
mosaHYc, H_2-Transport (Source: creos-net.de)

Sources:
https://grande-region-hydrogen.eu/de/projekte-2/mosahyc-deutsch/
Aktuelles - Creos Deutschland GmbH – (creos-net.de)
https://www.flow-hydrogen.com

HyGreen Provence Project - Use of solar energy and salt cavern | France

One power-to-gas project in France is the HyGreen Provence project in the Durance Luberon Verdon Agglomération Territory (DLVA). It aims to establish a local renewable energy generation system combining electricity from photovoltaics with hydrogen production through electrolysis and hydrogen storage in salt caverns. The hydrogen could be used for various local energy applications, such as local industry and mobility. HyGreen Provence is the first project in France based on large-scale hydrogen production and storage. Partners in the project are ENGIE, GEOMETHANE (50% owned by STORENGY, a wholly owned subsidiary of ENGIE) and DLVA.

The project aims to solve the challenges of sustainable mobility and local pollution in urban areas. Storage is intended to compensate for fluctuations in solar energy.



The HyGreen system (Source: ENGIE)

Further information:

https://www.gie.eu/hygreen-provence/

https://www.storengy.de/sites/default/files/mediateque/pdf/2021-11/HyGreen%20Provence%20EN.pdf

https://www.engie.com/en/business-case/engie-x-hygreen

Technical regulations for hydrogen infrastructure | Austria

On 1st of February 2023, two new hydrogen guidelines of the ÖVGW came into force, creating the conditions for the approval and construction of hydrogen pipelines and plants. "With these two new hydrogen guidelines, we have reached another milestone in the integration of green gases," says Michael Haselauer, President of the Austrian Gas and Water Association (ÖVGW) and Managing Director of Netz Oberösterreich GmbH. The technical regulations for Austria are constantly being expanded for the production and use of hydrogen. Haselauer goes on to say: "The ÖVGW technicians have done their homework - it is the politicians who are defaulting with the energy industry framework conditions."

Guideline H B100 / Hydrogen composition

This ÖVGW guideline defines the requirements for the quality of gaseous hydrogen for injection, transport, distribution and storage in a hydrogen infrastructure or gas infrastructure. Derived from international standards, this guideline describes the hydrogen quality, which will have a decisive influence on applications, networks and the production of hydrogen in Austria.

Guideline H E310 / Hydrogen feed-in systems

The planning, construction and initial testing of hydrogen feed-in systems is regulated in ÖVGW guideline H E310. This concerns both the feed-in into pure hydrogen networks and into gas networks. This makes it possible to connect climate-neutral hydrogen production with consumers on a large scale.

From research to implementation

In the course of the ÖVGW research initiative "Greening the Gas", more than 30 projects with national and international research partners have been implemented and open technical questions clarified in recent years. The knowledge gained is incorporated into the work on regulations and thus creates the technical prerequisites for the production, transport and use of green gases such as biomethane and hydrogen.

Source: ÖVGW · Aktuell 2022 (ovgw.at)

Cooperation between Alstom and Air Products for the introduction of hydrogen trains | Czech Republic

We have already reported on Alstom's activities in NL#21 and NL#41. On 5 December 2022, Alstom, together with Air Products, signed a Memorandum of Understanding to introduce hydrogen solutions in rail transport, including the necessary infrastructure in the Czech Republic. The decarbonisation in the mobility sector is to be accelerated to achieve the goals of the European Green Deal, in particular the "Fit for 55" package. To build the hydrogen infrastructure in the country, Alstom is in contact with the regions and is trying to take early action to support the creation of the necessary legislation, which is still lacking in the Czech Republic.

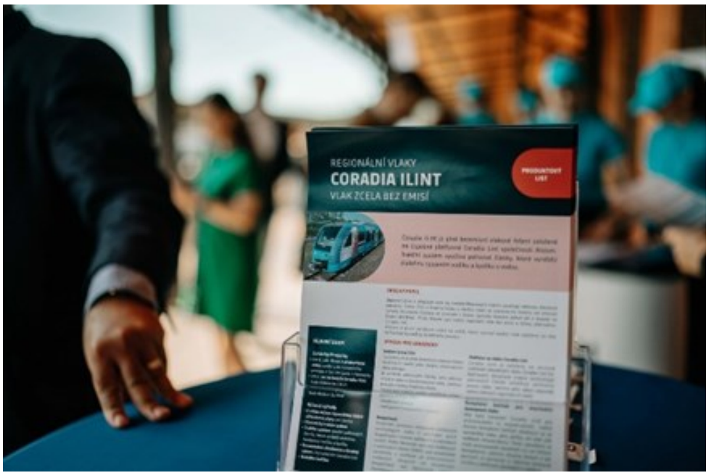
"Together with Alstom, we are convinced that we can build a functioning network of hydrogen trains that shows that hydrogen is the ideal propulsion for non-electrified lines. And that the operation of hydrogen trains is absolutely environmentally friendly and safe and also economically viable in the medium term" commented Vlastimil Pavlíček, Business Development Director New Technologies, Subregion CE&CIS Air Products.

Alstom was the first company in the world to put a hydrogen passenger train into operation in Germany in 2018. Since then, trains have been tested in Austria, the Netherlands, Sweden and Poland, and trains have been purchased by France and Italy. Alstom presented the hydrogen train in the Czech Republic and Slovakia during its Railshow, which took place from 17 to 25 May 2022.

As the world's largest producer of hydrogen, Air Products is taking important steps to accelerate the energy transition. In the Czech Republic, Air Products is active in the production, supply and storage of technical gases and advanced technologies, including hydrogen and hydrogen filling stations. As part of its activities, Air Products also focuses on new opportunities for the use of hydrogen in the field of propulsion of all types of transport, including rail vehicles. Air Products also participated in the presentation of the Coradia iLint train in the Czech Republic, in particular the refuelling of the train with hydrogen at a mobile filling station.

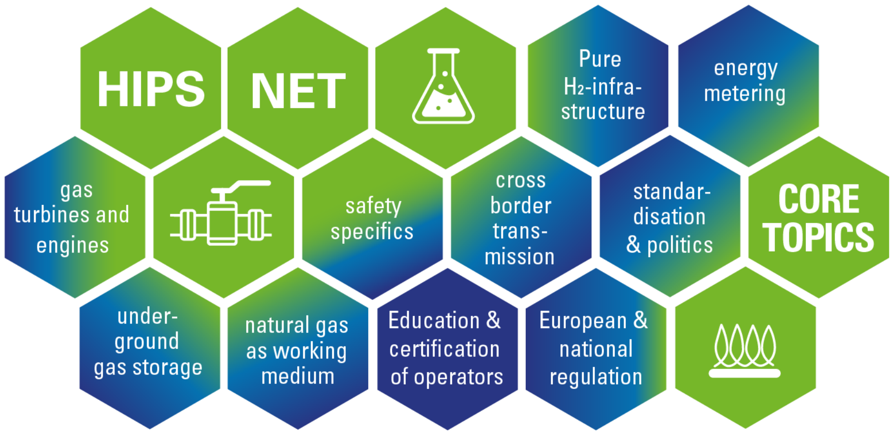
Source:

Alstom and Air Products sign a Memorandum of Understanding with an objective to introduce hydrogen trains in the Czech Republic | Alstom



Alstom hydrogen railshow in Česká Třebová (Source: Alstom)

HIPS-NET CORE TOPICS



EVENTS AND PARTNER

EVENTS (SELECTION)

April 2023

17-21 **Hydrogen + Fuel Cells Europe** | Hannover Messe, Germany, *https://www.h2fc-fair.com*

Mai 2023

2-3 **DVGW 27. Kolloquium Gas- und Wassermessung** | Hamburg, Germany, *https://www.dvgw-kongress.de/veranstaltungen/bereichsuebergreifende-themen/27-kolloquium-gas-und-wassermessung*

9-11 **World Hydrogen Summit & Exhibition** | Rotterdam, Netherlands, *https://www.world-hydrogen-summit.com*

17-17 **DBI-Fachforum Wasserstoff – Technologien** | Hamburg, Germany, *https://www.dbi-gti.de/termine/dbi-fachforum-wasserstoff-technologien.html*

23-25 **E-World** | Essen, Germany, *https://www.e-world-essen.com/de/besuchen*

PARTNER

Alliander AG, Cadent, DGC, DNV GL, Elogen, Enagás,
Enbridge, Energinet.dk, ENGIE,
EWE Netz, Gas Connect Austria GmbH,
Gasnetz Hamburg, Gasum OY,
Gasunie, GRTgaz, GRZI e.V. (figawa),
Infraserv GmbH & Co. Höchst KG,
INERIS, innogy SE, ITM Power,
Joint Research Centre (JRC), EC,
KOGAS, NAFTA a.s, Naturgy, Netze Südwest, ONTRAS, ÖVGW, Open Grid Europe GmbH,
Polymer Consult Buchner GmbH,
RAG Austria AG,
Shell, Solar Turbines Europe S.A.,
Storengy, SVGW,
Synergrid, Teréga, TNO,
Uniper Energy Storage GmbH,
Verband der Chemischen Industrie (VCI),
VNG AG, Wintershall Dea AG.

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GERG
THE EUROPEAN GAS RESEARCH GROUP

DVGW

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Certified DIN EN ISO 9001:2015

HIPS-NET NEWSLETTER

establishes a pan-European understanding of
admissible hydrogen concentration in the natural gas grid.

#44
May 2023

Hydrogen in Pipline System - NETWORK

HIPS NET

10th HIPS-NET WORKSHOP

save the date

14th & 15th June 2023

Content :

Dear HIPS-Net Partner,

the 44th newsletter starts with a look back at the beginnings of HIPS-NET exactly 10 years ago! Afterwards we are taking a look at the new developments in the field of hydrogen in Oman, where great goals are being pursued and much can be expected in the future. In addition to a detour to the Netherlands, we have compiled exciting projects in Germany for you on the entire H_2 value chain. As these projects fit perfectly with our core topics, the focus of this newsletter is on Germany. The next edition will then focus on another European country and the developments there in the field of hydrogen.

We hope you enjoy reading it!

The **10th HIPS-NET Workshop** will take place on 15 June 2023 in Brussels at the GERG Office (Avenue Palmerston 4). For those who are unable to travel to the workshop, we will ensure online participation. **Please register online for the workshop with an indication of how you will attend (online or Brussels), to ease our planning efforts. Thanks!**

Registration link: https://lets-meet.org/reg/3795085047d06c0f67

We are really looking forward to it!

Your HIPS-NET Team

Gert, Josephine, Ruven and Jenny

10 years of HIPS-NET - The beginnings

Once upon a time (exactly 10 years ago) ...

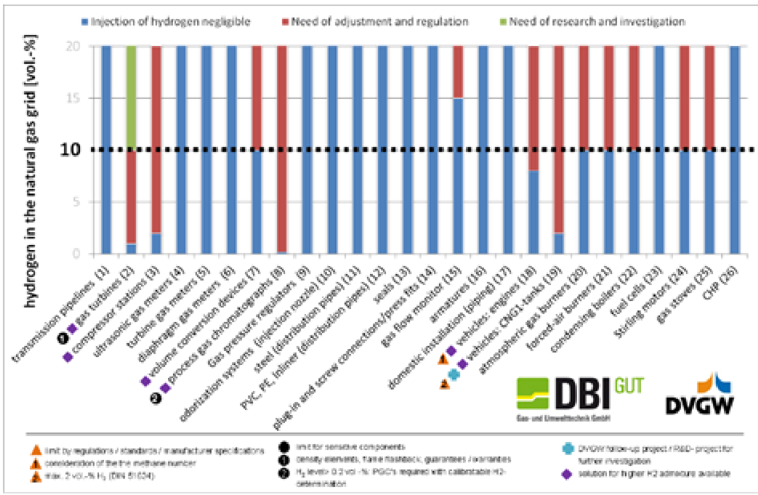
...the GERG Hydrogen Project HIPS "Admissible Hydrogen Concentrations in Natural Gas Systems" was concluded. The final workshop took place on 23 May 2013 in Brussels.

The project manager of the project was Dr Klaus Altfeld (E.ON New Build & Technology GmbH) and the project manager was Dave Pinchbeck (Secretary General of GERG at the time). The six project partners were DBI GUT, DGC, DNV Kema Nederland BV, E.ON New Build & Technology GmbH, GdF Suez and Kiwa Technology. The project advisory board included 27 other companies (among others still involved: Alliander, Enagás, Energinet, Gasum, Infraserv, ITM Power, KOGAS, OGE, ÖVGW, Shell, SVGW, ...).

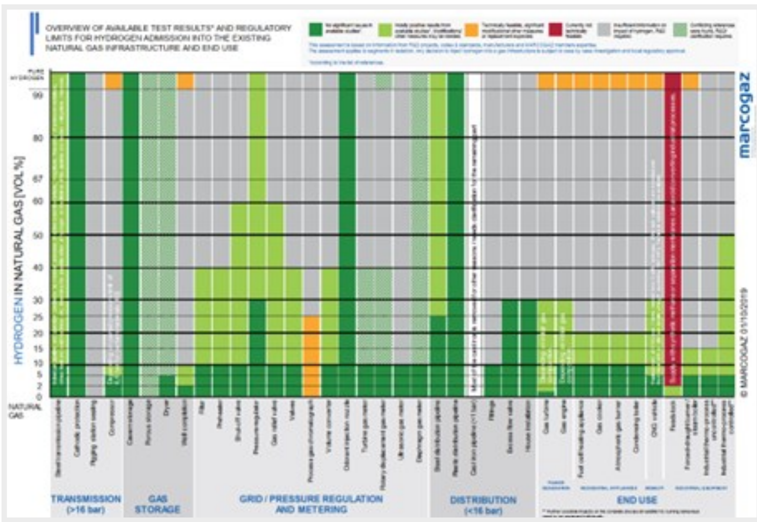
At the first workshop in 2013, the current state of knowledge on hydrogen tolerance of the gas grid infrastructure was mapped (see figure 2013). In the meantime, we gained some more experience in this area (see 2019 figure) and the research is transferred into practice. (Editor's note: an update of the 2019 Marcogaz figure is finalized and will be provided after approval by Marcogaz.)

At the end of the first workshop, it was proposed to maintain the already existing group of companies from the HIPS project and to jointly found the HIPS-NET network. Now we can look back on 10 successful years together, 9 workshops and 44 newsletters and look forward to the next 10 exciting years together with you!

10 years HIPS-NET



Hydrogen tolerance of the gas grid infrastructure - state of knowledge 2013 (Source: DBI GUT, DVGW)



Hydrogen tolerance of the gas grid infrastructure - state of knowledge 2019 (source: Marcogaz)

Hydrogen in Pipeline Systems - Network HIPS NET

Hydrogen Strategy in Oman | *Oman*

Frame and background

The hydrogen policy in Oman receives its subject to the general framework of Vision 2040, which stipulates, among other things, that renewable energies should cover between 35 and 39% of the energy demand by 2040. In 2020, Sultan Haitham bin Tariq took over as ruler of Oman and did not have good starting conditions (including debt and unemployment). With the expansion of the hydrogen sector, the Sultanate expects to create 70,000 new domestic jobs. By 2050, Oman is primed to complete decarbonisation with the help of an ambitious transformation path. The hydrogen economy is a core element of this.

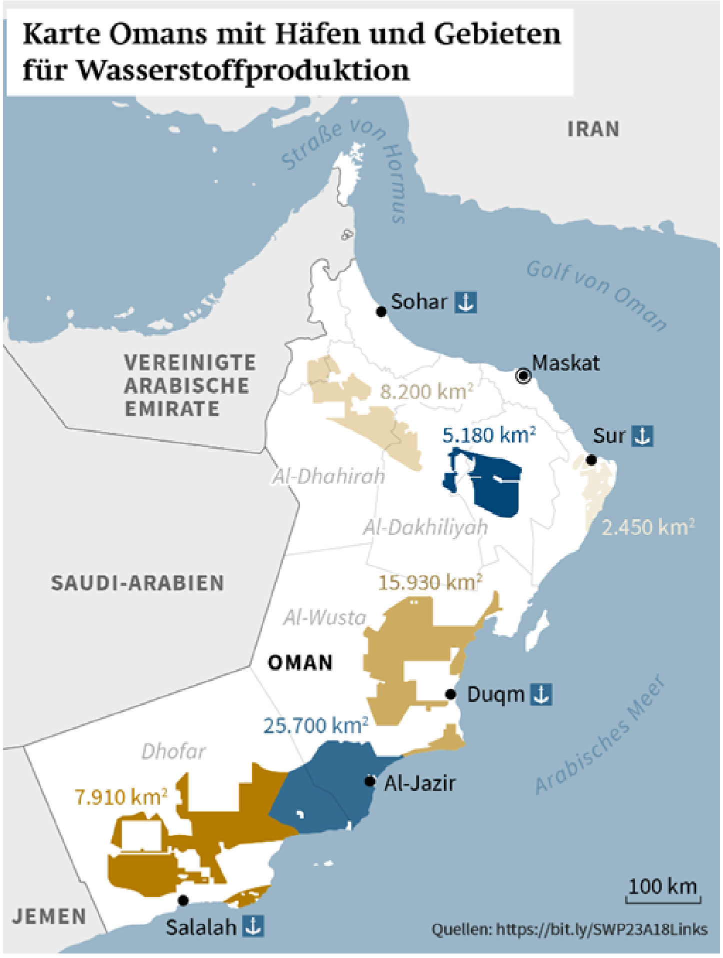
Plans for the Omani hydrogen economy

In October 2022, Oman published its national hydrogen plans. It plans to produce 1 to 1.25 million tonnes of hydrogen by 2030 and as much as 8 million tonnes of hydrogen by 2050. These are very ambitious aspirations. By comparison, the entire EU is currently "only" planning on 10 million tonnes of H_2 per year in the same period. The production sites are dispersed around the country and linked to ports (see figure).

The regions around Salalah in the Dhofar governorate and Duqm and Al-Jazir in the Al-Wusta governorate were chosen due to favorable solar and wind conditions and a location close to the coast. This is important due to the water needed for electrolysis, which shall be obtained through seawater desalination and no expensive transport pipelines to the ports have to be built.

The Omani Ministry of Energy already concluded numerous memoranda of understanding with consumer countries such as Germany, Belgium, Japan and the Netherlands and strategic partners (e.g. Shell). However, not only pure hydrogen is to be exported, but also green steel, green cement and green ammonia produced in Oman as ship fuel and fertiliser.

Another special feature of the Omani vision is



Map of Oman with ports and areas for hydrogen production (Source: Stiftung Wissenschaft und Politik, 2023)

that the domestic use of hydrogen and its derivatives to decarbonise the oil and gas sector as well as agriculture is part of it. A local distribution network is therefore also planned by which domestic demand will be met.

Source: Hydrogen from Oman for Germany and the EU - Stiftung Wissenschaft und Politik (swp-berlin.org)

HyNetherlands - Value chain for green hydrogen and e-methanol on a gigawatt scale | *Netherlands*

The aim of HyNetherlands (HyNL) is to establish and operate one of the first large-scale industrial value chains for the production of e-methanol in Europe. The project in the north of the Netherlands (Groningen) is sponsored by three companies, Engie, OCI and EEW and supported by the Dutch government within the framework of the Important Projects of Common European Interest (IPCEI). In the long term, HyNL is expected to play an increasingly important role in the decarbonisation of industry and transport in the region and contribute to the avoidance of 140 kilotonnes of CO_2 per year from the end of 2025.

Teamwork - hydrogen production, CO_2 capture and e-methanol production

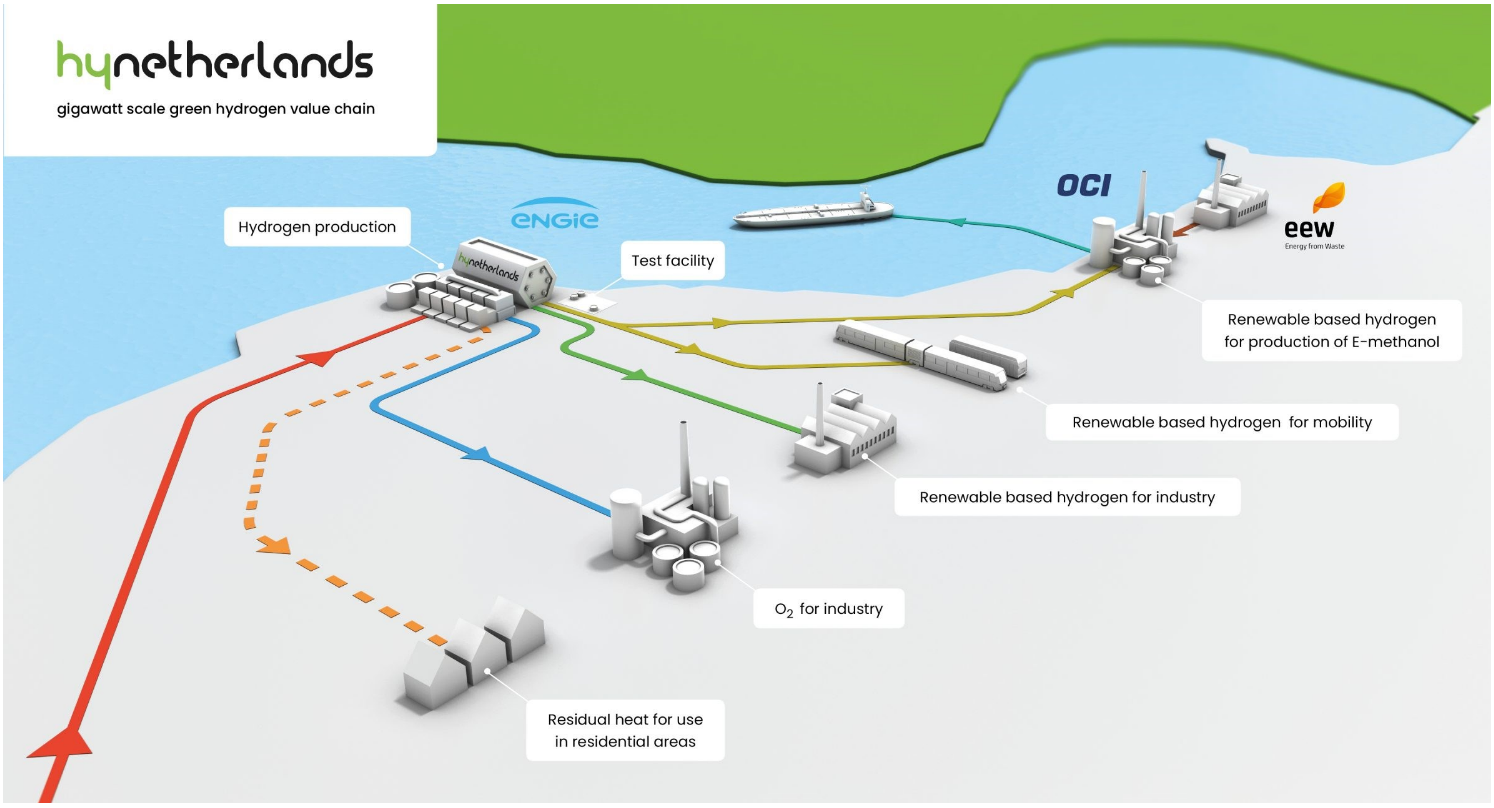
Engie`s hydrogen production plant will be located in Eemshaven and will be powered by green electricity from offshore wind turbines. There are plans for an electrolyser capacity of 100 MW by 2025 and 1.85 GW by the early 2030s.

The **EEW carbon capture plant** will be integrated into the existing waste-to-energy plant in Farmsum. It will capture biogenic CO_2 from the plant's waste gases. The CO_2 logistics and infrastructure will be provided by Groningen Seaports.

In **OCI**'s methanol plant at the Delfzijl Chemical Park in Farmsum, the e-methanol is then produced from the green hydrogen and the biogenic CO_2.

The ENGIE and OCI plants will be connected to the hydrogen network that **Gasunie** is building in the Netherlands and northern Germany. The majority of the national hydrogen network will consist of pipelines currently used for natural gas transport.

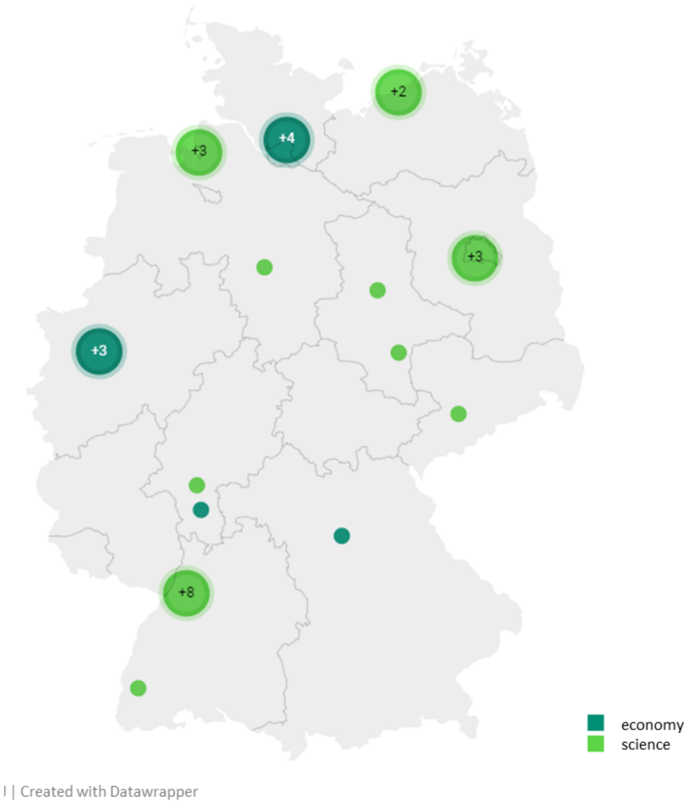
Source: HyNetherlands | A gigawatt scale green hydrogen value chain



HyNetherlands, value chain (Source: Hynetherlands_value_chain-scaled.jpg (2560×1440))

H2Mare - offshore generation | *Germany*

H2Mare is one of the three spearhead hydrogen lead projects in Germany (along with H2Giga and TransHyDe) and investigates the offshore production of green hydrogen. It is divided into the four projects OffgridWind, H_2Wind, PtX-Wind and TransferWind. A total of 32 partners and two other associated partners from science and industry are involved in H_2Mare (including BAM, cruh21, Dechema, DLR, EnbW, EnviroChemie, various Fraunhofer institutes, Helmholtz Centre, RWE, Siemens, thyssenkrupp, various universities and colleges, ...).



Project partner H2Mare (Source: H_2Mare/PtJ)

The hydrogen spearhead project H2Mare is funded by the German Federal Ministry of Education and Research and has a total funding amount of more than €100 million. It started in April 2021 and will run until March 2025. An electrolyser is to be integrated directly into the offshore wind turbine to produce green hydrogen offshore. The project is currently in the development and research phase. The goal is to have the first offshore test system installed by the end of the project.

In the project, the generation of renewable electricity by means of a wind turbine is directly coupled with the production of green hydrogen in the electrolyser. This is intended to minimise the costs of hydrogen production. Since no connection to the electricity grid is necessary, the infrastructure costs can be significantly reduced. In addition, the efficiency of the system increases due to the lower electrical losses. Decoupling from the electricity grid relieves the burden on local electricity grid structures. The production of downstream products such as green methanol and ammonia will also be considered within the framework of H_2Mare.

OffgridWind

In the OffgridWind sub-project, research is being conducted into a new type of wind turbine, a foundation for wind turbines that meets the requirements, hydrogen storage and transport to the mainland. The operation and costs of the system are simulated. The goal is to analyse under which conditions such a coupling can be operated profitably.

H_2Wind

The H_2Wind sub-project is developing a new type of compact water electrolysis system for the requirements at sea as well as a process for water treatment and supply for the electrolysis and storage of the hydrogen produced. In addition, the simulation of operation and costs is carried out to identify conditions of profitable operation of the plant.

PtX-Wind

The PtX-Wind sub-project focuses on the generation of further Power-To-X (PtX) products from the generated hydrogen, such as methanol and ammonia. Other substances are needed for this, such as CO_2 and nitrogen. These are to be obtained locally from the air or seawater. The technologies of steam electrolysis and seawater electrolysis are considered.

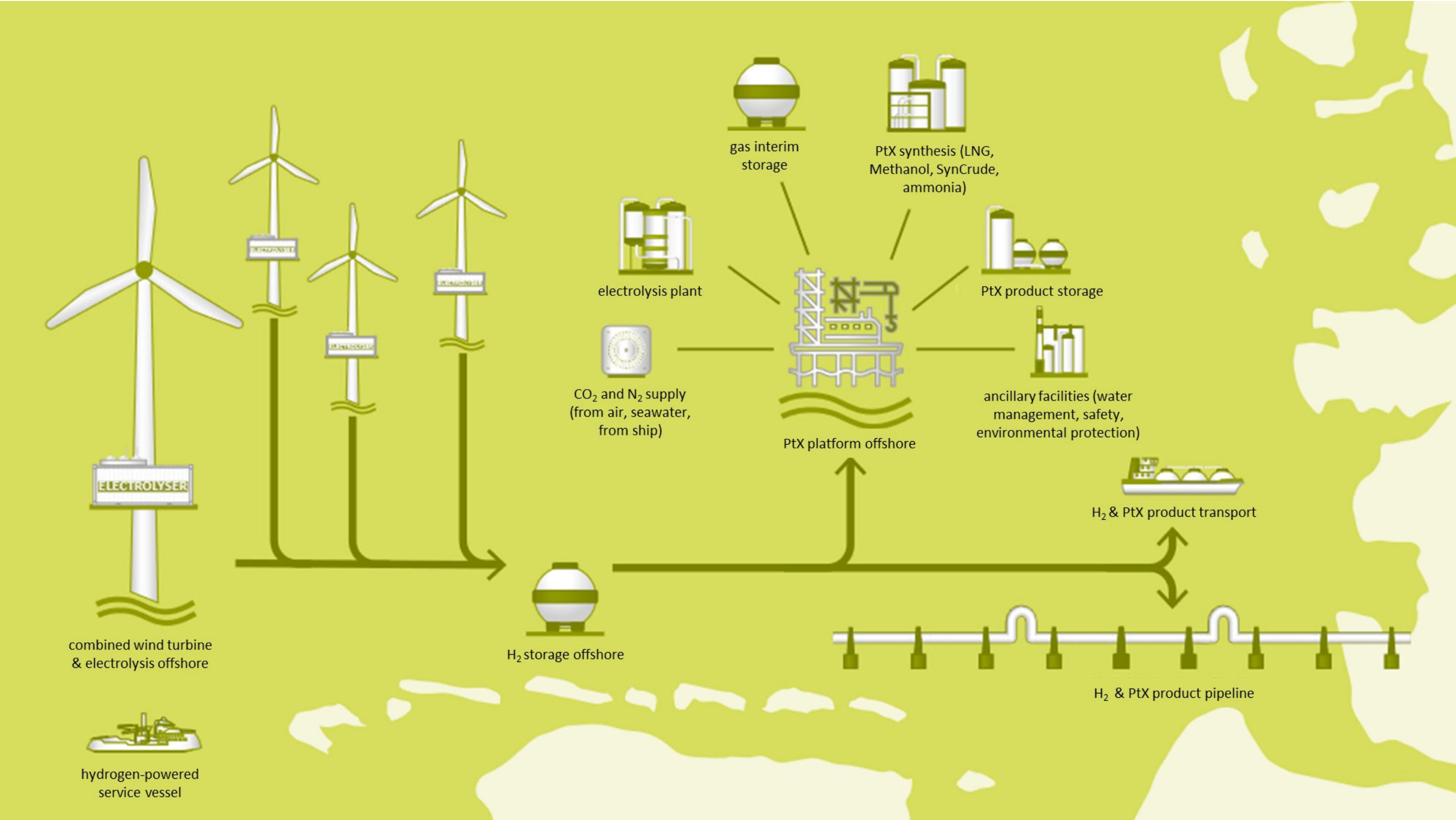
TransferWind

The TransferWind sub-project aims to answer overarching questions about H_2Mare. These include safety and environmental issues as well as infrastructure requirements. This sub-project brings together the results of the three other sub-projects. There is an exchange between science, business, politics and civil society.

Information on H_2Mare:

https://www.wasserstoff-leitprojekte.de/leitprojekte/h2mare

https://www.iwes.fraunhofer.de/de/forschungsprojekte/aktuelle-projekte/h2mare---offshore-technologien.html



H_2Mare balance sheet framework (source: https://www.wasserstoff-leitprojekte.de/lw_resource/datapool/systemfiles/elements/files/EFB4E949E6D04A74E0537E695E8620DB/live/document/H2Mare_2_2022_de_interaktiv.pdf)

GEFÖRDERT VOM

Wasserstoff Leitprojekte Grün. Groß. Global.

Bundesministerium für Bildung und Forschung

Leitprojekt H_2Mare

Transformation of the gas distribution networks of a German distribution network operator for hydrogen | *Germany*

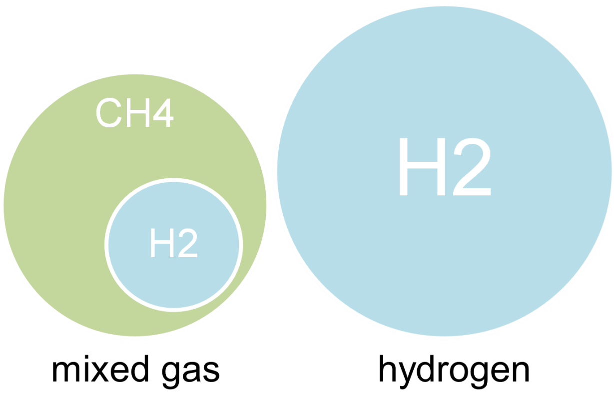
Motivation and goals

The expansion of renewables and the further measures to reduce greenhouse gas emissions, such as efficiency improvements and increased thermal insulation, especially in new buildings, also have a significant influence on the development of gas demand and the type of gases distributed in the future, especially hydrogen.

The project was commissioned by a German distribution network operator in 2022 and carried out by DBI. The aim was to support the creation of a long-term strategy for the refurbishment, renewal and optimization of the assets of a distribution network operator against the background of the anticipated changes in the supply task, through a technical and economic analysis and optimisation.

Scenario framework

Based on current studies [1, 2], and taking into account the grid operator's customer structure, two representative scenarios for the possible development of the future supply task were developed, a methane-based "mixed gas scenario" and a "hydrogen scenario" (see figure).



In the "mixed gas scenario", it was assumed that (renewable) methane will continue to be distributed, with up to 20% H2 blending by volume in 2030 and a maximum of 30% by volume in 2050. Gas mobility does not play a role in this scenario. Overall, the scenario assumes a 25% decrease in gas demand by 2050 and a reduction in power demand of 10% compared to 2019.

For the "hydrogen scenario", an H_2 admixture of up to 20 % by volume in 2030 is also assumed, but the gas supply is to be completely converted to hydrogen by 2050. An increase in (H_2) gas mobility is also taken into account, so that gas demand increases by 11% and power demand by 20% by 2050 compared to 2019.

Hydrogen tolerance

In order to assess the current hydrogen compatibility of the grids and facilities, data on pipeline materials and non-pipeline assets used were prepared and evaluated with regard to their hydrogen compatibility according to material and function. The classification of hydrogen compatibility is basically based on the VNB Compendium [3], with partial adjustments based on the experience of the network operator and DBI, including from the city gas supply.

The evaluation showed that basically all pipelines ≤ 16 bar are suitable for up to 100 % hydrogen without separate testing. The pipelines of the HP network > 16 bar are also made of steels suitable for hydrogen, but integrity proofs are required here at the respective time.

The non-pipeline assets are also mostly suitable for 100 % hydrogen. In addition to the process gas chromatographs that are not suitable for hydrogen, there is a need for adaptation of gas meters and volume correctors from an admixture of > 20 vol.% hydrogen. Gas flow monitors that are suitable for up to 30 % hydrogen by volume will be considered separately in future with regard to the conversion to hydrogen, as part of the creation of a holistic safety concept suitable for hydrogen.

Transformation of gas infrastructures

Based on the scenarios and the analysis results of the entire assets with regard to hydrogen compatibility, the cost-optimal transformation paths for increasing the hydrogen compatibility of all networks of the network operator in line with demand were determined. For this purpose, the mixed gas and hydrogen scenarios were considered and compared with a benchmark scenario.

In the benchmark scenario, only a continuation of the regular network renewal takes place, based on the technical service life. For both the mixed gas and hydrogen scenarios, the entire network area is adapted to the targeted hydrogen compatibility at the respective points in time, without taking into account any changes in network structures.

Some of the adjustments with regard to hydrogen compatibility can already be made as part of the regular network renewal, if each asset to be renewed is replaced by components suitable for hydrogen. Measures that are necessary to achieve the hydrogen compatibility target values are presented as unplanned replacement investments.

In the mixed gas scenario, unplanned replacement investments are incurred primarily in the area of measurement technology until 2030. By 2050, the expenses for increasing hydrogen compatibility to 30% by volume are about 1% higher than the expenses for regular network renewal. In the hydrogen scenario, in addition to the unscheduled replacement investments for hydrogen compatibility of 20 vol.-% by 2030, there are also approx. 16% additional investments compared to the expenditures for the regular grid renewals for achieving complete hydrogen compatibility by 2050.

Target network planning

Another focus was on the fluidic and capacitive aspects of the future gas distribution network. Within the framework of a target network planning, the networks were analysed and optimised, especially with regard to their suitability for the distribution of hydrogen. For this purpose, the regional high-pressure distribution network and two representative local networks were considered. A prerequisite for the conversion of the network to hydrogen is the examination and, if necessary, adaptation of the permissible flow velocities previously used by the network operator, both for pipelines and for gas pressure regulating stations (GDRA).

Cost comparison of the scenarios from the transformation paths (normalised, in percent) (Quelle: DBI)

With regard to the fact that hydrogen has only about one third of the volumetric energy content of natural gas, the flow velocity triples when converting to hydrogen due to the larger volume flow required. Compliance with the minimum pressures can, as a rule, still be maintained due to the fluidic properties of hydrogen.

The investigations have shown that the HP network is well dimensioned for operation with both natural gas and hydrogen. For a conversion to hydrogen, only a few measures are necessary from a fluidic point of view (under the above-mentioned premises regarding the flow velocities). These include a partial increase in nominal diameter as part of the regular renewal of the old pipeline stock and the permanent commissioning of a few GDRAs that were previously operated as emergency facilities.

In both local grids, a major focus of the investigations was on the optimisation of the grids. In both cases, the complexity of the networks can be reduced by standardising the pressure levels to medium pressure and supply security can be increased by connecting sub-networks. Depending on the network and the target network variant, approx. 30 to 75 percent of the GDRA can be saved. Furthermore, it could be shown that the local grids considered are essentially suitable for operation with hydrogen without additional adjustments (from a fluidic point of view). Only the areas in the networks where pressures and flow velocities were already at the limits of the current natural gas supply were also conspicuous in the observations with hydrogen, so that few adaptation measures were planned.

Conclusion & recommendations for action

Overall, it could be shown that the pipe networks in the high-pressure and distribution network are already suitable for 100 % hydrogen and the future supply task today without separate testing - both from a material and a fluidic point of view. There is a need for adaptation in the area of measurement technology, the replacement of which should take place as part of the scheduled renewal if possible.

From the point of view of strategic network planning, an increase in the hydrogen concentration in the gas mixture up to the conversion to hydrogen should always be assumed in perspective, also within the framework of regular renewal. For this purpose, assets with the highest hydrogen tolerance available on the market should always be used and the increase in the required volumetric transport capacities should be taken into account in the planning. In addition, the consumers connected to the gas distribution network, which were not considered in this study, should also be taken into account in the planning, as they represent an essential component in the conversion to higher hydrogen concentrations or pure hydrogen.

There is a need for further research and investigation especially on the following topics:

- Permissible flow velocities in the pipe network and in GDRA
- Capacity calculation of GDRA for hydrogen
- Tolerance of the existing gas flow monitors and their embedding in a hydrogen-compatible safety concept
- Concept of conversion from natural gas to hydrogen

Sources:

[1] Deutsche Energie-Agentur GmbH, „dena-Leitstudie: Integrierte Energiewende“, Juli 2018. [Online]. Verfügbar unter: https://www.dena.de/fileadmin/dena/Dokumente/Pdf/9261_dena-Leitstudie_Integrierte_Energiewende_lang.pdf

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[3] Poltrum, M. et al.: Kompendium Wasserstoff in Gasverteilnetzen: Analyse zur Verträglichkeit der Gasverteilnetze mit Wasserstoffanteilen im Gasgemisch in Schritten bis 100 Vol.-%, 19. Apr. 2019

H2CAST Etzel - Leak test H_2-salt cavern | *Germany*

As part of the H2CAST research project, STORAG ETZEL and its project partners have successfully completed the first gas-tightness test with hydrogen on a cavern borehole in Etzel.

"This is the kick-off for practical application research at the Etzel cavern storage facility," says overall project manager Carsten Reekers, STORAG ETZEL: "We have gained positive insights into the use of high-pressure hydrogen drilling equipment and how to handle hydrogen in the cavern field for future large-volume storage!"

Injection of hydrogen into the borehole of the H2CAST project cavern in Nov. 2022 (Source: H2CAST Etzel)

In addition to the leak test, material tests and measurement tests were also carried out under hydrogen and the controlled venting of hydrogen was tested. During the combustion of hydrogen, the ignition behaviour was observed, the safety devices were tested and sound emissions were measured. In addition, the practical handling of hydrogen was practised with the help of the local fire brigades and the State Office for Mining, Energy and Geology (LBEG) in the course of a practical training course.

The next step is to complete the expansion of the hydrogen caverns so that the storage of larger quantities of hydrogen in H2CAST can begin this year. We will report on the results again in the HIPS-NET newsletter.

Source: Successful completion of the first leak test with hydrogen at cavern in Etzel | H2CAST Etzel

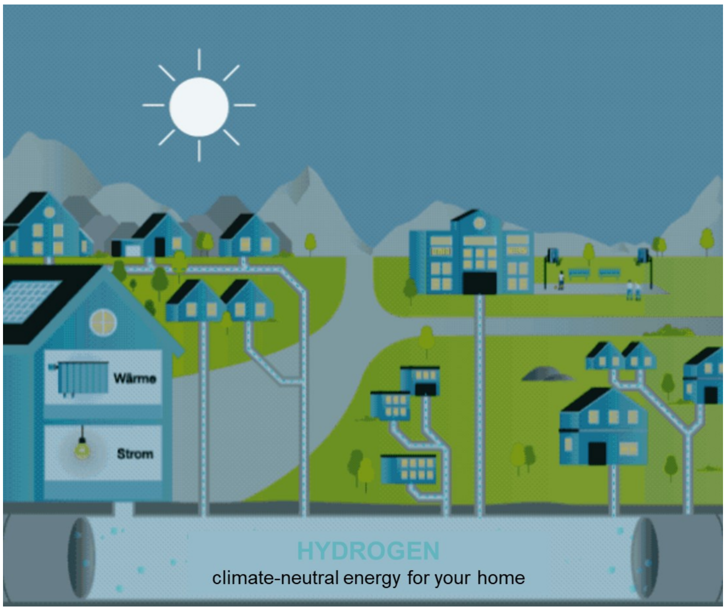
H2Direkt - Heating with 100 % hydrogen | *Germany*

GEFÖRDERT VOM

Leitprojekt TransHyDE

Bundesministerium für Bildung und Forschung

As part of the H2Direkt research project, it is to be demonstrated for the first time that heating with 100% hydrogen is an attractive option. For this purpose, a section of the natural gas network in Markt Hohenwart (Upper Bavaria, Pfaffenhofen district) is being converted to hydrogen. Ten private households and one commercial enterprise have been won as test customers. The contracts have already been signed: They will receive a free conversion to hydrogen condensing boilers from Vaillant and will start an initial 18-month test phase with the 2023/2024 heating period. For this purpose, a small section of the existing gas network will be separated from the rest of the network and thus run completely on 100% green hydrogen in isolated operation. The feed-in system will be refilled at short intervals. The project partners Energienetze Bayern GmbH & Co KG, Energie Südbayern GmbH and Thüga AG want



H2Direkt: Heating with 100 % hydrogen (source: https://www.esb.de/h2direkt) to show that a climate-neutral gas supply for private households and businesses is feasible and operationally reliable and that the existing gas infrastructure can continue to be used with hydrogen in the future with only minor technical modifications. The experience gained with technical and organisational processes will be incorporated into a guideline that will support gas network operators in future conversion processes. H2Direkt is funded by the Federal Ministry of Education and Research (BMBF) as part of the TransHyDE lead project. With four demonstration projects and five scientific projects, TransHyDe evaluates and tests hydrogen transport solutions.

Sources:

https://www.thuega.de/stadtwerke-der-zukunft/newsblog-h2direkt-heizen-mit-100-wasserstoff/

https://www.zfk.de/energie/gas/pilotprojekt-h2direkt-thuega-findet-wasserstoffpioniere

https://www.esb.de/h2direkt

Country analysis H_2-Compass - an overview | *worldwide*

The Hydrogen Compass of DECHEMA and acatech looks at potential options for policy action to successfully build a German hydrogen economy. In December, a country analysis was published as part of the project, comparing the hydrogen strategies of 22 countries and regions. The countries examined were China, Japan, California, South Korea, Australia, the Netherlands, Germany, Norway, the European Union, Portugal, France, Chile, Spain, Italy, the USA, Canada, Hungary, Poland, the UK, Russia, Morocco and the Czech Republic. The report also provides profiles of each of the 22 countries and regions with their respective targets, approach, hydrogen production methods and targeted fields of application.

The hydrogen strategies of the countries considered are oriented towards climate protection and economic goals. They focus on application possibilities, the establishment of international cooperation, the development and expansion of infrastructures and the promotion of R&D activities. Regulatory measures are also relevant, in which a cost parity between hydrogen from renewable and fossil energies is to be created by means of CO_2 pricing.

For the production of hydrogen, all countries considered rely on water electrolysis based on renewable energies (green hydrogen). As a transitional solution, some countries rely on hydrogen production using fossil energy sources and subsequent CO_2 capture (blue hydrogen). (Editor's note: The hydrogen strategies under consideration were developed before Russia's war of aggression in Ukraine. Since then, hydrogen production with natural gas seems unlikely, especially for European countries).

In the transport sector, hydrogen is to be used primarily in the short and medium term in (heavy) goods transport and in fleet alliances. In the passenger car sector, opinions differ widely. Either use is expected in the next few years or is not an issue. Hydrogen use in industry is targeted in areas that already have high hydrogen demand as well as the necessary infrastructure, for example the chemical industry and refineries. In heat and energy applications, the use of hydrogen is expected in the medium to long term. The figure shows which sectors the individual countries are focusing on.

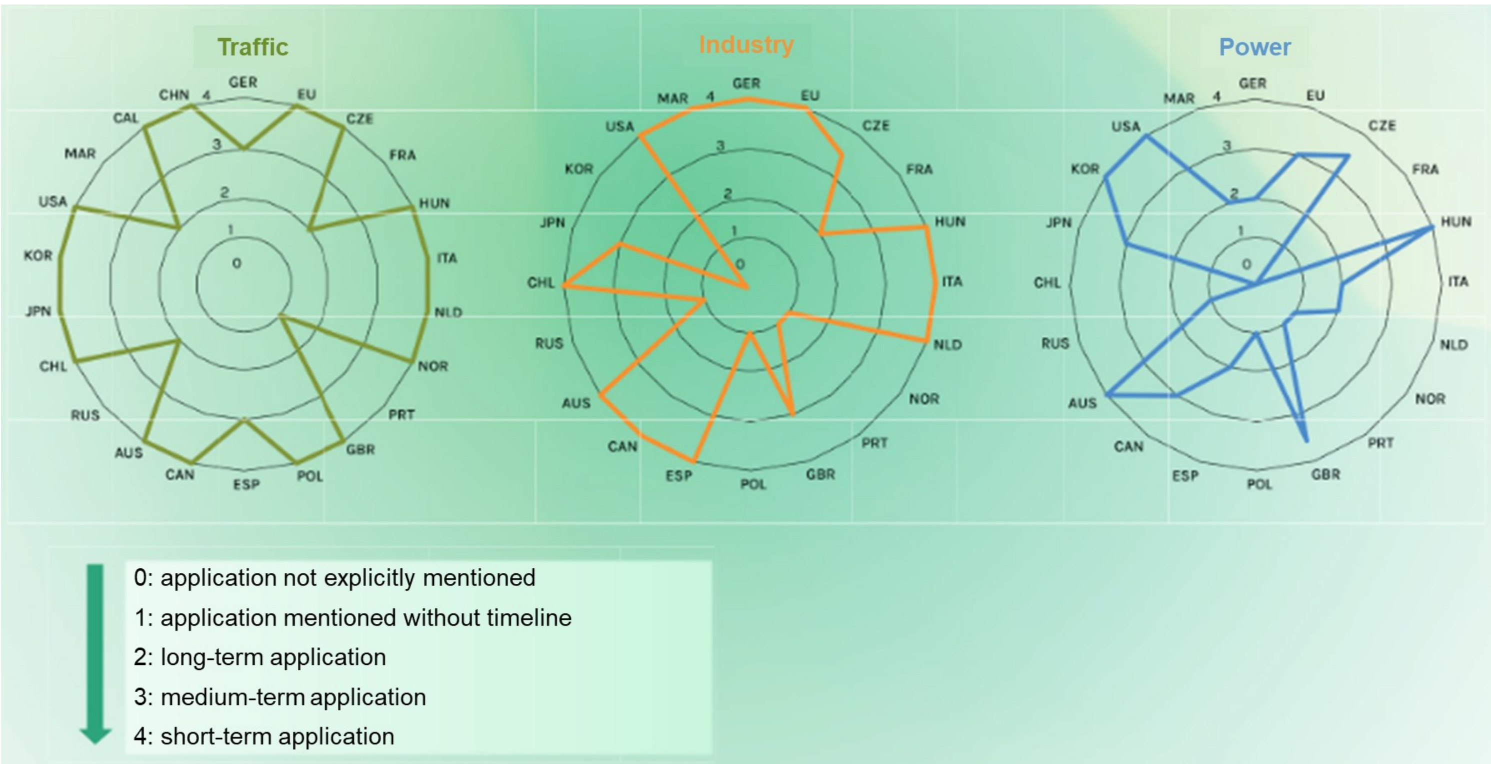
In addition, the question arises as to how the demand for hydrogen can be met in the future. A third of the countries considered, including Chile, Spain, Portugal and Morocco, see themselves as future exporters of hydrogen. The United Kingdom, Germany, Italy, the Czech Republic, Japan and the Netherlands see themselves as importing countries.

The country analysis concludes that this should be continued and supplemented so that new strategies can also be included. (Editor's note: Japan has announced that it will revise its H_2 strategy from 2017. The revised version is to be published at the end of May. In addition, several other countries, e.g. Romania, Algeria, Uruguay and Ireland are in the process of developing their own H_2 strategies. We will report on the updates in upcoming HIPS-NET newsletters).

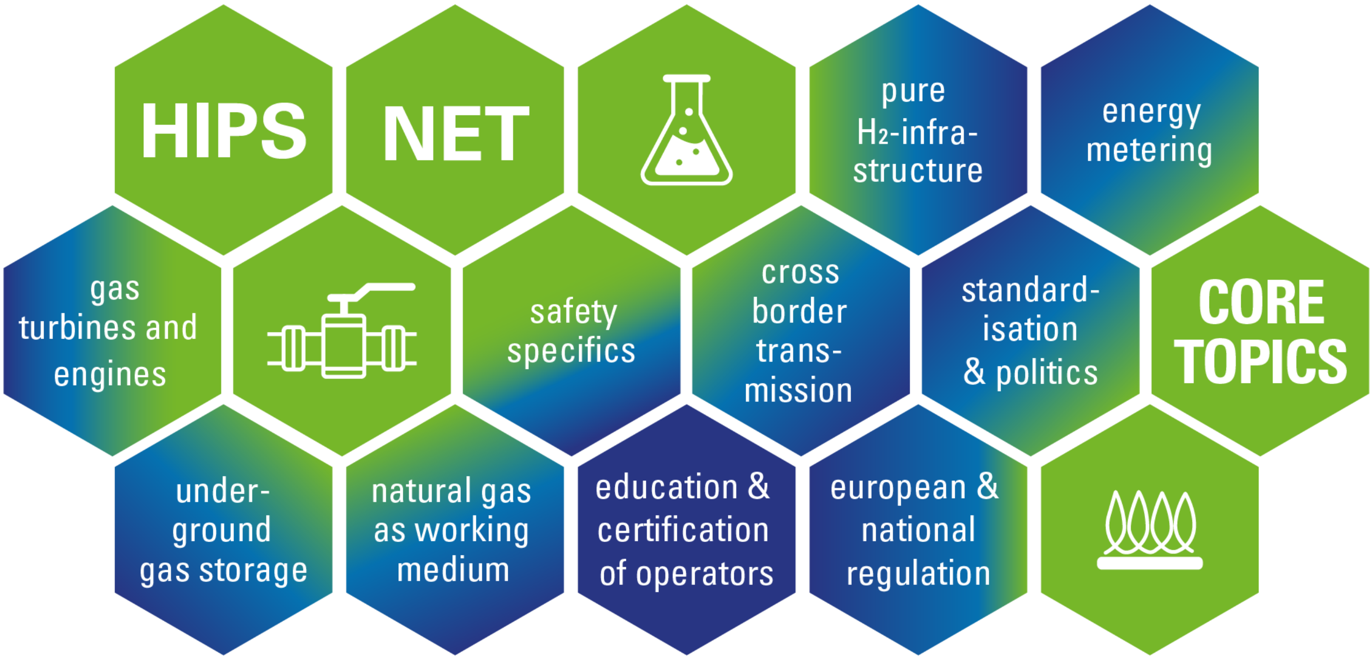
Sources:

https://www.wasserstoff-kompass.de/news-media/dokumente/wasserstoff-strategien-laender-vergleich

https://www.wasserstoff-kompass.de/kompass



Overarching evaluation for different sectors (source: https://www.wasserstoff-kompass.de/fileadmin/user_upload/img/news-und-media/dokumente/2022_H2_Laenderanalyse.pdf, p. 17)



Events (Selection) :

June 2023

6-7 3rd H2 FORUM 2023 | Berlin, Germany + online, *h2-forum.eu*

13-14 ees Europe | Munich, Germany, *ees-europe.com*

14-15 Hydrogen & P2X | Copenhagen, Denmark, *fortesmedia.com*

15 10. HIPS-NET Workshop | Brussels, Belgium, *dbi-gruppe.de/hips-net.html*

28-29 H2Expo & Conference | Hamburg, Germany, *h2expo.de*

Partner :

Alliander AG, Cadent, DGC,
DNV GL, Elogen, Enagás, Enbridge, Energinet.dk, ENGIE, EWE Netz,
Gas Connect Austria GmbH,
Gasnetz Hamburg, Gasum OY,
Gasunie, GRTgaz, grzi e.V. (figawa),
Infraserv GmbH & Co. Höchst KG,
INERIS, innogy SE, ITM Power,
Joint Research Centre (JRC), EC,
KOGAS, NAFTA a.s, Naturgy,
Netze Südwest, ONTRAS, ÖVGW,
Open Grid Europe GmbH,
Polymer Consult Buchner GmbH,
RAG Austria AG, Shell,
Solar Turbines Europe S.A.,
Storengy, SVGW, Synergrid, Teréga, TNO, Uniper Energy Storage GmbH,
Verband der Chemischen Industrie (VCI), VNG AG, Wintershall Dea AG.

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