HyUSPRe

Hydrogen **U**nderground **S**torage in **P**orous **Re**servoirs

E-Newsletter #4

In this issue:

Welcome by the Coordinators

It’s been some time since we published the previous (thrid) newsletter of the European HyUSPRe project in December 2022. With this fourth newsletter edition we update you on the progress of HyUSPRe and everything newsworthy from the past nine months.

Although HyUSPRe made good progress in the past months, we had to request a 6-month project extension because the time needed to execute the quite heavy experimental program was underestimated. The extension was recently approved and the new end date of HyUSPRe is now 30 June 2024.

HyUPSRe consortium member representatives at the periodic review meeting in Brussels, March 2023.

In March 2022, the project had its first periodic review. Representatives of all consortium partners met in Brussels to discuss results of the first period with the Clean Hydrogen Partnership’s project officer and two invited external reviewers. It was good to meet with the consortium partners face-to-face, as it makes critical discussion of results and challenges much easier. The review was very positive and also provided a couple of valuable recommendations for the second period.

Just recently, in October of this year, the consortium gathered at the Forschungszentrum Jülich in Germany to discuss progress, specifically of the site-specific field-scale simulations in the context of the case studies for hydrogen storage and the envisaged roadmap for implementing hydrogen storage in porous reservoirs in Europe.

This e-newsletter highlights a couple of recently delivered research reports and summarizes the key findings. They show how important (and challenging!) it is to conduct desk and laboratory research studies, and what learnings are gained from it that help large-scale hydrogen storage in the underground to make the step towards safe, reliable and affordable implementation.

Enjoy reading!

Holger Cremer, TNO, consortium manager

Remco Groenenberg, TNO, lead scientist

About HyUSPRe

Hydrogen **U**nderground **S**torage in **P**orous **Re**servoirs

The HyUSPRe project researches the feasibility and potential of implementing large-scale underground geological storage for renewable hydrogen in Europe. This includes the identification of suitable porous reservoirs for hydrogen storage, and technical and economic assessments of the feasibility of implementing large-scale storage in these reservoirs to support the European energy transition to net zero emissions by 2050. The project will address specific technical issues and risks regarding storage in porous reservoirs and conduct an economic analysis to facilitate the decision-making process regarding the development of a portfolio of potential field pilots. A techno-economic assessment, accompanied by environmental, social, and regulatory perspectives on implementation will allow for the development of a roadmap for widespread hydrogen storage by 2050, indicating the role of large-scale hydrogen storage in achieving a zero-emissions energy system in the EU by 2050.

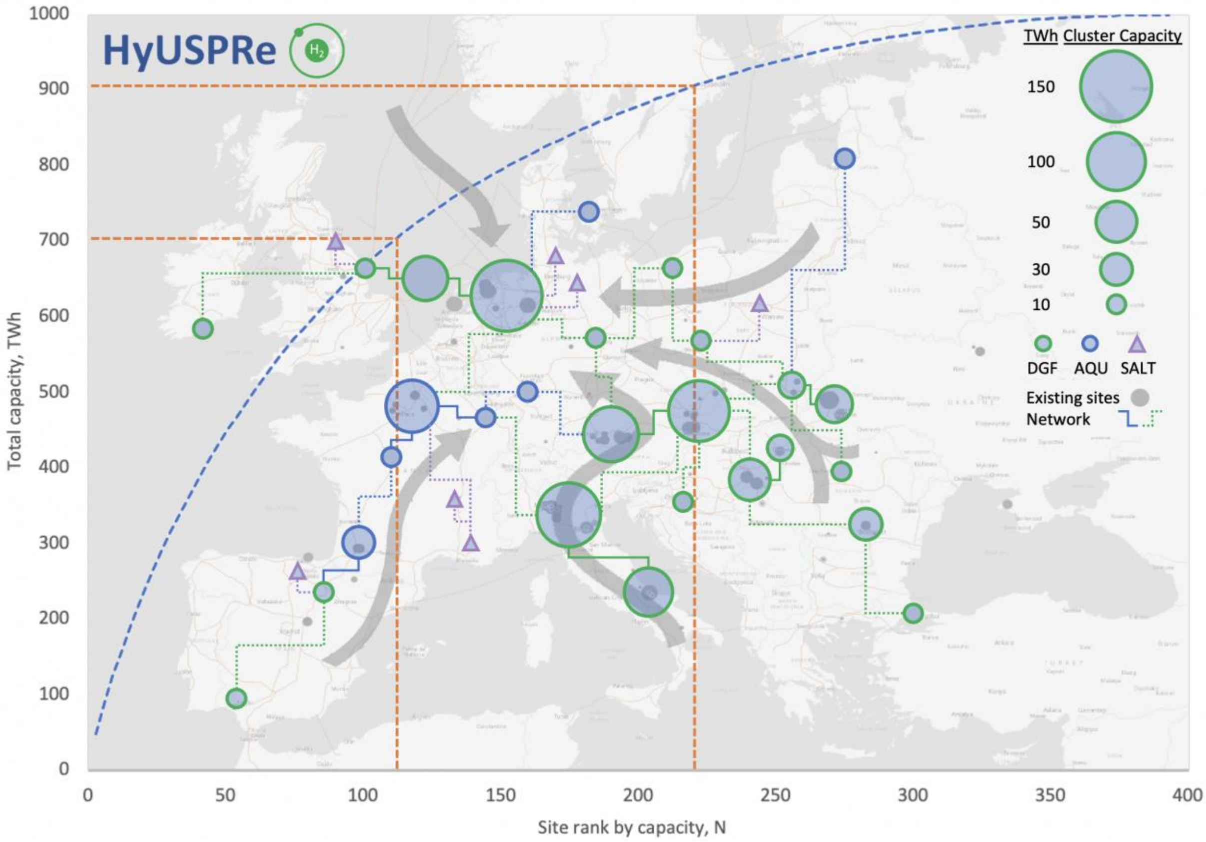
This project has two specific objectives. Objective 1 concerns the assessment of the technical feasibility, associated risks, and the potential of large-scale underground hydrogen storage in porous reservoirs for Europe. HyUSPRe will establish the important geochemical, microbiological, flow, and transport processes in porous reservoirs in the presence of hydrogen via a combination of laboratory-scale experiments and integrated modelling; and establish more accurate cost estimates to identify the potential business case for hydrogen storage in porous reservoirs. Suitable storage sites will be identified, and their hydrogen storage potential will be assessed. Objective 2 concerns the development of a roadmap for the deployment of geological hydrogen storage up to 2050. The proximity of storage sites to large renewable energy infrastructure and the amount of renewable energy that can be buffered versus time varying demands will be evaluated. This will form a basis for developing future scenario roadmaps and preparing for demonstrations.

Research reports in the spotlight

Classifying H_2 storage potential in porous reservoirs in Europe

This HyUSPRe report on *classifying hydrogen storage potential in porous reservoirs as an aid to European site selection* builds on the preceding HyUSPRe report, *hydrogen storage potential of existing European gas storage sites*, which identified a longlist of 140 natural gas storage sites with a potential hydrogen storage capacity of 375-750 TWh. This new study refines the initial reserve analysis for hydrogen storage in porous reservoirs to 320-415 TWh and a shortlist of 20 sites from regional clusters that identify attributes for targeting new porous reservoir sites to increase the reserve by 1,000 TWh.

Europe has developed underground gas storage over several decades, establishing a mature network of storage assets with known attributes. The longlist-shortlist approach to classifying European storage potential is a simple two-tiered methodology that is suited to a regional analysis of the substantial existing porous reservoir reserve with hydrogen storage potential. The first tier of analysis, the longlist, addressed the history, geography, and general attributes of the existing natural gas reserve. The second tier, the shortlist, refines the initial outcomes with a cluster analysis of the mapped reserve, identifying 'exemplars' and 'prototypes'. The ten exemplars are longlisted natural gas storage sites with good data for key attributes such as capacity, depth, pressure, temperature, and permeability, that are representative of storage for the associated cluster. The average values are used to build a prototype for each cluster. The exemplars and prototypes are an aid to future site selection based on known properties and regional attributes. Both the longlist and shortlist estimate the reduction in capacity, in TWh, that results from the conversion of natural gas storage to hydrogen.



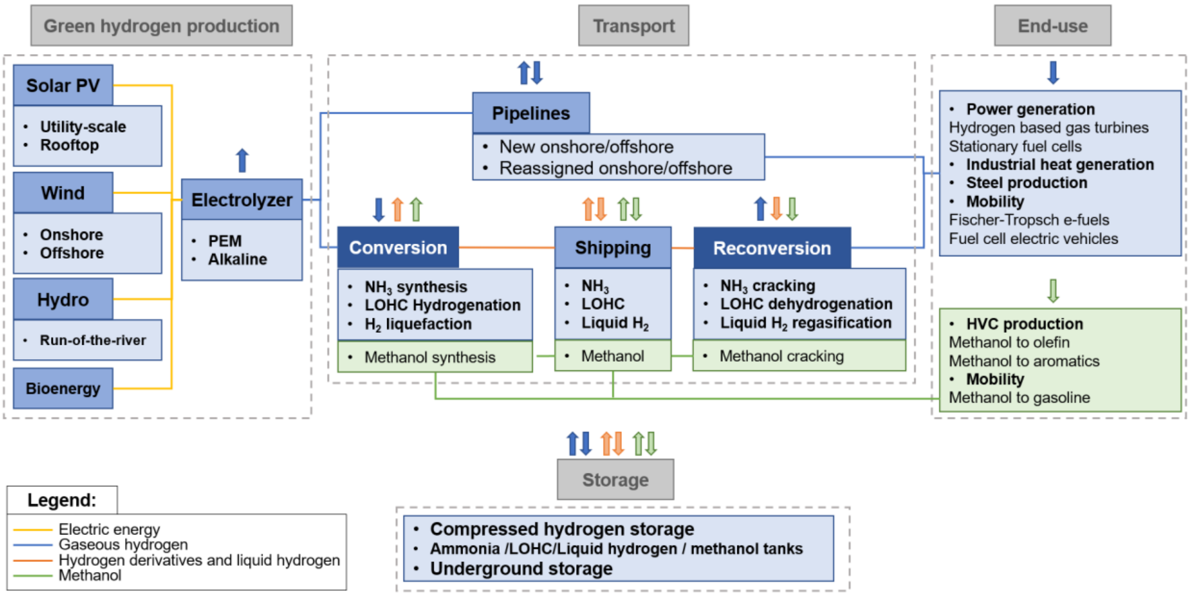
The gap: a high-demand low-supply scenario for 1,000 TWh *of hydrogen storage in 2050. The cumulative capacity curve overlays a map of forecast capacities associated with clusters, and the small fraction of capacity that is located outside the clusters.* ***Depleted gas field storage, 840 TWh*** *(green rings****), aquifer storage, 160 TWh*** *(blue rings), unquantified salt cavern storage (purple triangles).* ***Supply corridors, as envisioned by the European Hydrogen Backbone initiative****, are depicted as arrows in the background (EHB, 2022). The 1000 TWh scenario requires 400 storage sites, although* ***70% of the capacity is located in 110 sites****, and 90% in 220 sites (orange dashed lines).* ***Mid-demand and low-demand scenarios of 500 and 250 TWh have the same distribution*** *for 200 and 100 sites respectively. The logarithmic distribution is derived from the existing longlist. The shortlist provides the fractional distribution amongst the clusters. Related regional clusters are linked via the network. Figure reproduced from [Cavanagh et al., 2023](#).*

The longlist-shortlist approach is a top-down reserve analysis. It differs significantly from the more common bottom-up resource analysis that is based on a theoretical estimate of regional resources and suited to undeveloped domains such as emergent petroleum provinces and CO_2 storage regions. The two approaches complement each other, in that the former lends itself to a gap analysis of required additions to meet demand, whereas the latter identifies the vast potential resource that needs to be matured through exploration and target development to provide a portfolio of contingent prospects that can address the gap.

The shortlist and longlist analyses indicate the following. Most potential hydrogen storage sites will have a capacity of 1-5 TWh, and will mostly be developed in relatively small depleted gas fields hosted in sandstone reservoirs at a depth of 500-2,500 m, with a small number of large sites, 10-20 TWh, which are typically deeper and have lower working gas ratios, reflecting the higher reservoir pressure conditions. Aquifer and carbonate reservoirs will make a fractional contribution to storage.

Equipment requirements, capital and operation costs for various hydrogen scenarios

HyUSPRe project studies involve spatio-temporal optimization modeling of a green hydrogen supply chain linking production and demand centers within the European energy system. The aim is to assess future scenarios of hydrogen contributing to the European energy system. It is of particular interest to assess the role of large-scale, seasonal, hydrogen storage in perspective of an energy system with as strongly growing share of non-dispatchable, intermittent renewable power supply.



Schematic illustration of the green hydrogen value chain assessed in this study.

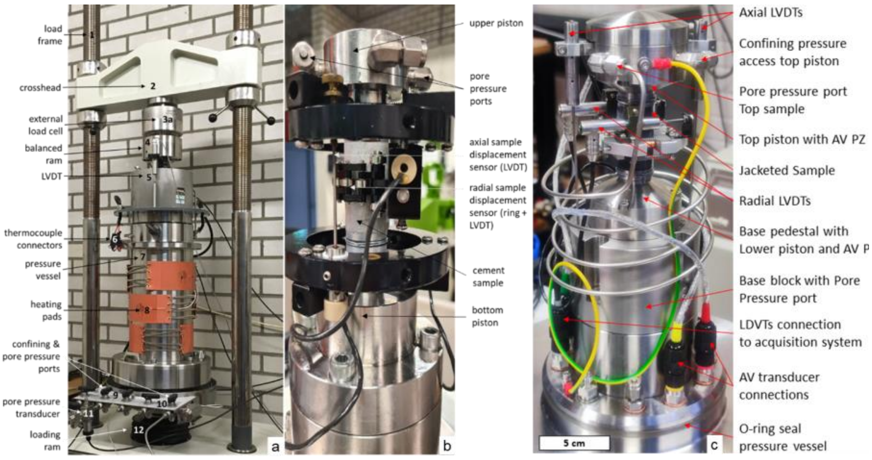
Hydrogen scenarios require a strong basis of input parameters along with their future forecasts. Firstly, solar and wind resource potentials for the production of green hydrogen as well as hydrogen demand scenarios need to be assessed. Second, the green hydrogen supply chain needs to be characterized in terms of techno-economic parameters of its constituent elements. This report summarizes the results of an extensive bibliographical research of techno-economic parameters with the aim of creating a solid dataset to be used for scenario definition. Most technologies of the hydrogen supply chain benefit from extensive literature coverage, leading to plenty of values per single parameter. The report can be downloaded from the HyUSPRe website.

Experimental results of reactions between hydrogen and well cement

This experimental study presents data on the effects of hydrogen exposure and cyclic loading on mechanical properties of oilwell cement. The team analysed changes in mechanical properties (Young's modulus, Poisson's ratio, ultimate strength) using unconfined compressive strength and confined cyclic loading tests on class G cement samples that were unreacted and exposed to lime-saturated brine and nitrogen or hydrogen for 1 and 2 months. Changes in cement mineralogy were analysed by XRD analysis.

The main conclusion of the experimental study is that effects of H_2 exposure and cyclic loading on mechanical properties and mineralogical changes of class G cement is limited compared to unreacted or N_2 exposed samples for the investigated conditions. There is no indication that changes in mechanical properties of cement are such that cement integrity of wells used for underground hydrogen storage will be significantly affected.

The mechanical properties of elastic modulus and Poisson's ratio are within the expected range of an oilwell cement. Differences in Young's modulus, Poisson's ratio and ultimate strength are limited between unreacted, N_2-exposed and H_2-exposed samples, when comparing UCS or confined cyclic loading tests. During cyclic axial loading of confined cement samples, irreversible (plastic) deformation (compaction) occurs that affect static Young's modulus. Also, effects of exceeding yield and failure strength on Young's modulus are observed.

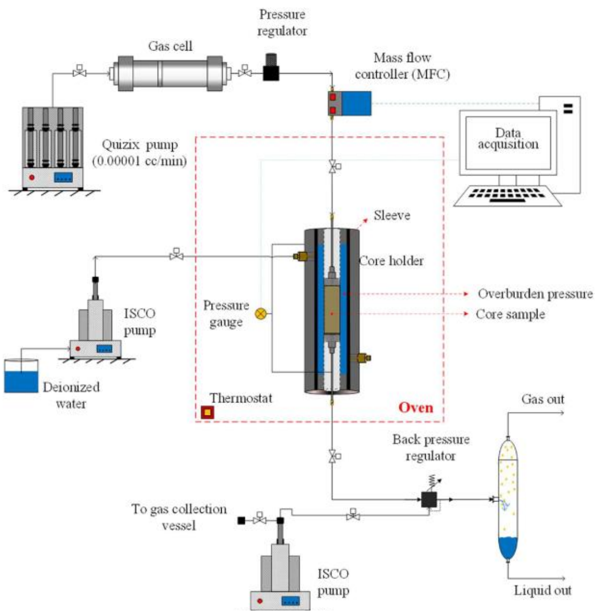


(a) Triaxial load frame and pressure cell. (b) Sample setup for UCS tests. (c) Sample setup for cyclic tests with acoustic velocity sensors (AV). Both sample setup are placed inside the triaxial pressure cell (comparable to) the cell shown in (a).

Dynamic Young's moduli and Poisson's ratios derived from acoustic velocity measurements during confined cyclic tests show limited variation, in particular if static and dynamic Young's modulus are compared. The mineralogical changes as identified using XRD analysis suggest minor changes between unexposed and H_2- and N_2-exposed samples. Data are available from Zenodo.

Relative permeability curves for the hydrogen-brine system

Underground hydrogen storage comes with several research gaps, including the flow behaviour of hydrogen gas in porous media. Colleagues at University of Edinburgh studied the effect of pressure, brine salinity, and rock type on hydrogen flow behaviour and compared it to that of CH_4 and N_2 at high-pressure and high-temperature conditions representative of potential geological porous media storage sites. The team provided unsteady state relative permeability curves with H_2-Brine, on two different types of sandstones and a carbonate rock. The history matching method was used for modelling relative permeability curves using the measured data within the experiments.



Schematic of the setup used for gas-brine relative permeability measurements. The sizes of different objects have been rescaled to make them visible.

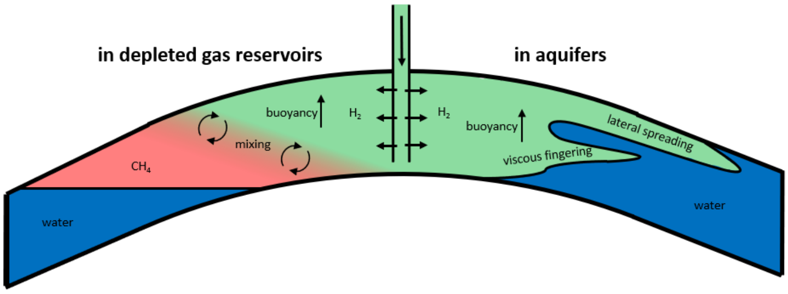
Results suggest that nitrogen can be used as a proxy gas for hydrogen to carry out multiphase fluid flow experiments, to provide the fundamental constitutive relationships necessary for large-scale simulations of geological hydrogen storage. The relative permeability of hydrogen was significantly higher than that of brine in all three rock types. Additionally, the relative permeability of hydrogen was found to increase with increasing temperature, while the relative permeability of brine decreased with increasing temperature. The authors also observed that the relative permeability of hydrogen was higher in sandstone than in carbonate rocks and that the effective porosity of a rock has the most evident impact on H_2-brine relative permeability.

The results of this study have significant implications for the development of hydrogen as an energy source. The higher relative permeability of hydrogen in reservoir rocks indicates that it may be feasible to store hydrogen as an energy carrier in large volumes in porous reservoirs in the subsurface.

Results were published in a HyUSPRe report and a peer reviewed paper published at https://doi.org/10.1029/2022GL099433 and the data are publicly accessible at https://doi.org/10.6084/m9.figshare.19722520.v1.

Hydrogen flow behavior: molecular diffusion, mechanical dispersion and relative permeability

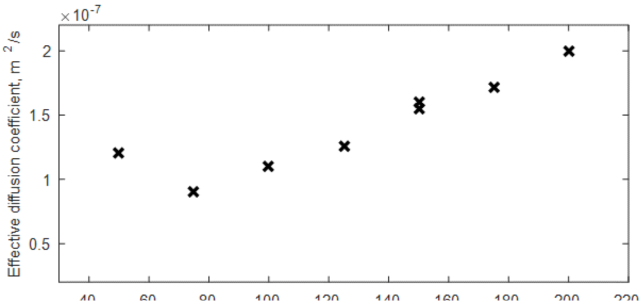
A second study investigated the hydrogen flow in porous media under subsurface storage conditions. To close existing knowledge gaps, several experiments were carried out.



Sketch of gas mixing and hydrodynamic effects in an underground hydrogen storage.

The first experimental series studied the molecular diffusion for a binary H_2-CH_4 system in different reservoir rocks. The second experimental series studied the mechanical dispersion also for a H_2-CH_4 system. The measurements of molecular diffusion and mechanical dispersion were both conducted at a range of temperatures and pressures to investigate the effects of the two parameters on diffusive and dispersive mixing. The third study investigated unsteady state drainage H_2/brine relative permeabilities as affected by variations in sample mineralogy and pore structure, as well as variations in pressure and pore fluid salinity. The fourth study outlines the effect of pore fluid pressure on H_2 injectivity and recovery.

29 measurements of molecular diffusion were performed and interpreted. The influence of pressure, temperature and water saturation was examined using a Bentheimer sandstone as reference sample. The determined effective gaseous diffusion coefficients varied between $5 \cdot 10^{-9}$ and $2.3 \cdot 10^{-7}$ m²/s. The results showed clear trends, but deviations were observed from conventional correlations at pressures above 75 bar and for the dependence on temperature at 100 bar. The decreasing trend of effective diffusion coefficient with increasing water saturation fits the expectation. The comparison of effective diffusion coefficients for



Effective diffusion coefficient vs. pressure for a Bentheimer Sandstone sample at 40 °C.

different samples at reference conditions indicated that the effective diffusivity increases with porosity and permeability.

For the mechanical dispersivities 13 measurements were carried out. The measurements examined the effects of pressure, temperature and flow velocity on dispersivity. The interpreted longitudinal mechanical dispersivity was between 0.018 m and 0.060 m. The results showed that dispersivity is not independent of these parameters, indicating that fluid properties such as density and viscosity play a role. However, Scheidegger's theory for dispersion was found to sufficiently predict dispersive mixing between two gases under subsurface storage conditions.

The experiments further showed that relative permeability of hydrogen is influenced by pore structure and porosity, with increasing porosity resulting in increased relative permeability. When pressure is increased at higher hydrogen saturations, the viscosity of hydrogen increases, which reduces its relative permeability. Salinity also has an effect on relative permeability, with an increase in salinity causing a reduction in relative permeability, possibly due to an increase in interfacial tension. All relative permeability curves on three different samples exhibit a strongly water-wet behaviour.

The study results are fully described in this HyUSPRe report.

DuMu^x: a validated open-source reservoir modelling software

DuMu^x is a validated open-source reservoir modeling software. It was recently extended with functionality to simulate hydrogen-induced processes and then calibrated to laboratory observations. The newly developed implementation enables users to model two-phase n-component transport of hydrogen-rich gaseous mixtures in porous media coupled with bio- and geochemical reactions. The consumption of hydrogen by methanogenic and sulfate-reducing microorganisms is implemented, which produces methane and hydrogen sulfide (H_2S) respectively. Furthermore, the pyrite-to-pyrrhotite reduction reaction is implemented, which also generates H_2S.

With the new functionality, this model is able to reproduce laboratory experiments of hydrogen-related processes and can be used to simulate coupled flow, geochemical and microbiological processes in a porous reservoir under operational hydrogen storage conditions at field-scale.

The developed implementation is available as a separate module of DuMu^x including examples in the Gitlab repository. An accompanying report can be downloaded from the HyUSPRe website.

HyUSPRe scientific publications

In 2023 members of the HyUSPRe consortium published a number of scientifc publications that are listed here in alphabetical order together with the paper abstract.

Hogeweg, S. et al. (2023) Numerical Simulation of Bio-Geo-Reactive Transport during UHS - A Modelling Approach. Tagungsbericht der DGMK Frühjahrstagung.

The increased share of renewable energy sources leads to larger fluctuations of energy availability but also increases the significance of energy storage. Large scale hydrogen storage in the subsurface may hence become a vital element of a future sustainable energy system because stored hydrogen is an energy carrier that will be available on demand. Large capacities of hydrogen can be stored in porous formations such as former gas fields or gas storages, while caverns will contribute with high deliverability. However, the storage of hydrogen induces unique processes on fluid-fluid and rock-fluid interactions (for example, bio- and geochemical reactions), which may affect the efficiency of the storage. In the present study, a numerical model describing the two-phase multi-component flow in porous media, including bio- and geochemical reactions, is developed. The proposed model extends an existing model in the open-source simulator DuMux describing the bio-reactive transport process considering methanogenesis and sulfate-reduction by geochemical reactions. Based on the kinetical formulation, the hydrogen-driven reduction of pyrite to pyrrhotite with the production of harmful hydrogen sulfide is modelled. Due to limited literature data, a simplified model describing the conversion process is used, and artificial rates are defined. Preliminary simulations on a semiartificial geological model show the potential hydrogen consumption and consequently lead to a reduced withdrawal of stored hydrogen. Furthermore, changes in mineral composition can be observed, though with a minor impact on the petrophysical parameters. Within the scope of the study, the established numerical model is validated and improved by accompanying laboratory experiments to assess the risk of hydrogen conversion during UHS. Finally, field scale simulations with actual field data are planned to be conducted. [Link; p. 221]

Michelsen, J. et al. (2023) Experimental investigations and development of a correlation to characterize the diffusion process of hydrogen and methane during UHS. Tagungsbericht der DGMK Frühjahrstagung.

Renewable energy sources are becoming increasingly important during the current energy transition. The growing share of renewable energy sources problematically leads to fluctuations challenging the entire energy system. To keep the balance between energy demand and production in the future, and therefore to maintain energy availability, excess energy can be converted into hydrogen, stored and thereby acts as a buffer. Porous reservoirs, such as depleted natural gas fields, offer a good potential to store hydrogen in appropriate quantities. A reliable and effective storage operation requires a fundamental understanding of the mixing processes between the injected hydrogen and residual/cushion gas, supporting the deliverability of the storage. Besides the pressure-driven advective flux, mechanical dispersion and molecular diffusion influence the progressive mixing with the initial gas, typically natural gas. In the present study, experimental investigations are performed to determine gas diffusion coefficients of the binary hydrogen-methane system. Here, diffusion experiments using a novel pseudo-stationary approach with dry reservoir rock samples at typical storage conditions (temperatures and pressures) are performed. Evaluations of the experiments showed effective diffusion coefficients for the system to lie within a range of 9.00 · 10−8 − 2.00 · 10−7 m2 /s. A temperature and pressure dependent correlation is developed to predict effective diffusion coefficients for the porous rock samples. Furthermore, the experimental results are used to establish an additional correlation describing the interdependence between bulk and porous medium diffusion. This relationship depends on petrophysical properties such as porosity, permeability, and tortuosity. For the correlation, the polynomial regression approach is used; nevertheless, more general forms can be produced by measuring other binary gas constellations. The achieved correlation can be used in various models, such as the simulation of underground hydrogen storages on field scale. [Link; p. 231]

Aftab, A. et al. (2023) Geochemical integrity of wellbore cements during geological hydrogen storage. Environmental Science & technology Letters, 10: 551-556.

Increasing greenhouse gas emissions have put pressure on global economies to adopt strategies for climate change mitigation. Large-scale geological hydrogen storage in salt caverns and porous rocks has the potential to achieve sustainable energy storage, contributing to the development of a low-carbon economy. During geological storage, hydrogen is injected and extracted through cemented and cased wells. In this context, well integrity and leakage risk must be assessed through in-depth investigations of the hydrogen−cement−rock physical and geochemical processes. There are significant scientific knowledge gaps pertaining to hydrogen−cement interactions, where chemical reactions among hydrogen, in situ reservoir fluids, and cement could degrade the well cement and put the integrity of the storage system at risk. Results from laboratory batch reaction experiments concerning the influence of hydrogen on cement samples under simulated reservoir conditions of North Sea fields, including temperature, pressure, and salinity, provided valuable insights into the integrity of cement for geological hydrogen storage. This work shows that, under the experimental conditions, hydrogen does not induce geochemical or structural alterations to the tested wellbore cements, a promising finding for secure hydrogen subsurface storage. [Link]

Peecock, A. et al. (2022) Mapping hydrogen storage capacities of UK offshore hydrocarbon fields and exploring potential synergies with offshore wind. Geological Society Special publications 528.

Energy storage is an essential component of the transitioning UK energy system, a crucial mechanism for stabilizing intermittent renewable electricity supply and meeting seasonal variation in demand. Low-carbon hydrogen provides a balancing mechanism for variable renewable energy supply and demand, and a method for decarbonizing domestic heating, essential for meeting the UK's 2050 net-zero targets. Geological hydrogen storage in porous rocks offers large-scale energy storage over a variety of timescales and has promising prospects due to the widespread availability of UK offshore hydrocarbon fields, with established reservoirs and existing infrastructure. This contribution explores the potential for storage within fields in the UK Continental Shelf. Through comparison of available energy storage capacity and current domestic gas demands, we quantify the hydrogen required to decarbonize the UK gas network. We estimate a total hydrogen storage capacity of 3454 TWh, significantly exceeding the 120 TWh seasonal domestic demand. Multi-criteria decision analysis, in consultation with an expert focus group, identified optimal fields for coupling with offshore wind, which could facilitate large-scale renewable hydrogen production and storage. These results will be used as inputs for future energy system modelling, optimizing potential synergies between offshore oil and gas and renewables sectors, in the context of the energy transition. [Link]

HyUSPRe event attendance

2nd International Summer School on UHS at TU Delft

4-7 July 2023, the TU Delft's Department of Geoscience and Engineering organized the 2nd International Summer School on Underground Hydrogen Storage. Subscribing participants were offered a varied program with three days fully packed with topical presentations and discussions. On day 2, HyUSPRe lead scientist Remco Groenenberg presented an update on HyUSPRe's progress in a session where updates were also given on the Hystories and HyStorPor R&D projects. You can see the program with titles and speakers here. The event was also addressed in detail on LinkedIn.

Hystories project final meeting

25-26 May 2023, HyUSPRe's sister project Hystories (Hydrogen Storage in European Subsurface) held its final meeting in Paris. The two day meeting offered a varied program presenting project results. Topics include microbiology, a database of porous media traps and its capacities, geochemical reactions, UHS environmental footprint assessment, European regulation review, and many more. The conference offered a total of three panel discussions on 'Impacts of microbiological activity in underground storages', 'Technical lessons learnt from European pilot projects' and 'Strategies for the deployment of hydrogen storage in Europe'. One of the panelists of the first discussion was HyUSPRe's researcher Anne-Catherine Ahn.

Slide decks of all talks and video's of the panel discussions can be revisited and downloaded from Hysteries' conference page.

HyUSPRe consortium meeting

On 4-5 October, 2023 the HyUSPRe consortium gathered in Jülich, Germany, at the Forschungszentrum in order to discuss recent activities, progress and results of our research activities. We were guests at the Institute of Energy and Climate Research – Techno-Economic Systems Analysis (IEK-3) – colleagues there study sustainable energy systems in the broadest sense.

During the two-day meeting, 38 participants representing nearly all consortium partners intensively discussed selected research activities that will be concluded in the coming months. Among these is series of site-specific, field-scale simulation studies to assess performance and integrity of the reservoir when injecting large quantities of hydrogen. Not surprisingly, such case studies are based on a lot of assumptions and stimulate a lot of questions leading to critical, lively discussions.

A second topic participants focused on was the roadmap towards EU-wide implementation of underground hydrogen storage in porous reservoirs that the consortium is aiming to formulate at the end of the project. Using the so-called world-café approach relevant aspects of underground hydrogen storage were discussed: technology development, policy and regulation, economics and market, environmental challenges and risks, and social awareness and acceptance. A lot of post-its were filled with hundreds of comments and ideas (see right) – not surprisingly when almost 40 people discuss about aspects that are relevant for a roadmap document. The roadmap core team will have to spend many hours to sort and evaluate the entire input and distill a European hydrogen roadmap out of it.

Meet the Scientist | Engineer

In this newsletter edition HyUSPRe's two colleagues from Wageningen University and Neptune Energy, respectively get the stage to introduce themselves to the readership.

Diana Z. Sousa, Wageningen University

My name is Diana Sousa and I lead the Microbial Physiology group at The Laboratory of Microbiology from Wageningen University and Research. Originally from Portugal, I pursued my education in Biological Engineering at the University of Minho, in the beautiful (sometimes rainy, sometimes hot) city of Braga. At the time of my studies I specialized in Environmental Technology. I've been always interested and enthusiastic to contribute to a better and greener world! After my graduation I worked for 2 years in a company where we designed and implemented industrial wastewater treatment plants. I loved going to the field, and was challenged for the diversity of problems you encounter when purifying different types of wastewaters. I had fun working on the practical aspects, but the curiosity to learn about the more fundamental issues, to work on the forefront of knowledge was still there. Therefore I started a Ph.D. on Biochemical Engineering and Biotechnology. I worked on the valorisation of lipid-rich wastewaters using biological processes. It was during this time that my path led me to the Laboratory of Microbiology at Wageningen, where my fascination for the microscopic world of microbes truly blossomed! Following my Ph.D., I worked for 5 years as an assistant professor at the University of Minho, and in 2013 moved to the Netherlands. From exploring untapped microbial diversity in natural settings to unravelling intricate microbial interactions,

our group is dedicated to devising innovative solutions to pressing environmental challenges. In HyUSPRe, our endeavours are diverse, spanning the comprehensive analysis of microbial composition in subsurface samples, extensive laboratory incubations of these samples, all to learn how different microbes can strive in these environments, and what we could do to prevent their activity during subsurface H_2 storage. Working alongside **Anne-Catherine Ahn**, our H_2-team expert in molecular ecology, **Adrian Hidalgo Ulloa**, our accomplished high-pressure bioreactor specialist, and **Yehor Pererva** providing the technical support, our collaborative efforts are propelled by a shared enthusiasm for ground-breaking research on the microbiological aspects of H_2 underground storage. We are confident that together with the HyUSPRe team, we can create a meaningful impact within H_2 underground storage!

Paul Huibregtse, Neptune Energy

Between 1991-1996 I studied geosciences at the Free University of Amsterdam where I graduated in Structural Geology with an MSc thesis on Strike-Slip Tectonics of the Betic Cordillera, Spain. Understanding the interplay between basin scale tectonics, relative sea level changes, sedimentological and stratigraphic processes and what ultimately remains preserved in the geological record triggers my interest since. I further started my industry career with the Offshore Kazakhstan International Operating Company (OKIOC) preparing the first exploration well on the giant Kashagan oil field in the North Caspian. In continued with NAM (Shell) as Wellsite Petroleum Engineer drilling gas appraisal & production wells in the North of the Netherlands followed by 20 years of exploration & production geology work with operators and as a consultant on projects across the globe. The last 6 years I am part of the Neptune Energy subsurface team in the Netherlands maturing infill and near field oil & gas opportunities in the Southern North Sea. Over the last 20 years it has become evident that human society, together with the energy industry stands for the enormous task trying to meet growing energy demands and at the same time try to reduce carbon emissions to slow down climate change. Neptune Energy contributes to investigate to what extent Hydrogen (storage), together with other renewable forms of energy can be part of the energy mix required to achieve our climate and energy targets. Neptune Energy states in its updated energy strategy (2023) to aim to store more carbon than is emitted from their operations and the use of their sold product by 2030. This is an ambitious and challenging target but the submission of the L10 CCUS Storage License Application and progress of the "H_2opZee" (~500MW) and "PosHYdon" (1MW) offshore green hydrogen generation pilot projects amplifies Neptune's intentions. I am therefore happy to be able to contribute to the HyUSPRe project on Neptune Energy's behalf providing subsurface data and models from some of our assets and I am looking forward integrating results into our way forward with potential Hydrogen Underground Storage (UHS) projects for Neptune Energy. My love for the outdoors and natural sciences once drove me to the subject of geology. So when not at work trying to crack puzzles posed by the subsurface I enjoy going outside in the countryside either hiking, mountain walking, cycling or running.

Workshops & Conferences

- European Hydrogen Week 2023
  The fourth edition of the European Hydrogen Week will take place on 20-24 November 2023.
- EU Hydrogen Research Days 2023
  This year's edition of the EU Hydrogen Research Days is an online event taking place on 15-16 November 2023. The session about hydrogen storage is on Thrsday, 16 November 2023, 11.30 – 13.00 CET. Please refer to the Clean Hydrogen Partnership website for further information and registration.
- GET2023 - EAGE Global Energy Transition Confeence & Exhibiion
  The fourth edition of this event takes place in Paris from 14-17 November 2023. HyUSPRe personnel will give various talks, please check the conference website for the program.
- **HyUSPRe final conference 2024**
  Save the date already for the HyUSPRe final conference in your agenda: 16-17 May 2024, Rijswijk, The Netherlands. Attendance will be also possible online.

HyUSPRe Consortium & Funding

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More Information

Visit the HyUSPRe website to learn more about the project. Inquiries should be addressed to pr-vvh2020hyuspre@tno.nl.