HyUSPRe

Hydrogen Underground Storage in Porous Reservoirs

E-Newsletter #2

In this issue:

Welcome by the Coordinator

The 2nd HyUSPRe newsletter is out just before the summer period starts and many people will enjoy a few holiday weeks somewhere in the world. Hopefully easy travelling within Europe remains possible in the coming months so that we can all meet in person at the mid-term consortium meeting scheduled on Thursday 1 Sept. 2022 in Edinburgh.

HyUSPRe in the meantime is nine months underway and starts to yield first results. In this newsletter we shortly introduce three research reports published in the past weeks: (1) an assessment of H_2 supply regions, demand centers and transport infrastructure in Europe; (2) a review of current practices and existing experimental data for studying the effects of H_2 injection and withdrawal on well and rock materials and interfaces, and an assessment of hydrogen storage potential of existing European gas storage sites in depleted gas fields and aquifers. We invite you to download the full reports from the HyUSPRe website and seek discussion with other consortium partners.

The online joint HyUSPRe – HYSTORIES knowledge sharing workshop held on Thursday 23 June was a big success. Speakers from both projects shared and discussed their thoughts on various topics that are relevant for subsurface hydrogen storage. The contributions to the discussions by the many attending colleagues from our industry partners showed how important it is to involve industry in European research projects in order to avoid a too academic perspective on hydrogen research.

Also in this newsletter two colleagues introduce themselves to the HyUSPRe community with short resumes / biographies.

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.

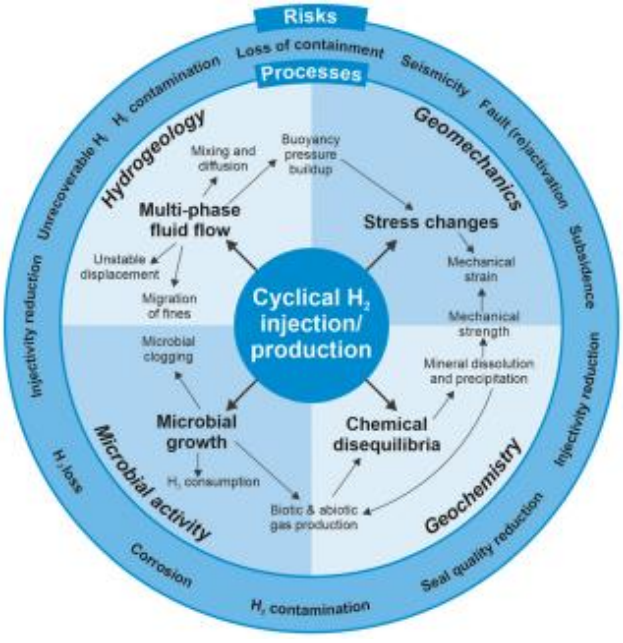
Research reports in the spotlight

H_2 supply, demand centers and transport infrastructure

The team of Forschungszentrum Jülich recently concluded a review report about mapping of potential sites of hydrogen production, demand and transport infrastructure in Europe. The report offers an assessment of wind and photovoltaic potentials in Europe that would be available to produce green hydrogen. The study calculates that theoretically more than 65 PWh_{H2} of green hydrogen could be produced in Europe using renewable energy sources. The study also looked at hydrogen demand scenario's on the short and longer term. For the longer term scenario the calculated (green) hydrogen demand per year ranges between 3,000 and 5,000 TWh_{H2}/a, taking various industrial processes and transport modes into account. The report concludes with a look at the existing natural gas transport infrastructure that could be repurposed for hydrogen transport and new to be built hydrogen transport infrastructure and offers scenarios for a future hydrogen grid in Europe. Download the full report to learn more about these relevant topics.

Effects of H_2 injection and withdrawal on wells and rocks

TNO's geomechanics team performed an extensive review of current practices and existing experimental data for studying the effects of cyclic hydrogen injection and withdrawal on well and rock materials and interfaces. The review outlines some main effects of cyclic injection and withdrawal of hydrogen-containing gas streams on the quality of the back-produced hydrogen gas stream, reservoir rock properties, caprock properties, faults, well systems and the surface environment.

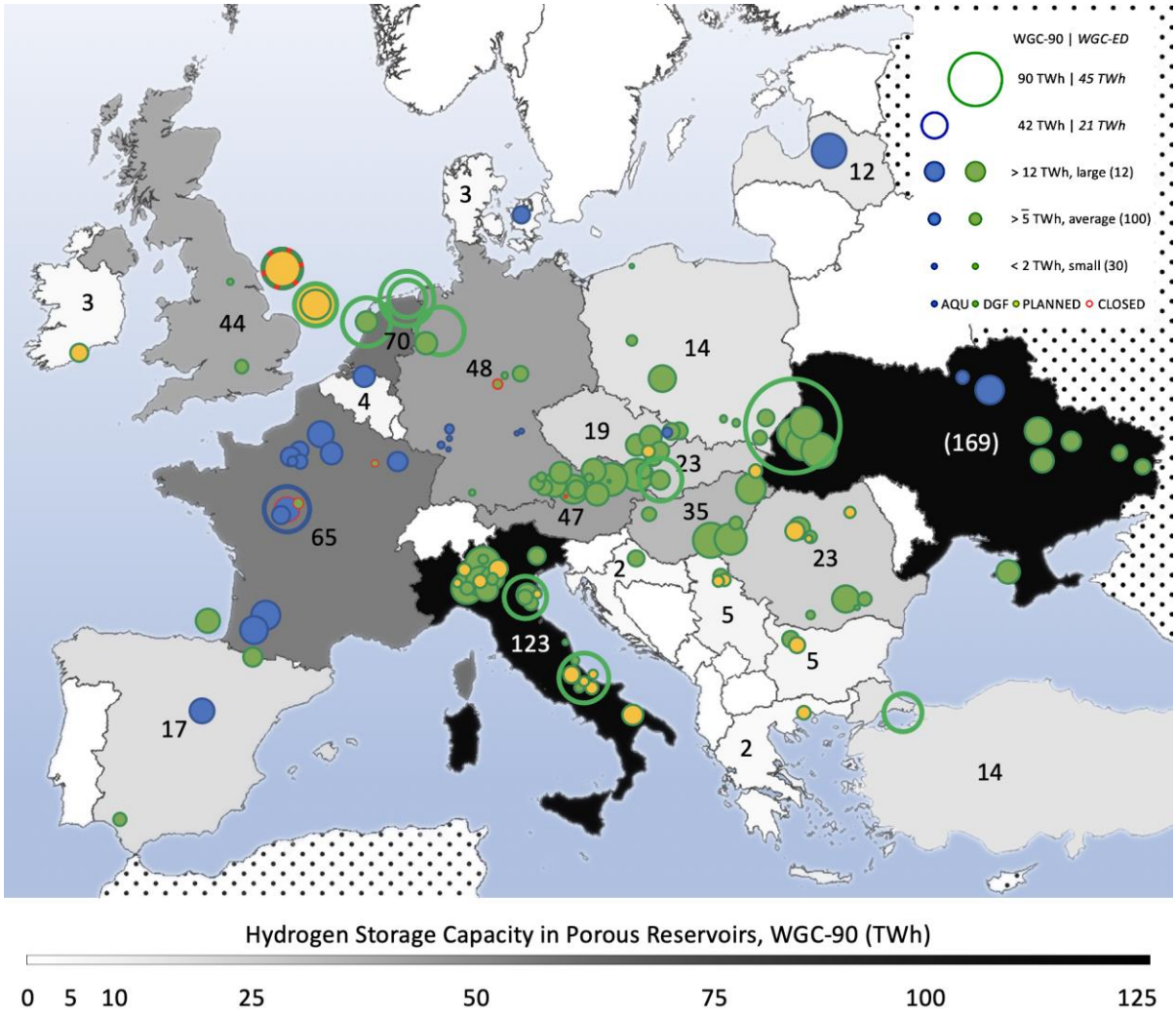


Aspects involved in the storage of hydrogen in porous media (from Heinemann et al. 2021, Energy Environ. Sci. 14, 853-864).
The effect of cyclic hydrogen injection and withdrawal on the geomechanics is represented in the upper right corner of the figure.

In particular, the effects on rock and well materials and well systems were adressed by summarizing existing theory and experimental data. Each of the effects is separately studied based on published literature. To learn more about this important topic, please have a look at the full report.

H_2 storage potential of existing UGS sites in Europe

The University of Edinburgh together with TNO recently pbulished a report (HyUSPRe project deliverable D1.3) on the hydrogen storage potential of existing European underground gas storage (UGS) sites in depleted gas fields and aquifers when repurposed for hydrogen. The report establishes the location and capacity of these existing resources and summarises the outcomes as a long list and map of potential hydrogen storage sites. The main outcome of the research is that the potential for hydrogen storage in porous reservoirs consists primarily of depleted gas fields, and to a much lesser degree, aquifers. The known reserve of operational and planned natural gas storage sites - 86% depleted gas fields and 14% aquifers – if converted, provides 750 TWh of hydrogen storage capacity. This is a substantial bankable foundation for the 2050 hydrogen economy, given the known attributes of the existing inventory and its networked status, and would be sufficient for a mid-range scenario of 2,500 TWh of annual hydrogen demand in 2050, supported by 30% storage.



To match a high-demand scenario (1000 TWh storage) with additional depleted gas fields alone, the potential hydrogen storage capacity of the existing operational resource, 560 TWh, would need to be approximately doubled. Current additions to the known reserve of operational and planned storage – pilots, prospects, exploration targets - are relatively small, at most a few percent of the total inventory. The significance of additions will be addressed in more detail in the follow-up report – deliverable D1.5 for this project, March 2023 – that will focus on the selection criteria for a short list of sites and the potential for expanding the hydrogen storage capacity beyond the long list of the existing natural gas storage reserve when converted.
To learn more about this important topic please have a look at the full report.

Joint HyUSPRe – HYSTORIES workshop

On 23 June there was a one-day digital knowledge sharing workshop of the two projects granted in the Horizon2020 call 'Underground storage of renewable hydrogen in depleted gas field and other geological stores'. Consortium members of HyUSPRe and HYSTORIES shared and discussed burning research questions, results and challenges of both research programs. A total of 90 colleagues attended the workshop and engaged in lively discussions. A workshop summary will be available soon on the HyUSPRe website. In the meantime, please have a look at at the program below:

HYSTORIES - HYUSPRE knowledge sharing workshop | 23 June 2022 | 10.00 - 16.15 CET | Virtual (Teams)

Time	Program	Speaker
10:00	Welcome by Clean Hydrogen Europe and HYSTORIES and HyUSPRe representatives	Claudiu Pavel (CH JU), Arnaud Réveillère (Geostock), Holger Cremer (TNO)
10:10	Introduction Hystories	Arnaud Réveillère (Geostock)
10:30	Introduction HyUSPRe	Remco Groenenberg (TNO)
10:50	Short break	
11:00	Evaluation of H2 storage sites in porous reservoirs (convenor: Arnaud Réveillère, Geostock) - European geological database of aquifer and depleted field candidates for H2 storage (Hystories) - Hydrogen supply, demand and transport infrastructure (HyUSPRe) Discussion	Ceri Vincent (CO2Geonet/BGS) Theresa Groß (Forschungszentrum Jülich)
11:45	Short break	
11:50	Microbiology and hydrogen storage: challenges & studies & solutions (convenor: Anne-Catherine Ahn, Wageningen Univ.) - Microorganisms in porous reservoirs and their potential risks for underground hydrogen storage Discussion	Dieu Huynh (MicroPro)
12:30	Lunch break	
13:30	Reservoir Engineering and geochemistry (convenor: Rama Kotni, TNO) - Learnings from geochemical experiments (HyUSPRe) - Static and dynamic evaluation of the storage potential (Hystories) Discussion	Katriona Edlmann (Univ. Edinburgh) Yann Le Gallo (Geostock)
14:15	Short break	
14:20	Porous media storage integrity (convenor: Louis Londe, Geostock) - Investigations of the integrity of casings steel materials in contact with hydrogen (Hystories) - Mechanical behavior of porous reservoirs and caprocks during underground hydrogen storage (HyUSPRe) Discussion	Bernd Loder (Montanuniversität Leoben) Vincent Soustelle (TNO)
15:05	Short break	
15:15	Techno-economic assessment (convenor: Theresa Groß, Forschungszentrum Jülich) - Review of European regulation for Hydrogen underground storage (Hystories) - Bottom-up cost estimate of the development of an underground H2 storage site (Hystories) Discussion	Sara Martínez (FHa) Hubert Jannel (Geostock)
16:00	Closing remarks by convenors	

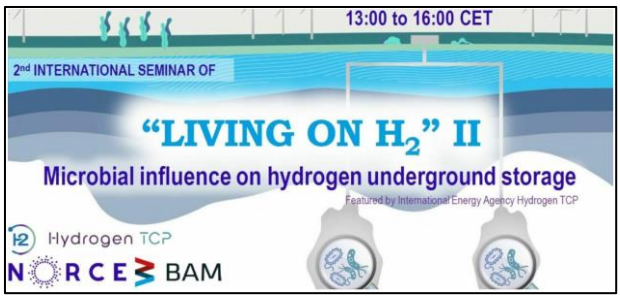
HyUSPRe event attendance

GIE 2022 Annual Conference, Budapest, April 4-8, 2022

In early April, HyUSPRe consortium member Hungarian Gas Storage (HGS) together with GSZ Hungarian gas Transmission Ltd. and HEXUM Földgáz hosted the GIE (Gas Infrastructure Europe) annual conference 2022 in Budapest. Each year this conference brings together key decision-makers and energy stakeholders to debate, raise awareness and find solutions for decarbonisation while safeguarding security of energy supply. On the first day, after keynote speeches by the GIE president,the minister of foreign affairs and trade of Hungary, and the EU commissioner fro Energy, several panel debates were held focusing on topics such as the current (natural) gas infrastructure and emerging new supply routes to overcome the current crisis, the role of renewable and low-carbon molecules (read: hydrogen) and natural gas in decarbonizing our energy system and securing supply, infrastructure requirements for low-carbon and renewable gases, and implications of the hydrogen and decarbonized gas market package.On day 2 the focus was on the key importance of storage in securing supply of energy for Europe, with first a panel discussion on the importance of having the right mix of storage of electrons and molecules, after which Remco Groenenberg presented the HyUSPRe research project on hydrogen storage in porous reservoirs, explaining its rationale and relevance, its scope and objectives and the expected impact of the project. On the evening of day 1, the participants enjoyed a fantastic networking dinner at the Hungarian National Gallery that is located in the former Royal Palace of Budapest. All in all, it was very enjoyable to participate in this year's GIE, which was well attended and very well organized. Conference contributions can be downloaded from this website. Thank you HGS for inviting HyUSPRe!

Webinar 'Living on hydrogen', digital, May 4, 2022

On 4 May, 2022, the 2nd International Seminar "Living on Hydrogen" - II Microbial Influence on Hydrogen Underground Storage took place. It was an online seminar well-organized by colleagues of NORCE and BAM. More than 150 colleagues interested in the topic attended the seminar. The organizers offered a varied program of topics relevant for the microbial impact on hydrogen storage. The show started with Serge van Gessel (TNO) who gave an overview on IEA's Hydrogen Technology Collaboration Programme, Task 42: Underground Hydrogen Storage. Other contributions tackled the microbial impact on hydrogen storage in salt caverns, the conversion of green hydrogen and carbon dioxide to methane in porous underground storages and the response of microbes to



elevated sulphate and iron concentrations. The program also included project introductions of both the HyUSPRe and HyPSTER projects, both funded by the Clean Hydrogen Partnership and Horizon 2020 funding schemes.

Meet the Scientist | Engineer

Matteo Robino, SNAM

In 2016 I graduated from Politecnico di Torino in Energy and Nuclear Engineering, after an 8 months experience at the DLR (German Aerospace Center) in Stuttgart, where I developed my Master Thesis focused on static, dynamic and degradation PEM water electrolysis cell models. This experience introduced me to the hydrogen sector and made me understand the great potential of its application in the industry and the contribution that hydrogen can bring to the European energy sector. In the same year I joined Snam, where the first discussions about the adoption of this energy vector and its impacts on the natural gas transport, distribution and storage infrastructure, were underway. In my early years at Snam I studied the normative and regulatory implications related to the injection of hydrogen into the network, and the associated barriers and gaps. In the following years, with the creation of the Hydrogen Business Unit, I also began to face the challenges from a technical point of view, coordinating the contributions of the Snam experts in the different fields in various European and Italian research projects. Large-scale hydrogen storage is a crucial building block necessary in order to enable a sustainable hydrogen-based economy. The flexibility and energy security guaranteed by underground storage (of natural gas currently, and in the future hydrogen) have no equal in the panorama of the current state of the art, when compared to above-ground storage. With these consideration in mind, Snam participates in the HyUSPRe project where the technical and economic feasibility of hydrogen storage in underground porous reservoirs will be assessed. HyUsPRe represents a strategic and fundamental project for my company and Europe, in order to support the development of the entire hydrogen value chain.

Vincent Soustelle, TNO

I studied Geosciences at the University of Montpellier in France up to my PhD during which I investigated the interactions between fluids and minerals of the Earth's mantle and how these interactions affect the physical properties of mantle rocks. I continued on the same topic during my postdoctoral years; not anymore from naturalistic observations but from an experimental approach. That's during these years that I developed my taste for squeezing rocks in large presses at various environmental and chemical conditions, recording their mechanical and physical properties and studying the effect of each parameters. After that and for about 5 years I was appointed Professor at the China University of Geosciences, carrying on my research and teaching tectonics and rock mechanics to the younger generations.

Gradually, I felt the need to apply my knowledge and skills to societal challenges and my passion for Earth's sciences naturally drove me toward the domain of the Energy Transition. I had the opportunity to join TNO early 2021 when the Applied Geosciences Team, which dedicate itself to make the use of subsurface resources sustainable and safe, decided to expand their geomechanical laboratory: the iM4RockLab. Since then, I have mostly contributed to grow our experimental facilities and characterize the mechanical properties of geothermal reservoirs in the Netherlands. Hydrogen is regarded as the best energy carrier to supply people and industry with clean sustainable energy and the question of its storage in subsurface reservoirs is now a hot topic. So when I was proposed to join the HyUSPRe project I immediately accepted. In HyUSPRe, I will use a combination of chemical and geomechanical experiments to study mechanical integrity geological reservoirs when injected with hydrogen.

HyUSPRe mid-term event

The HyUSPRe mid-term event will be organized by University of Edinburgh on Thursday 1 September 2022. The consortium will use the meeting to critically discuss progress and achieved research results and, if necessary, revise the research program for the second half of the project. HyUSPRe consortium partners have recently received a save-the-date. The meeting program will be communicated soon. The event is open for consortium members of the HyUSPRe project.

Workshops & Conferences

- TU Delft 1st International Summer School on Underground Hydrogen Storage: 11-14th July 2022. See website for more information about the programme and registration.

- GET 2022: 3rd EAGE Global Energy Transition Conference & Exhibition, 7-9 November, The Hague, Netherlands (hybrid event). https://eageget.org/

- Clean Hydrogen Partnership annual programme review days, probably in October 2022, to be announced soon.

HyUSPRe Consortium & Funding

HyUSPRe is funded by

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Disclaimer

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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.