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# HyUSPRe

## Hydrogen **U**nderground **S**torage in **P**orous **R**eservoirs

### Interactive GIS story map of hydrogen storage potential in porous reservoirs in Europe

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## The HyUSPRe consortium



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## Disclaimer

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## Executive summary

This report is a brief description of the GIS story map and database of hydrogen storage potential in porous reservoirs in Europe that are developed in the context of the HyUSPRe project. The database includes site-specific information of 140 existing underground gas storage sites in depleted gas fields and aquifers. The location, storage capacity, estimated rates of injection and withdrawal, and other useful characteristics of the storage sites were reported in D1.3 of the HyUSPRe project. This information is used to create the database of storage sites that serves as the source for the interactive GIS story map. The interactive story map spatially visualizes the information in the database on a map of Europe, i.e., geographic location and key characteristics of the potential storage sites in Europe and other contextual data. The story map-like visualization was developed with the “ArcGIS Story Map” software. The story map has its own URL and is publicly accessible from the [HyUSPRe website](#) (and via this direct [link](#)). The main benefit of creating a GIS story map is that information about the storage sites can be visualized in an atlas-like manner on a website together with texts and photos to present a visually-aided narrative about the topic of hydrogen storage potential in Europe rather than just a visual.

Besides the hydrogen storage potential, the European Hydrogen Backbone (EHB) is added to the map to see the location of storage sites and predicted hydrogen network (pipeline transportation) in future. This map could be extended to add hydrogen demand and supply centres in the future to make it a comprehensive source of information for the emerging European hydrogen value chain.

In this report, the ArcGIS Story Map software is briefly described. The list of available attributes (containing the site characteristics) in the HyUSPRe database of hydrogen storage sites and in the EHB is presented and the website link and information about texts and maps on the website are provided.

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## About HyUSPRe

### Hydrogen **U**nderground **S**torage in **P**orous **R**eservoirs

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.

## Document information, revision history, approval status

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## Glossary

EHB	European Hydrogen Backbone
GIS	Geographic Information System
GIE	Gas Infrastructure Europe
IGU	International Gas Union
AQU	Aquifer
DGF	Depleted gas field
WGC	Working gas capacity, TWh
CUG	Cushion gas, TWh
TOG	Total gas, WGC+CUG, TWh

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## 1 Introduction

This report is a brief description of the GIS story map and database of hydrogen storage potential in porous reservoirs in Europe that are developed in the context of the HyUSPRe project. The previous report from WP1 of the HyUSPRe project (Cavanagh, et al. 2022) showed the hydrogen storage potential in existing depleted gas fields and aquifers. The current report details the development aspects of the GIS-enabled story map (ArcGIS Story Map) that is designed to spatially visualize the geographic location and site-specific information of (potential) storage sites for hydrogen in the HyUSPRe database.

The HyUSPRe database leverages the GIE and IGU public databases of existing (natural) gas storage sites in Europe and provides detailed data on location, hydrogen storage capacity, injection and withdrawal rate, etc. The interactive story map spatially visualizes the information in the database on a map of Europe, together with other contextual data, and enables the user to explore the information in the database in more detail by clicking on each specific site.

## 2 ArcGIS Story Map

ArcGIS Story Map is a web-based application that allows to integrate maps, texts and pictures to tell a story about a particular topic to the user while also offering interactive querying of map content in a live environment (ArcGIS StoryMaps 2022). It is very suited for dissemination of the site-specific information in the HyUSPRe database of (potential) hydrogen storage sites by adding geographic context to the project. The story map is a stand-alone resource that has its own website URL that can be accessed publicly via internet.

The HyUSPRe story map exposes data from two sources:

1. The HyUSPRe database (deliverable of the HyUSPRe project);
2. The European Hydrogen Backbone initiative.

### 2.1 Hydrogen storage database

The HyUSPRe database of European hydrogen storage sites consists of 140 available underground gas storage (UGS) sites in porous reservoirs with information about the name, operator, location, type (depleted gas field and aquifer), status (operational, closed and planned), estimated working gas and cushion gas capacity for hydrogen and estimated withdrawal and injection rate for hydrogen. The full list of the attribute in the database is given below:

- Site name
- HyUSPRe code: the site code in the HyUSPRe database
- Country
- Operator
- Operational since
- Status: operational, planned, closed
- Type: Depleted Gas Field (DGF), Aquifer (AQU)
- WGC-NG: Working gas capacity for natural gas [TWh]
- CUG-NG: Cushion gas capacity for natural gas [TWh]
- TOG-NG: Total gas capacity (WGC+CUG) for natural Gas [TWh]
- Ratio WGC/TOG
- Source or Reference: GIE, IGU or individual operators
- WGC-ED: Working gas capacity for hydrogen based on the energy density calculation (low-end estimate) [TWh]
- WGC-90: Working gas capacity for hydrogen based on the gas deliverability equation and 90-day storage period (high-end estimate) [TWh]
- INJ-NG: Injection rate for natural gas [GWh/day]
- WIR-NG: Withdrawal rate for natural gas [GWh/day]
- HINJ-ED: Injection rate for hydrogen based on the energy density calculation (low-end estimate) [GWh/day]
- WHIR-ED: Withdrawal rate for hydrogen based on the energy density calculation (low-end estimate) [GWh/day]
- HINJ-90: Injection rate for hydrogen based on the gas deliverability equation and 90-day storage period (high-end estimate) [GWh/day]
- WHIR-90: 90-day Withdrawal rate for hydrogen based on the gas deliverability equation and 90-day storage period (high-end estimate) ([GWh/day]

The technical definition of different types of hydrogen storage capacity has been reported in the D1.3 report (Cavanagh, et al. 2022).

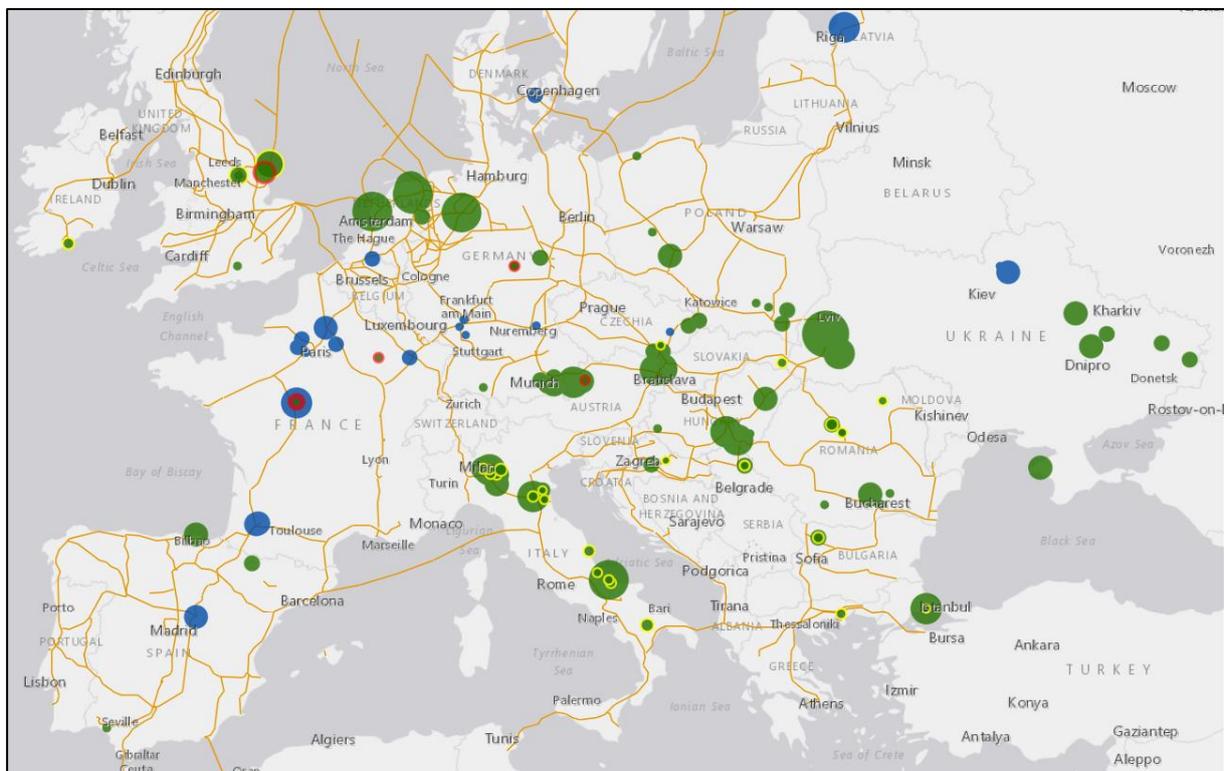
## 2.2 European Hydrogen Backbone

The European Hydrogen Backbone (EHB) initiative, a group of energy infrastructure companies, recently published a map that shows the envisioned pipeline network for transport of hydrogen that they plan to develop until 2040 (European Hydrogen Backbone Maps 2022). They will do this by combining re-use of sections of existing pipelines for natural gas with new sections that are to be constructed. The available data are listed below:

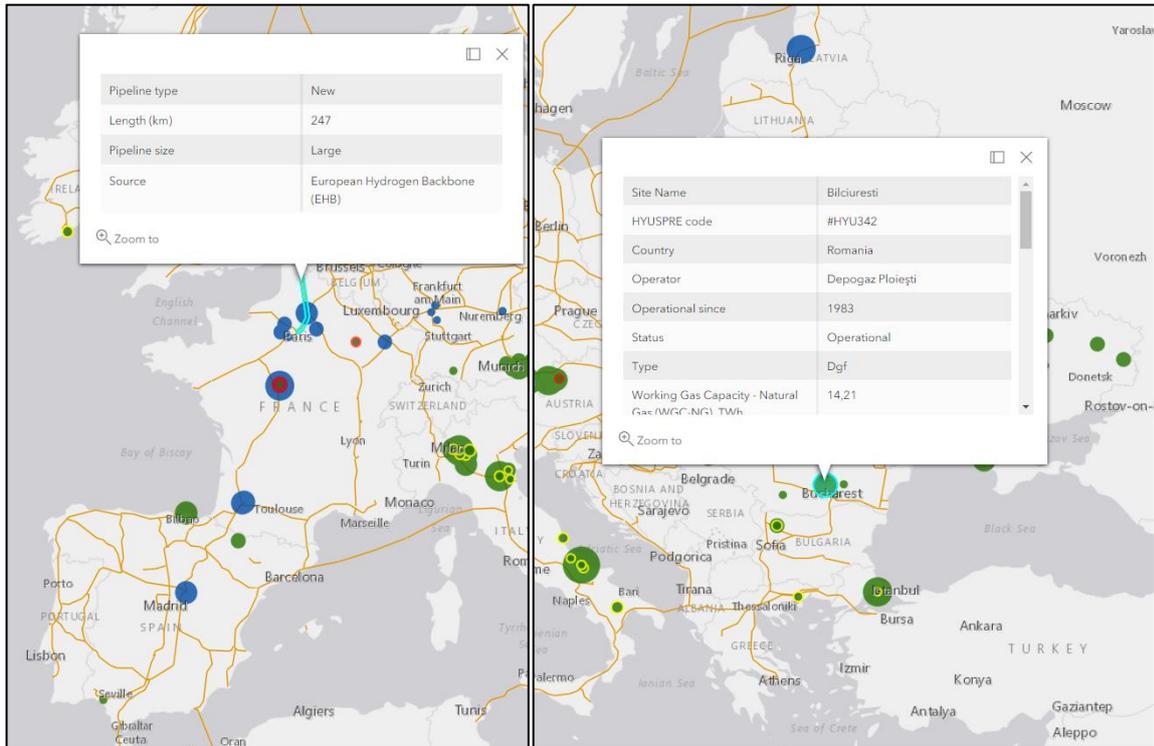
- Pipeline type: Repurposed, New, Subsea, Import/Export,
- Pipeline length
- Pipeline size: Large, Medium, Small
- Source: EHB

## 2.3 Website

The story map has its own URL and is publicly accessible from the [HyUSPRe website](#) (and via this direct [link](#)). Figure 1 shows the map of Europe with the locations of potential hydrogen storage sites and the hydrogen backbone (orange line) in 2040, which is shown at the beginning of the story map. Afterwards, the regional analysis for Europe (North West, Central, Eastern and Southern) is detailed with a focus on country-level hydrogen storage capacities. Figure 2 shows the available information for storage sites and the hydrogen backbone that is displayed when you click on an object in the interactive maps in the story map.



**Figure 1. Existing European gas storage sites (highlighted DGF in green and AQU in blue); the circle size shows the hydrogen storage capacity in 140 porous reservoirs. The orange pipeline represents European Hydrogen Backbone predicted in 2040. Closed and planned sites are ringed in red and yellow, respectively.**



**Figure 2. The available information (attribute) in the interactive map for the hydrogen storage site and hydrogen backbone**

### 3 References

ArcGIS StoryMaps. <https://www.esri.com/en-us/arcgis/products/arcgis-storymaps/overview>.

Cavanagh, Andrew, Hamid Yousefi, Mark Wilkinson, and Remco Groenenberg. 2022. *Hydrogen storage potential of existing European gas storage sites in depleted gas fields and aquifers*. H2020 HyUSPRe project report.

*European Hydrogen Backbone Maps*. <https://ehb.eu/page/european-hydrogen-backbone-maps>.