HyUSPRe

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

Report of initial workshop to determine focus of aquifers and oilfields

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The HyUSPRe consortium

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Disclaimer

Executive summary

The HyUsPRe project includes the identification of potential sites for geological hydrogen storage in Europe. While present underground (methane) gas storage sites and depleted gas fields are likely targets for storage, aquifers (i.e. water filled porous rocks) and depleted oil fields are less well established as potential hydrogen storage sites. A workshop was held to deliver decisions on 2 key questions concerning the approach that the project would adopt to assess the role of the aquifers and oil fields.

The partners endorsed the approach to not include aquifers in the initial long-listing of sites, but rather to search selectively where justified by a lack of alternative storage. For oilfields, the partners endorsed a similar approach to that of aquifers, with a possible focus on gas caps above oilfields.

It was agreed that a 2nd workshop will discuss the screening methodology and the criteria used to select potential storage sites.

About HyUSPRe

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

The HyUsPRe project researches the feasibility and potential of implementing large-scale storage of renewable hydrogen in porous reservoirs in Europe. This includes the identification of suitable geological reservoirs for hydrogen storage in Europe and an assessment of the feasibility of implementing large-scale storage in these reservoirs technologically and economically towards 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 towards 2050; indicating the role of large-scale hydrogen storage in achieving a zero-emissions energy system in EU by 2050.

This project has two specific objectives. Objective 1 concerns the assessment of the technical feasibility, risks, and potential of large-scale underground hydrogen storage in porous reservoirs in 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, establish more accurate cost estimates and identify the potential business case for hydrogen storage in porous reservoirs. Suitable stores 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 hydrogen stores 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 the basis to develop future scenario roadmaps and prepare for demonstrations.

Document information, revision history, approval status

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Revision history

Version	Name	Delivery date	Summary of changes
V01	M. Wilkinson	2022.02.17	First draft
V02	M. Wilkinson	2022.02.22	Modified draft (introduction added)
V02.1	M. Wilkinson	2022.02.23	Minor edits
V03	H. Cremer	2022.02.24	Definitive version, layoutet

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Role	Name	Delivery date
Deliverable responsible:	Univ. Edinburgh	
Task leader:	Mark Wilkinson, UEDIN	2022.02.23
WP leader:	Mark Wilkinson, UEDIN	2022.02.23
HyUSPRe lead scientist	Remco Groenenberg, TNO	2022.02.24
HyUSPRe consortium manager:	Holger Cremer, TNO	2022.02.24

Table of Content

1. Summary of the workshop

The HyUsPRe project includes the identification of potential sites for geological hydrogen storage in Europe. While present underground (methane) gas storage sites and depleted gas fields are likely targets for storage, aquifers (i.e. water filled porous rocks) and depleted oil fields are less well established as potential hydrogen storage sites. This is because oil fields always have residual oil within the reservoir, so that 3-phase flow (oil, water and hydrogen) will occur, resulting in extremely low relative permeabilities and consequenrly low flow rates. In addition, the residual oil will evaporate into the hydrogen, causing contamination that will be very difficult to predict. For aquifers, the problem is a lack of data compared to gas fields or current underground gas storage sites, and the unproven seal above the reservoir, which could result in leakage of the hydrogen into the overlying stratigraphy. This workshop, involving both academic and industry partners, was held to deliver decisions on these 2 key questions concerning the approach that the project would adopt to assess the role of the aquifers and oil fields, i.e. should oilfields and aquifers be included in the assessment?

1.1 Agenda

- Introductions
- Short recap of the goals of WP1, and in particular tasks 1.4 and 1.5 that concern subsurface storage
- Key questions: aquifers and oil fields (decision needed)
- Discuss data requirements to perform the assessment.

1.2 Acronyms

AQF: aquifer
CNS: Central North Sea
DGF: depleted gas field
DOF: depleted oil field
NNS: Northern North Sea
UGS: underground gas storage

1.3 Summary

- Cushion gas: Economics of cushion gas a major factor, as expected. For example, Rough field has been depleting for 4 years, needs to restore cushion. May not be methane due to cost of natural gas and H_2. Other options being considered (e.g. CO2?) This justifies low expectations for aquifers in general, and will make the pressure state of depleted gas fields (DGF's) a crucial criteria.
- Chris McLane (Centrica): Will provide data on Rough.
- Markus Pichler (RAG): Already has one hydrogen pilot site in Austria and open to sharing data about 1 or 2 commercial sites that they have on their shortlist. A site for the D1.2 on existing storage projects.
- Paul Huibregtse (Neptune): Shortlist is too immature to share yet, mostly CCS based.
- Walter Eikelenboom (EBN): data is public for Netherlands, so easy to compile but no shortlist yet.
- SNAM: will share data of their assets and requests that they be anonymized.
- Gion Strobel (Uniper): Hydrogen tests planned (2022) in DGF and possible aquifer site (not decided yet) in Germany. German data not as open as rest of EU.
- Roman Zavada (NAFTA): Operating across EU, open to sharing data of assets. Would like to have a discussion on screening criteria.

- Julia van Winden (Shell): will share (anonomized) data of (selected) onshore and offshore assets. Highlights the importance of including biological suppression criteria as part of the screening. Temp/salinity curve as a Tier 2 filter for long-listed sites. Mapping of cut-off isotherm and salinity (55 °C and 2M / 117,000 ppm).
- Allard Martinius (Equinor): Proximity to infrastructure and production a key consideration. No interest in oil fields, low value in modelling Volve. Referred to the NPD website for data about Norwegian DGFs.
- Katriona Edlmann (UEDIN): Problem of no gas fields/salt? In Scotland – is best option to go to second-choice gas-capped oil fields and aquifers?
- Mark Wilkinson (UEDIN) – problem of oil field high well count and distance of most CNS NNS oil fields from shore (expensive to develop) Brent capacity calculation in UK study – massive gas cap.
- Esther Vermolen (Shell): Be careful of mobile oil and medium/strong aquifer dynamics as this will potentially lose working gas volume.
- Paul Huibregtse (Neptune) – end-member filter approach for oil fields.

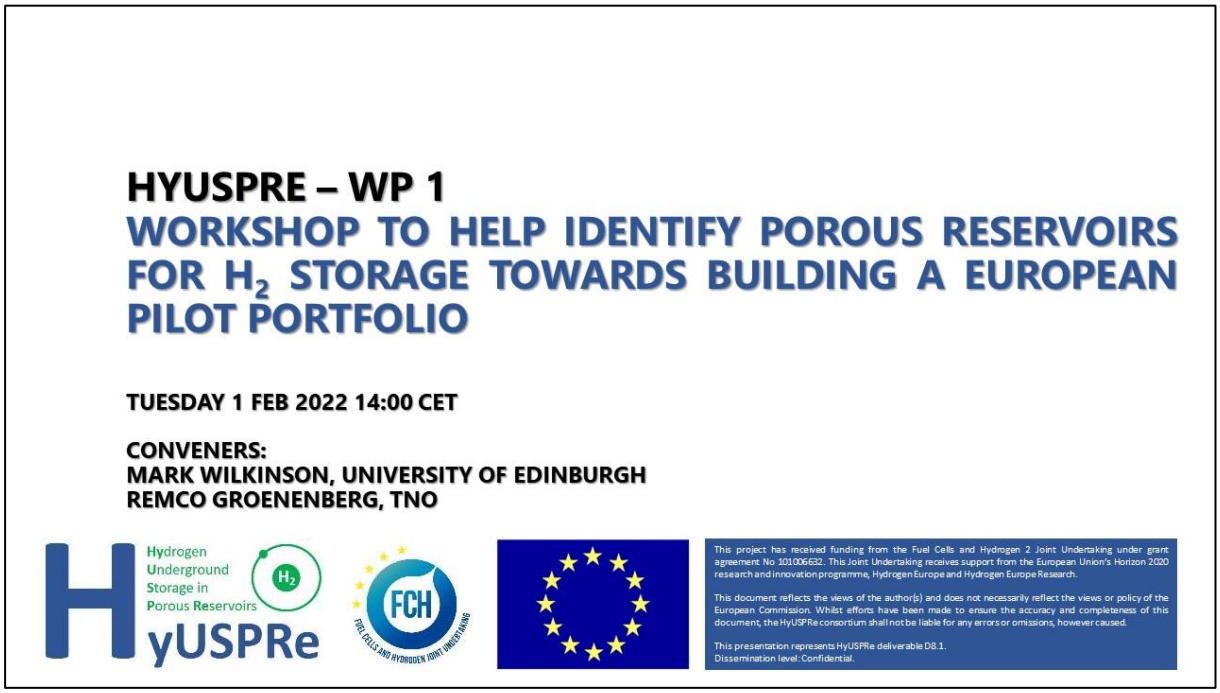
1.4 Decisions

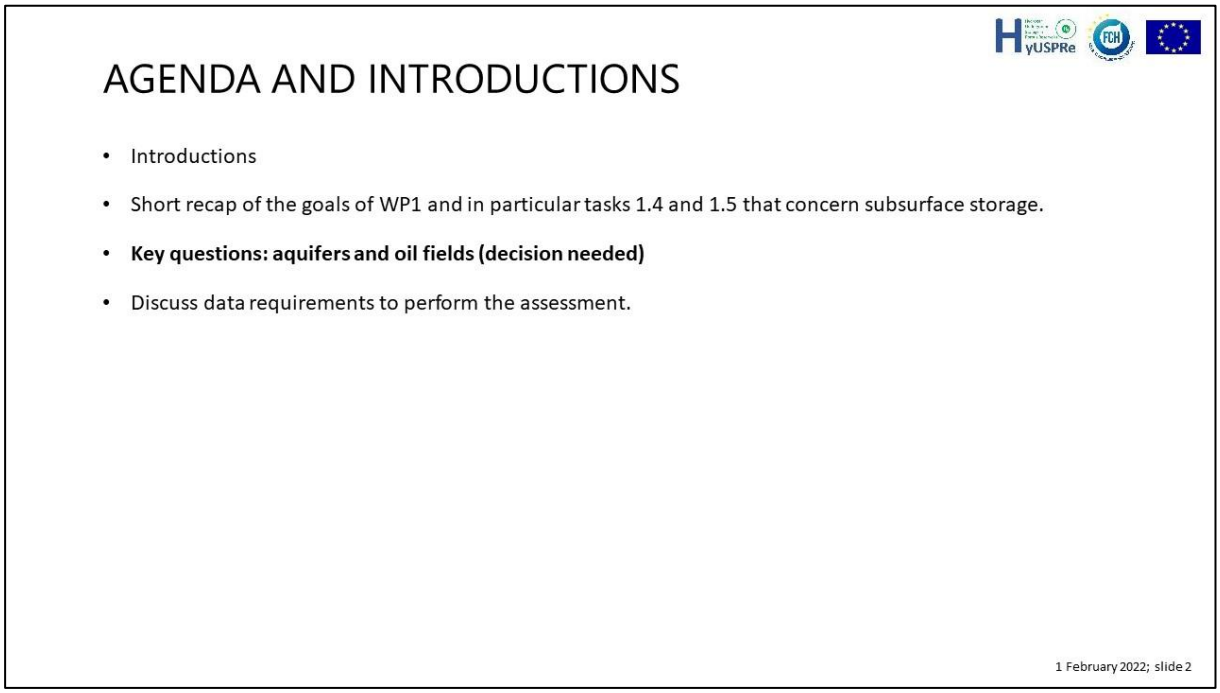
- On aquifers, the partners endorsed the approach to not include aquifers in the initial long-listing of sites, but rather to search selectively, i.e., either as a back-up option in regions where there is need for storage but no potential in the form of UGS or DGF, or when there is a (suitable known) aquifer very close to demand centres for H_2, ideally where there is already existing experience of using the aquifer for storage.
- On oil fields, the partners endorsed a similar approach to that of aquifers, with the remark to possibly focus on DOFs that have gas caps that are close to generation and/or demand centres and infrastructure.
- It was agreed with the partners to organize a 2nd workshop to discuss the screening methodology and the criteria including their ranges.

1.5 List of Participants

- TNO: Remco Groenenberg; Durgesh Kawale; Holger Cremer; Hamid Yousefi; Jan ter Heege
- TU Clausthal: Alexander Sebastian Hogeweg
- NEPTUNE: Paul Huibregtse
- UEDIN: Andrew Cavanagh; Mark Wilkinson; Alexis Taylor Cartwright; Katriona Edlmann; Ali Hassanpouryouzband
- HGS: Lajos Erdélyi; Tamás Mérő
- RAG: Pichler Markus
- CENTRICA: Christopher McClane
- NAFTA: Roman Zavada; Michal Čižnár
- UNIPER: Annette Lenze; Gion Strobel
- FBK: Jacopo De Maigret; Diego Viesi; Farhad Farajimoghadam
- WUR: Anne-Catherine Ahn; Bart Lomans; Diana Machado de Sousa; Yehor Pererva
- EQUINOR: Allard Martinius
- SHELL: Esther Vermolen; Julia van Winden
- EBN: Walter Eikelenboom; Esmee Boter
- SNAM: Emanuele Baronio; Andrea Mantegazzi; Matteo Robino; Francesco Marzano
- FZ Julich: Theresa Groß

2. The PowerPoint slides from the workshop





WP 1 GOALS AND DELIVERABLES

GOALS

- Map potential sites of renewable hydrogen production, transport infrastructure, and demand centres.
- Realize a database of potential hydrogen storage sites in geological reservoirs and quantify their storage potential.
- Develop a classification scheme with selection criteria for identification of suitable geological reservoirs.

DELIVERABLES

• Report on this workshop to determine and refine focus	(D1.1 – February '22)
• Report on potential sites of hydrogen production, transport, and demand	(D1.2 – March '22)
• Report on existing hydrogen storage sites	(D1.3 – June '22)
• Database and GIS of potential storage sites for hydrogen	(D1.4 – September '22)
• Report of classification framework with selection criteria for storage sites	(D1.5 – March '23)

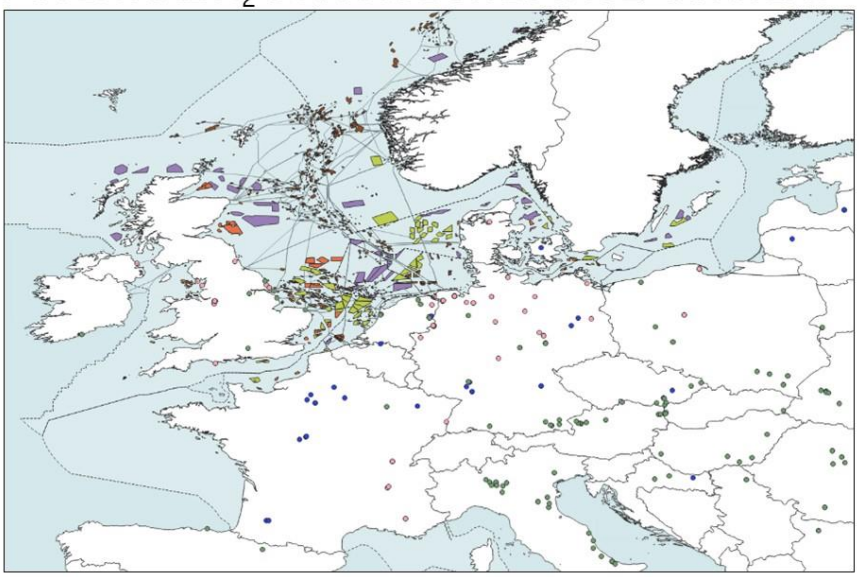
1 February 2022; slide 3

QUESTIONS / DECISIONS

- Industry insight: do partners have shortlists of potential sites that they can share to support the assessment?
- Scope of porous reservoirs: do we include aquifers?
  - None since 1994 (except Yela, Spain) – economics of cushion gas?
  - Lack of data and seal integrity
  - Except – if a lack of gas fields / UGS in a region or close to demand / supply
- Do we include oil fields?
  - Relative Permeability from 3 phase flow
  - H_2 contamination from oil evaporation
  - H_2 loss by solution in oil
- Screening approach: How do we identify sites from a large number of prospects?
  - Approach – sites likely to be developed in foreseeable future are already known, either publicly or to industry
  - Do not list all possible aquifers / gas fields as confusing and unhelpful (as with CCS)
- Screening criteria: What selection criteria to narrow down the (short) list to a preferred site?

1 February 2022; slide 4

WORKING TOWARDS AN ONLINE ATLAS OF POTENTIAL H_2 STORAGE SITES INCL. CONTEXT



1 February 2022; slide 5

DATABASE WITH CHARACTERISTICS OF POTENTIAL STORAGE SITES

GENERIC DATA TO BE INCLUDED

- Surface location, name, type, and ID for site
- Nr. of (current) wells and diameters
- Reservoir Fm. name, stratigraphy, thickness, mineralogy, porosity, permeability
- Caprock Fm. name, stratigraphy, thickness, mineralogy
- Working gas volume, TWh and scm
- Injection rate, GWh/day
- Withdrawal rate, GWh/day
- Cushion gas volume, scm
- Depth range, m
- Pressure range, MPa
- Temperature range, °C
- Any chemical or microbiology information of relevance (e.g. formation water composition, microbial communities, etc.)

SPECIFIC FOR DEPLETED GAS FIELDS

- Gas Initially in Place (GIIP), scm;
- (Expected) Ultimate Recovery (UR), scm
- (Initial) Chemical composition of gas

SPECIFIC FOR AQUIFERS

- Trap volume, m^3
- Cushion gas volume required, m^3 and scm
- *Cushion gas type (H2, natural gas, CO_2)?*

SPECIFIC FOR DEPLETED OIL FIELDS

- *Suitability – gas cap?*
- *Central European experience?*
- *Volve case study?*

1 February 2022; slide 6

QUESTIONS

- Industry insight: do partners have shortlists of potential sites that they can share to support the assessment?
- Scope of porous reservoirs: do we include aquifers?
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  - Approach – sites likely to be developed in foreseeable future are already known, either publicly or to industry
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- Screening criteria: What selection criteria (and ranges) to narrow down the (short) list to a preferred site?

DGF:	Germany, 48% of GIE (112/235)	64% 9 TWh NG
Salt:	Germany, 36% of GIE (84/235)	21% 4 TWh NG
Aquifers:	France, 11% of GIE (27/235)	10% 6 TWh NG
Oil fields:	Czech Republic, 4% of GIE (10/235)	5% 8 TWh NG

1 February 2022; slide 8

THANK YOU FOR LISTENING!

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking under grant agreement No 101006632. This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme, Hydrogen Europe and Hydrogen Europe Research.

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