Hydrogen storage in salt caverns: *FrHyGe* Project

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*Full qualification in **Fr**ance of large scale **Hy**drogen underground storage and replication from **Ge**rmany to all European countries*

Co-funded by the European Union

Clean Hydrogen Partnership

The project is supported by the Clean Hydrogen Partnership and its members

Overview of the FhGyHe project

FrHyGe Underground Hydrogen Storage

Leadership : storengy

A company of ENGIE

Project highlights:

- ✓ **European Project (17 partners)** with 4 different nationalities
- ✓ Budget**: 43 million euros**, of which **20 million euros** are provided **from the Clean Hydrogen Partnership (** (Call: HORIZON-JTI-CLEANH2-2023-02-01)
- ✓ Five years duration: from **2024 to 2029**
- ✓ **Feasibility to convert caverns** from natural gas storage or brine to hydrogen storage
- ✓ At least, ***H2 Storage 100 injection & withdrawal cycles*** *at various pressures/volumes of* ***100 tons of hydrogen***
- ✓ **TRL 7 to 8**
- ✓ Study the **local hydrogen value chain and the technico-economical impacts on local actors**
- ✓ **Safety and environmental acceptability** of commercial storage of H2 in salt caverns
- ✓ **Replication** towards other salt fields, in EU, starting by **GeoH2 in Manosque**, and SaltHy project in Germany



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17 Partner

FrHyGe Underground Hydrogen Storage

storengy
A company of ENGIE

ARMINES
MINES PARIS | PSL

Artelys
OPTIMIZATION SOLUTIONS

Axens

Capenergies

ECO-MED
écologues et médiateurs

enagas

ESK

GÉOMÉTHANE

Geostock

natran
At the heart of your energies

IFP Energies nouvelles

RÉPUBLIQUE FRANÇAISE
Liberté
Égalité
Fraternité

INERIS
maîtriser le risque pour un développement durable

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The 4 Core Objectives

To focus on the *processes involved in converting a saline cavern or a natural gas cavern into hydrogen storage*

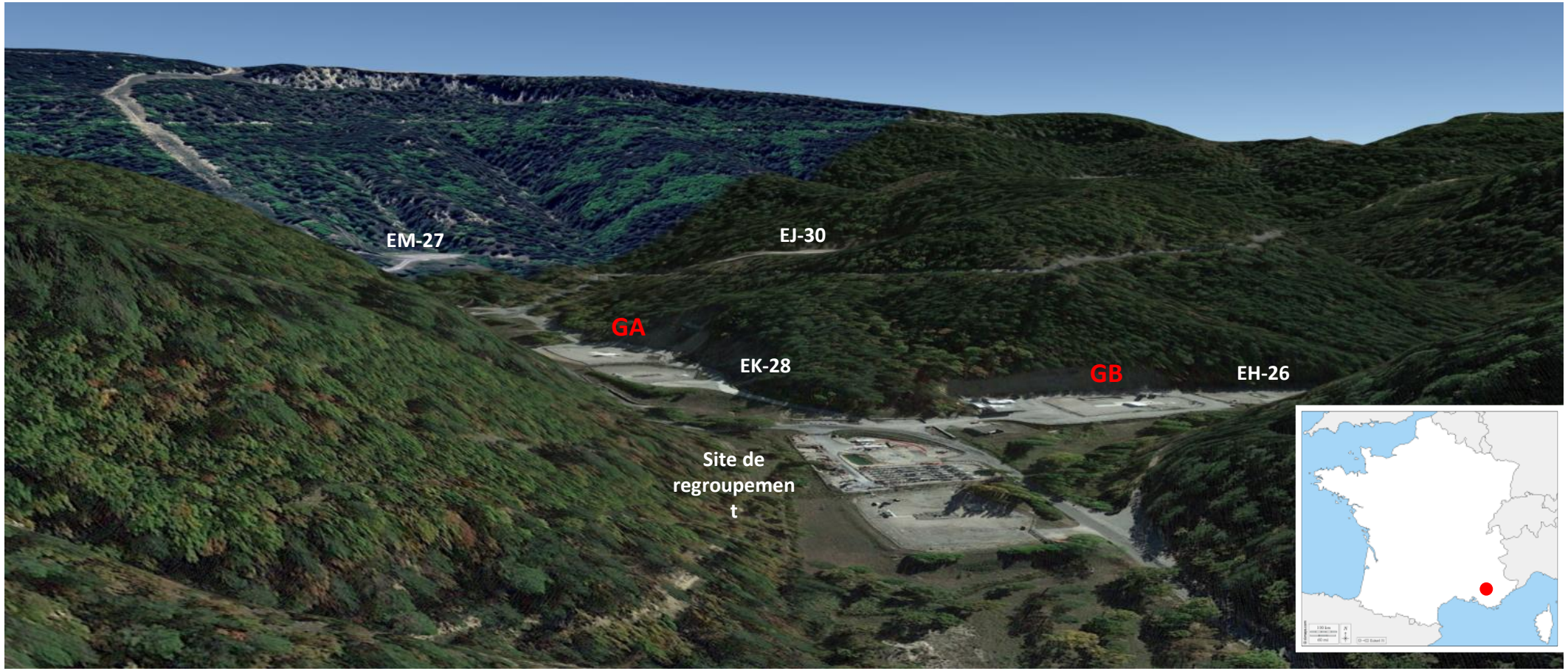
Implement the saline cavern conversion protocol by *demonstrating the withdrawal of 100 tons of hydrogen over cycles ranging from 1 hour to 1 week* in the converted caverns at Manosque/GeoH2 (FR).

Studying the *market penetration* and preparation for *replication at GeoH2 (FR) and SaltHy (DE),* and then on a European scale in a second phase.

Evaluating *environmental, safety, and regulatory considerations* to prepare for deployment at the GeoH2 (FR) and SaltHy (DE) sites, followed by scaling up to a European level.

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Manosque site view from the North



- South East of France on Manosque natural gas storage site
- In a protected area (National Park)
- Hilly and surrounded by forest

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Timeline

2024 - 2025

- Conducting analyses for the Manosque (FR) demonstrator and SaltHy (DE) site replicability

2026 - 2027

- *Construction phase*

2027 – 2029

- Implementing *100 injections and withdrawals at Manosque.*
  Studying hydrogen reactions under various pressures.
  Comparing results with theoretical predictions

From 2029

- Application of concepts to the GeoH2 (FR) and Salthy (DE) projects

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Work Packages

WP1
Project management and coordination

WP2
Manosque Demonstrator objectives, conceptual design, scientific developments, application of both to industrial scale replicators

WP3
Demonstration of hydrogen storage and cyclability



WP4
From regional implementation to market integration along the EU H2 value chain

WP5
Environmental safety and regulatory assessment

WP6
Communication
Dissemination
Exploitation

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WP1's main tasks



Coordination and project management

Task 1.1 – Strategic and technical project management

Task 1.2 – Administrative, financial and contractual coordination

Task 1.3 – Internal communication

Task 1.4 – Overall quality and risk control

Task 1.5 – Annual reporting for the Clean Hydrogen JU

Task 1.6 – KPIs Reporting

Task 1.7 – Synergies

These tasks will be performed for each reporting period:
M1-M18 (P1), M19-M36 (P2), M37-M48 (P3), M49-M60 (P4)

69 Deliverables

12 Milestones

13 Critical Risk

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WP2's main tasks

Manosque Demonstrator Context, Objectives and Conceptual Design

Task 2.1 – Definition of the Manosque storage demonstrator objectives and conceptual design

Task 2.2 – H2 dissolution and water vaporisation kinetics and impact at cavern scale

Task 2.3 – Geomechanical and thermodynamical predictive modelling of the demonstrator and models validation

Task 2.4 – Developments in the interpretation of MIT tightness test results and support towards a standardization of H2 caverns tightness tests

Task 2.5 – Analysis of the risk of gas quality at the outlet of industrial salt Cavern and porous media underground storages

Task 2.6 – Technical review of completion options for evolutive salt cavern Hydrogen storage

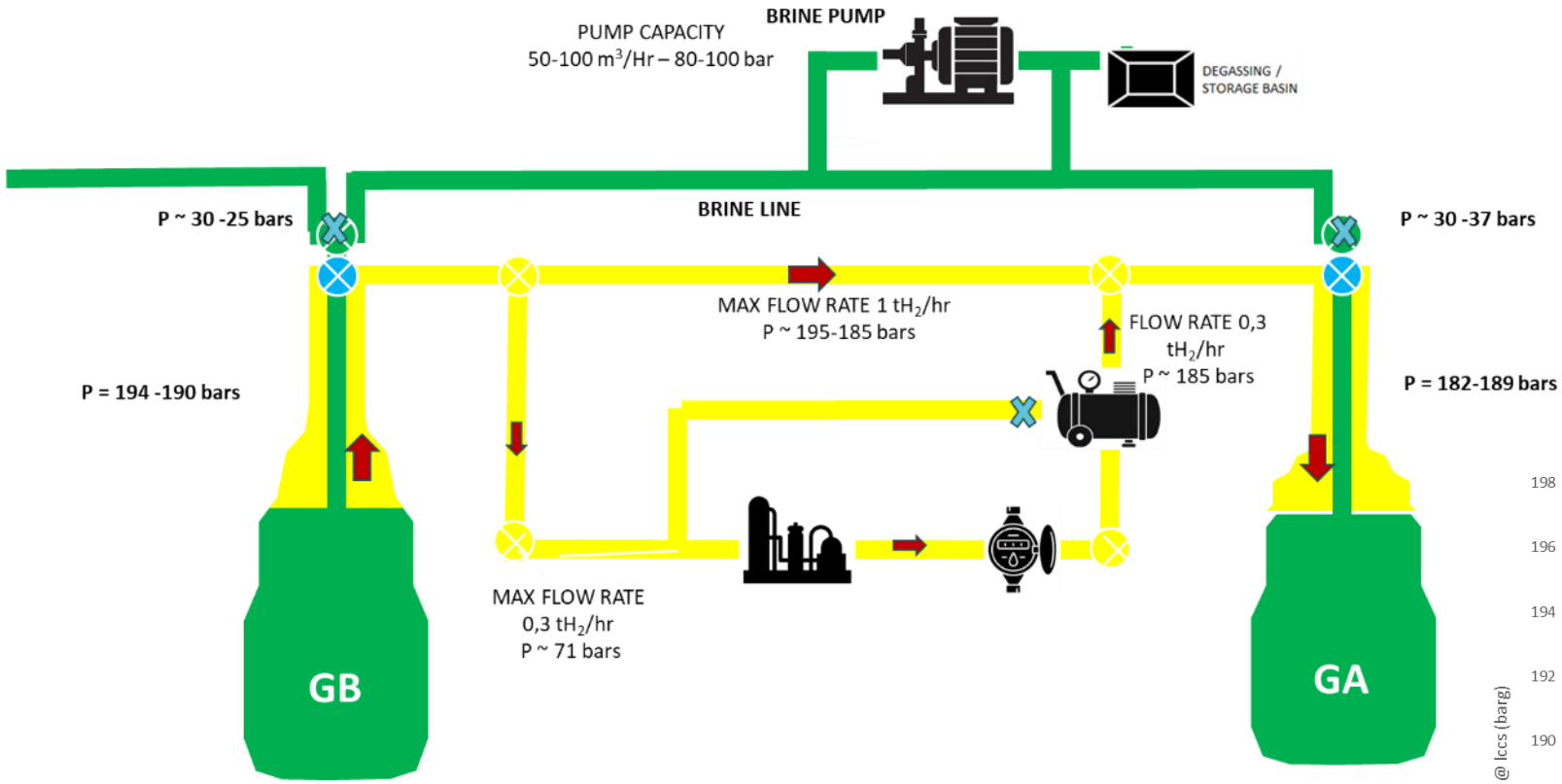
Task 2.7 – Replication of the technology developments and demonstration results on site by expending the Manosque demonstrator to an industrial underground storage project

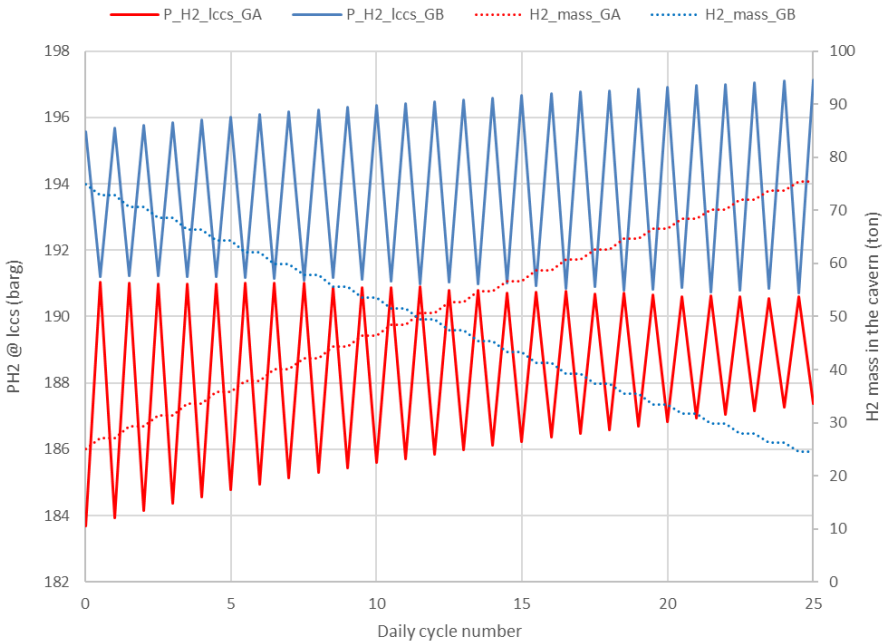
Task 2.8 – Replication of the technology developments and demonstration results at industrial scale to expand a natural gas storage to hydrogen

Task 2.9 – Incorporation of the results in a cost model enabling replicability assessment at European scale

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T2.1 Definition Manosque demonstrator



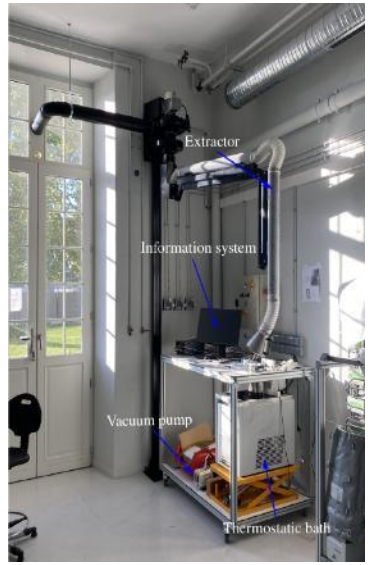


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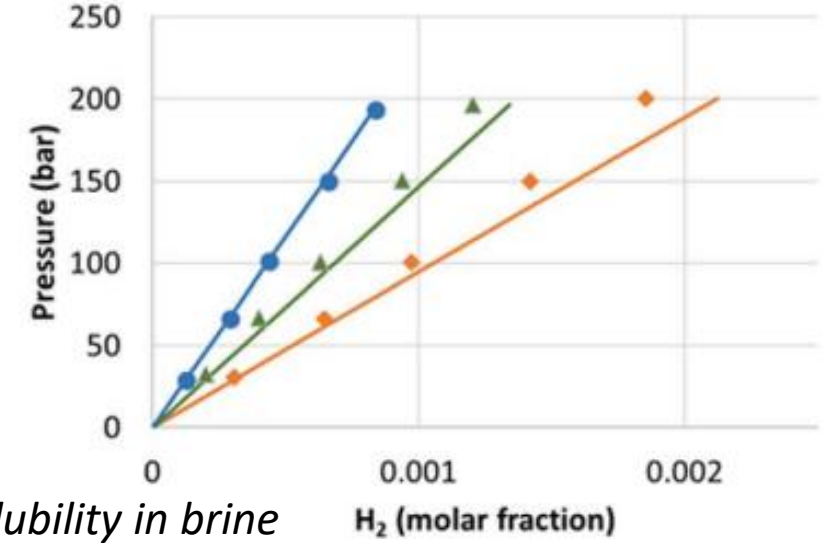
T2.2 Hydrogen dissolution & water vaporisation kinetics & impact at cavern scale

Objective:

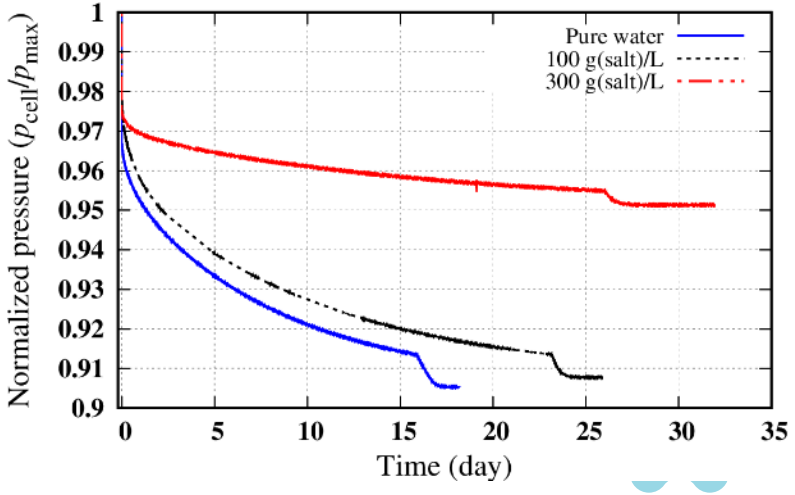
- Study hydrogen dissolution in brine and water vaporisation under controlled thermodynamic conditions
- Simulate conditions relevant to underground hydrogen storage in salt caverns



An increase in brine salinity leads to a reduced pressure decay, reflecting decreased gas solubility in the liquid phase.



H_2 solubility in brine



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T2.5 Analysis of the risk of gas quality at the outlet of industrial salt Cavern and porous media underground storages

Methanogenesis: $4\,H_2 + H^+ + HCO_3^- \xrightarrow{MET} CH_4 + 2\,H_2O$

Sulfate Reduction: $4\,H_2 + H^+ + SO_4^{--} \xrightarrow{SRB} HS^- + 4\,H_2O$

Acetogenesis: $4\,H_2 + 2\,H^+ + 2\,HCO_3^- \xrightarrow{ACE} CH_3COOH + 4\,H_2O$

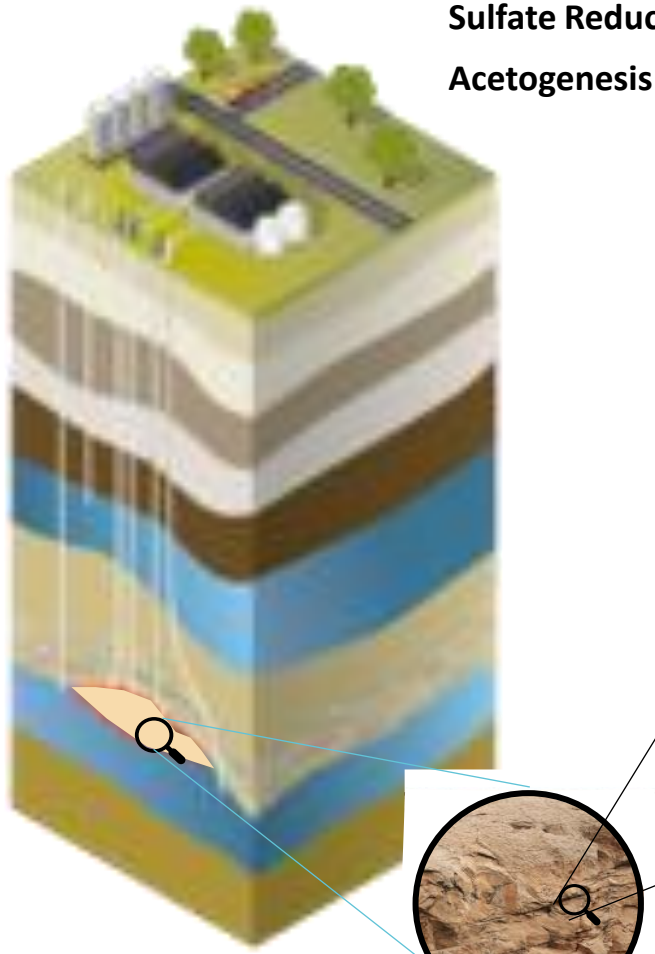
Main results

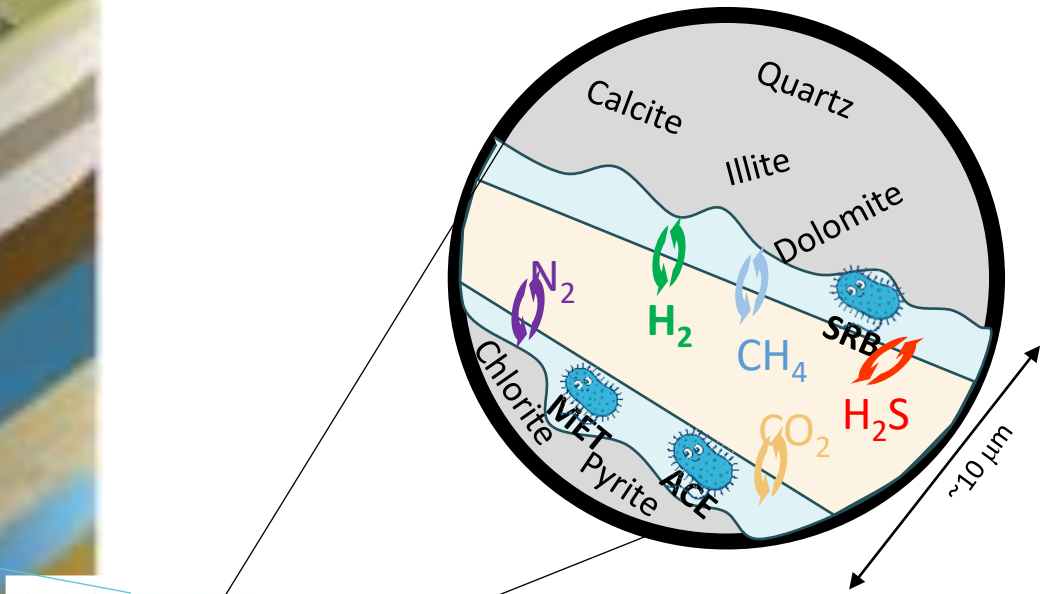
No significant impact of bacteria on quality of hydrogen produced

No significant impact of rock on quality of hydrogen produced

Purity of hydrogen highest for aquifers

No significant H_2S production (<< ppb)





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WP3's main tasks

Demonstration TRL8 of H2 storage and cyclability in gas cavern

Task 3.1 – Surface design and equipment selection

Task 3.2 – Subsurface operation and equipment, design and selection

Task 3.3 – Construction and commissioning

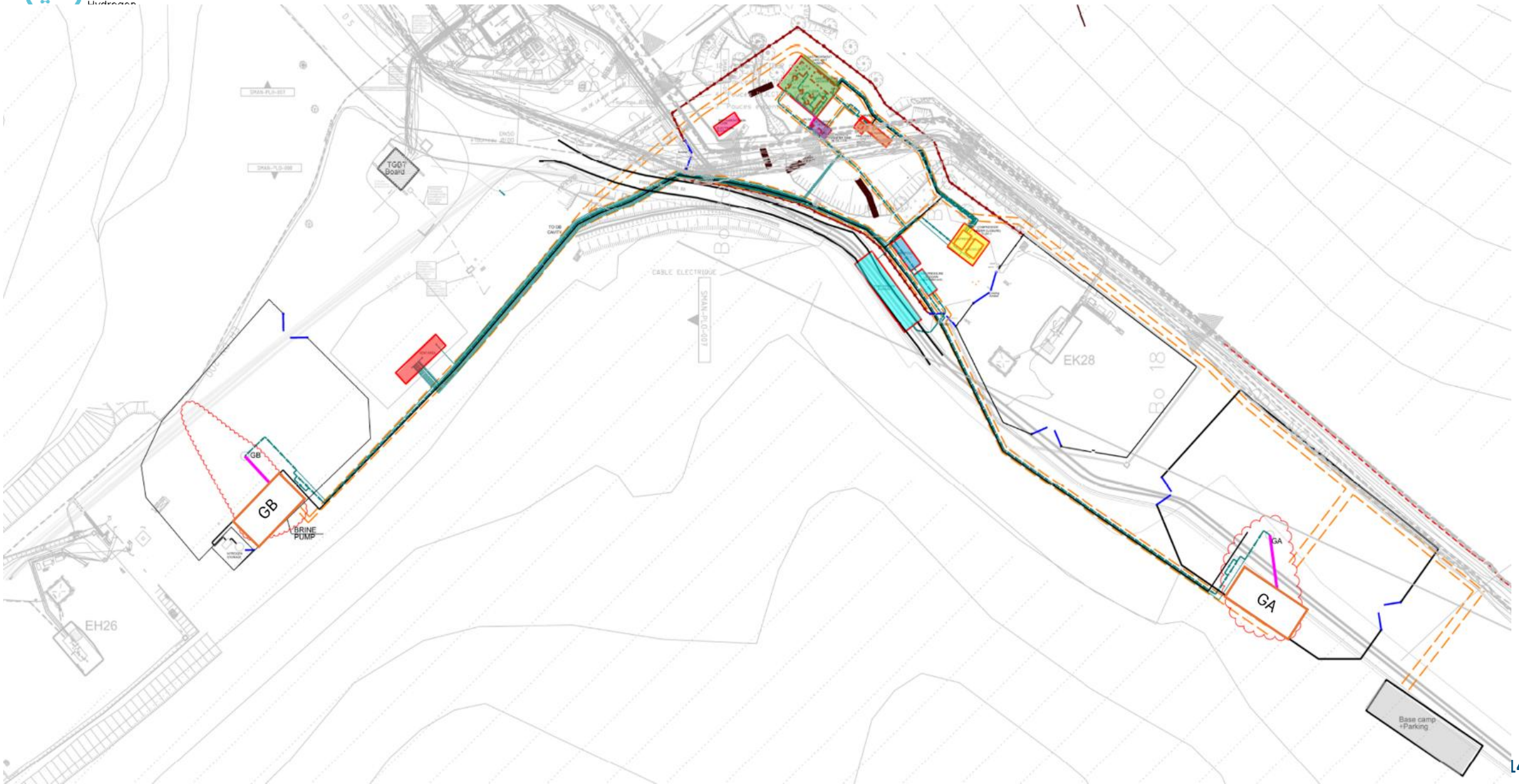
Task 3.4 – Operating the cycling testing plan: data acquisition & analysis

Task 3.5 – End of demonstration period and after project procedure

Task 3.6 – Main operational lessons learned from the demonstrator

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Focus on plant general layout



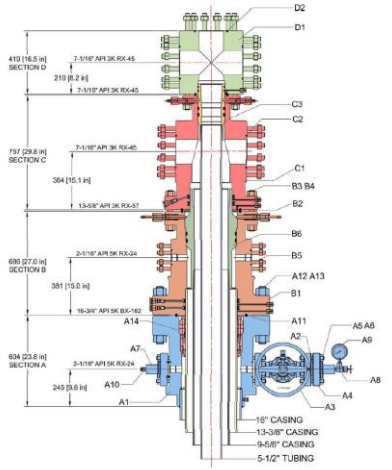
Completion – Inner & Outer string / Wellhead

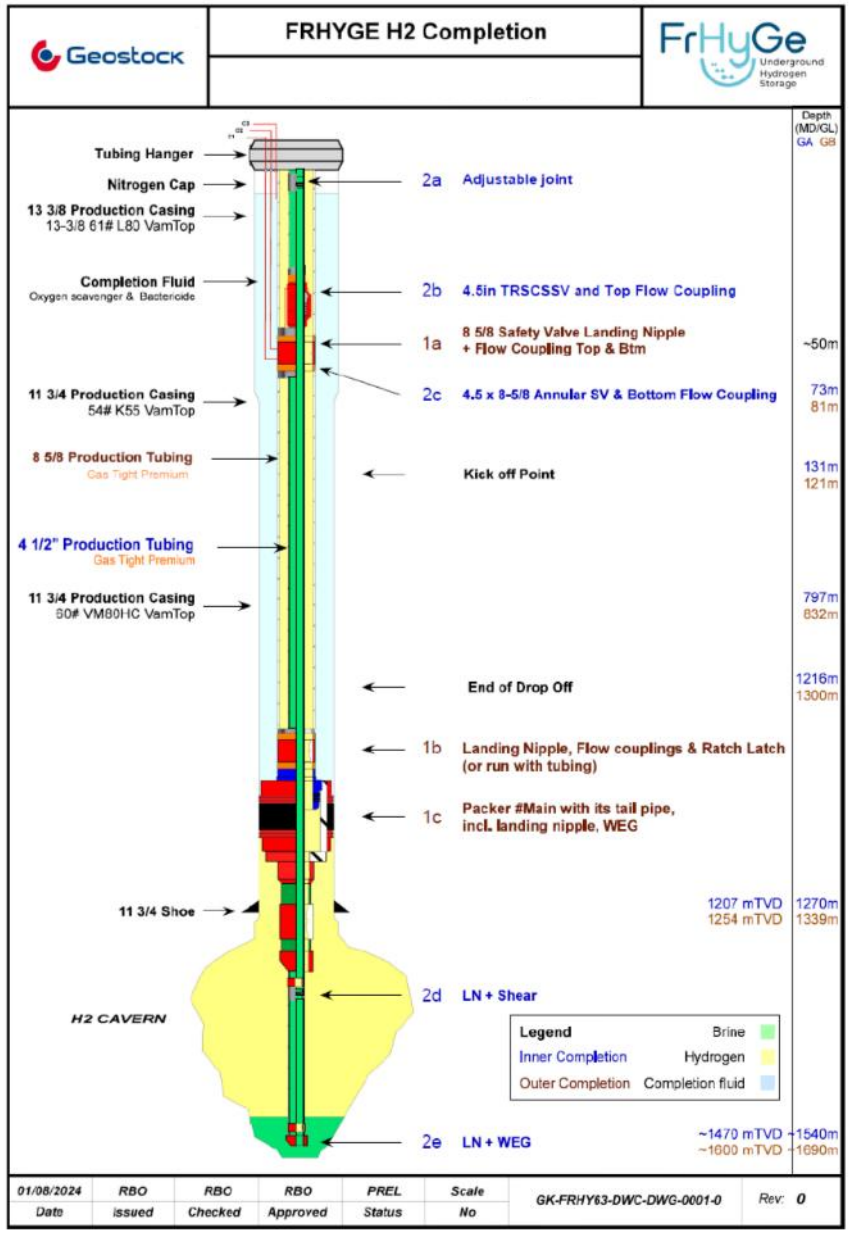
- Safety barriers: double independently verified well barriers with barrier elements independently tested
- Type of tubular connection: threaded
- Dewatering package: to cope with French common practice a dewatering package with Annular Safety Valve (ASV) and TRSV (Tubing Retrievable Safety Valve) will be run with the debrining string and set in the Safety Valve Landing Nipple (SVLN).
- Tubular specifications:

OD (in)	Weight (ppf)	Grade	Connection	ID (in)	Collapse (bar)	Burst (bar)
8 5/8	40	VM80S/TN80S*	Gas tight	7.725	380	500
4 1/2	11.6	VM80S/TN80S*	Gas tight	4	437	536

* Or other proprietary grades with similar resistance to hydrogen induced cracking

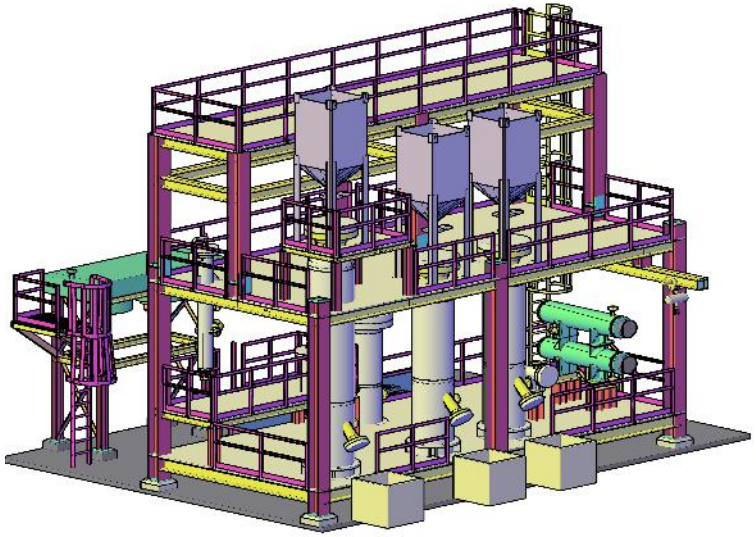
- **Wellhead equipment**
  - Christmas tree
  - Pressure rating: 5000 psi - API 6A / ISO 15848 certified equipment.

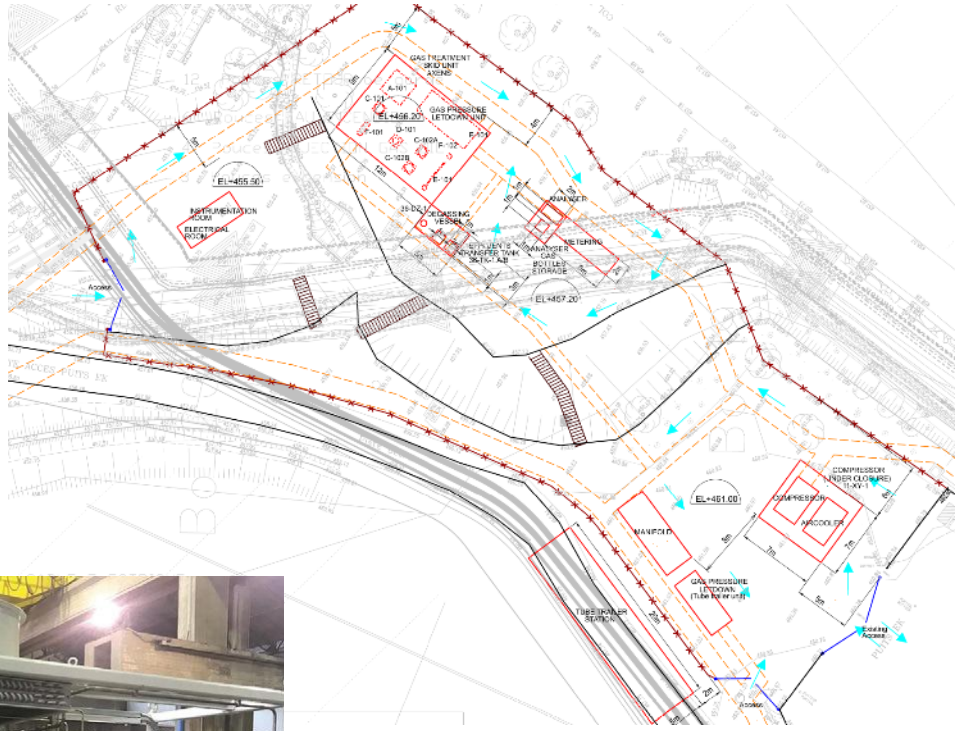




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Plant treatment and compression









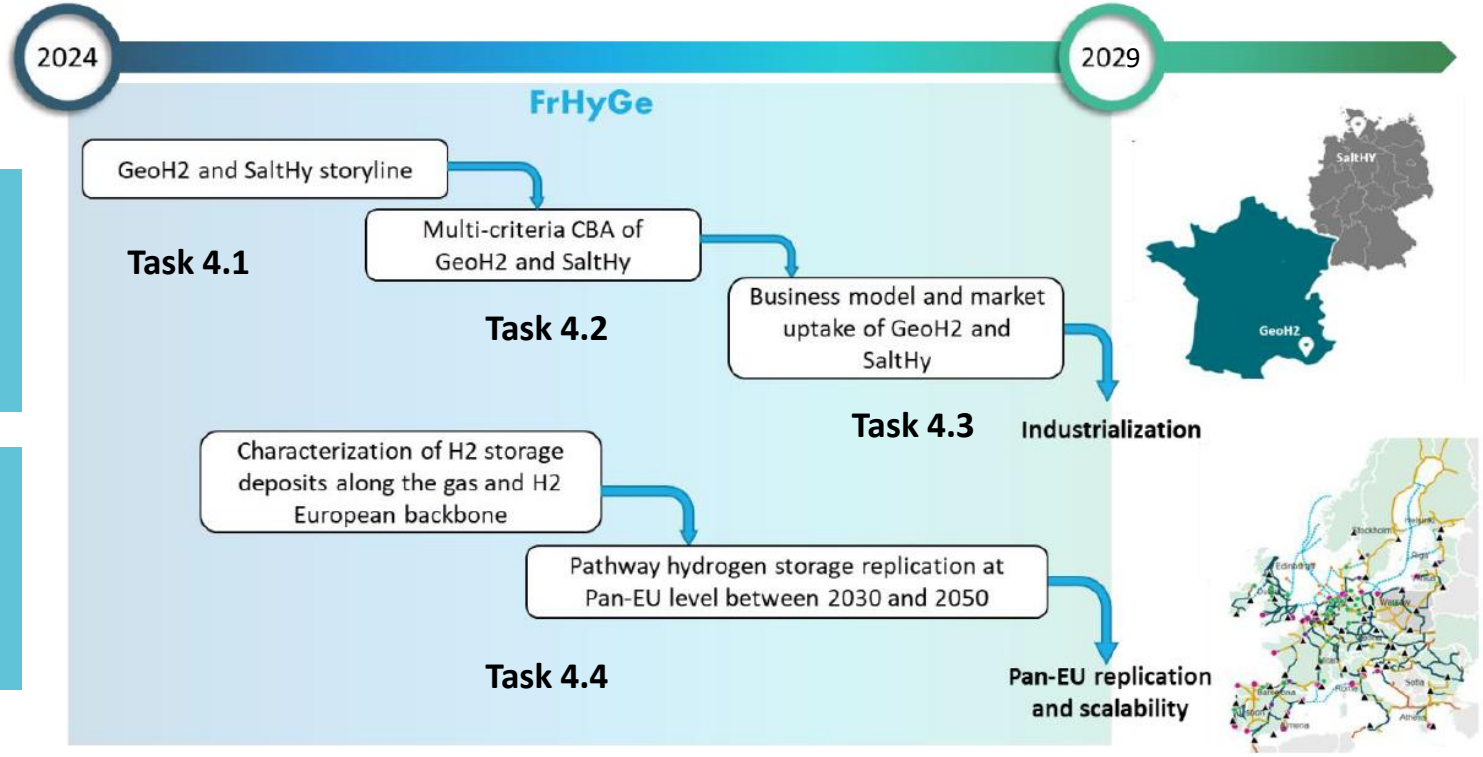
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WP4 objectives

From regional implementation to market integration along EU H2 value chain

Objectives

1	Support the identification and characterisation of business models for GeoH2 (FR) and SaltHy (DE)
2	Establish a replication strategy for UHS at European level



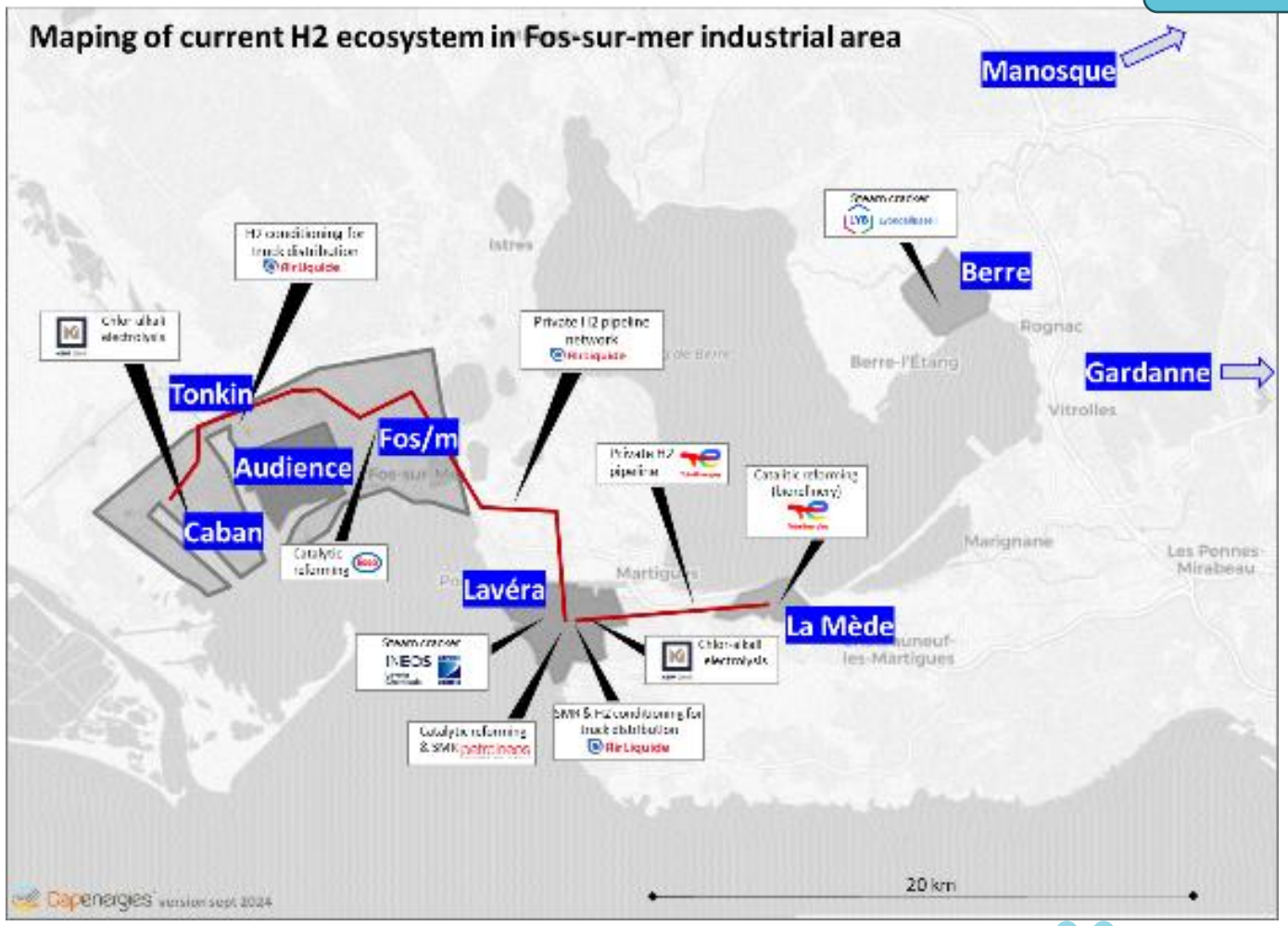
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Building a storyline for GeoH2

GeoH2

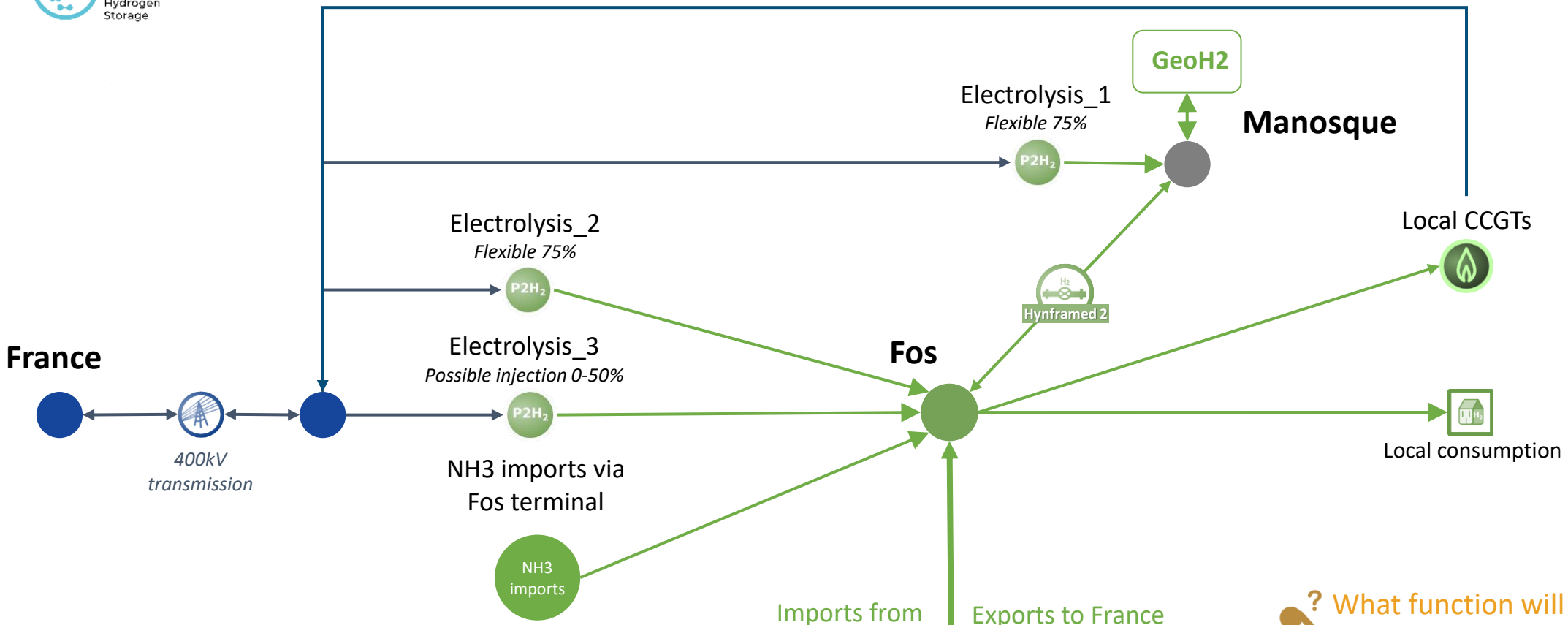
Main activities

1	Mapping of local off-takers
2	Interaction with national and European infrastructures
3	Definition of Prospective scenarios (2030 to 2050)



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Translating it into a model



What function will GeoH2 storage serve **for users** and **for the network balance ?**

Electricity layer
Hydrogen layer

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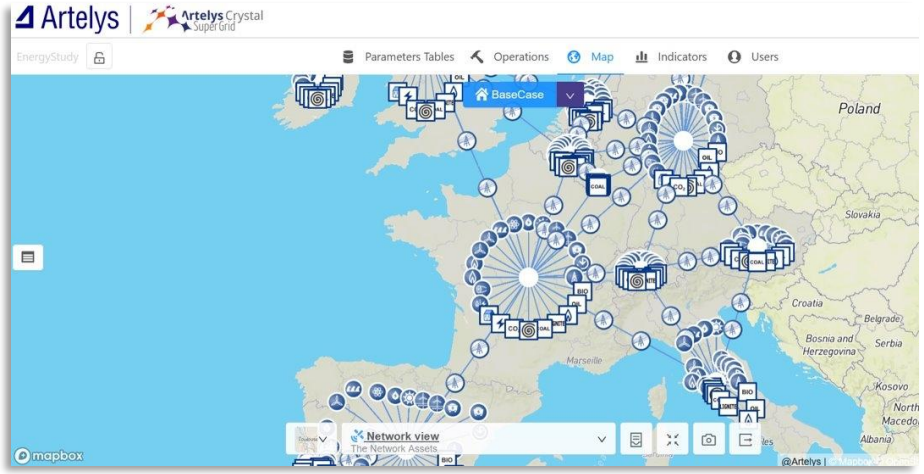
Translating it into a model

FrHyGe Underground Hydrogen Storage

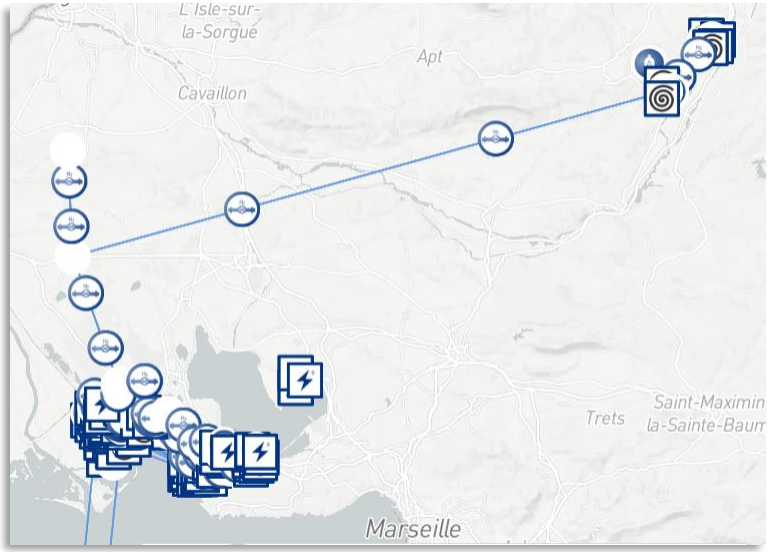
Artelys Crystal SuperGrid

- A multi-energy modelling solution dedicated to interconnected systems
- Coupled hourly energy dispatch and capacity expansion optimisation based on the minimisation of total system costs

Can be used for Pan European studies



Or to model GeoH2's storyline and simulate its operation



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WP5's main tasks

Environmental, safety and regulatory assessment

Task 5.1 – Major hazard risk assessment

Task 5.2 – Numerical modelling

Task 5.3 – Permitting & authorities

Task 5.4 – Lessons learning

Task 5.5 – Surveillance

Task 5.6 – Life cycle analysis

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Major Hazard Risk Assessment — Manosque Demonstrator

Task Overview: Phases, Scope & Stakeholder Contributions

PHASE 1

Risk Identification

Ineris

PHASE 2

Risk Assessment & Criticity (EDD)

StoSAS

PHASE 3

Underground Scenarios

GeoS

PHASE 4

Engineering Tool Comparison

Natran

INCLUDED IN SCOPE

- Caverns GA and GB
- Well completions
- Wellheads
- H_2 treatment unit
- Compressor
- Tube-trailer delivery unit
- H_2 transfer pipeline (GA ↔ GB)

EXCLUDED FROM SCOPE

- H_2 road transfer to demonstrator site
- Electrolyzer

KEY DELIVERABLES

The completion of Hazard Study (EDD) that will be provided to French authorities to authorize the Frhyge projet.

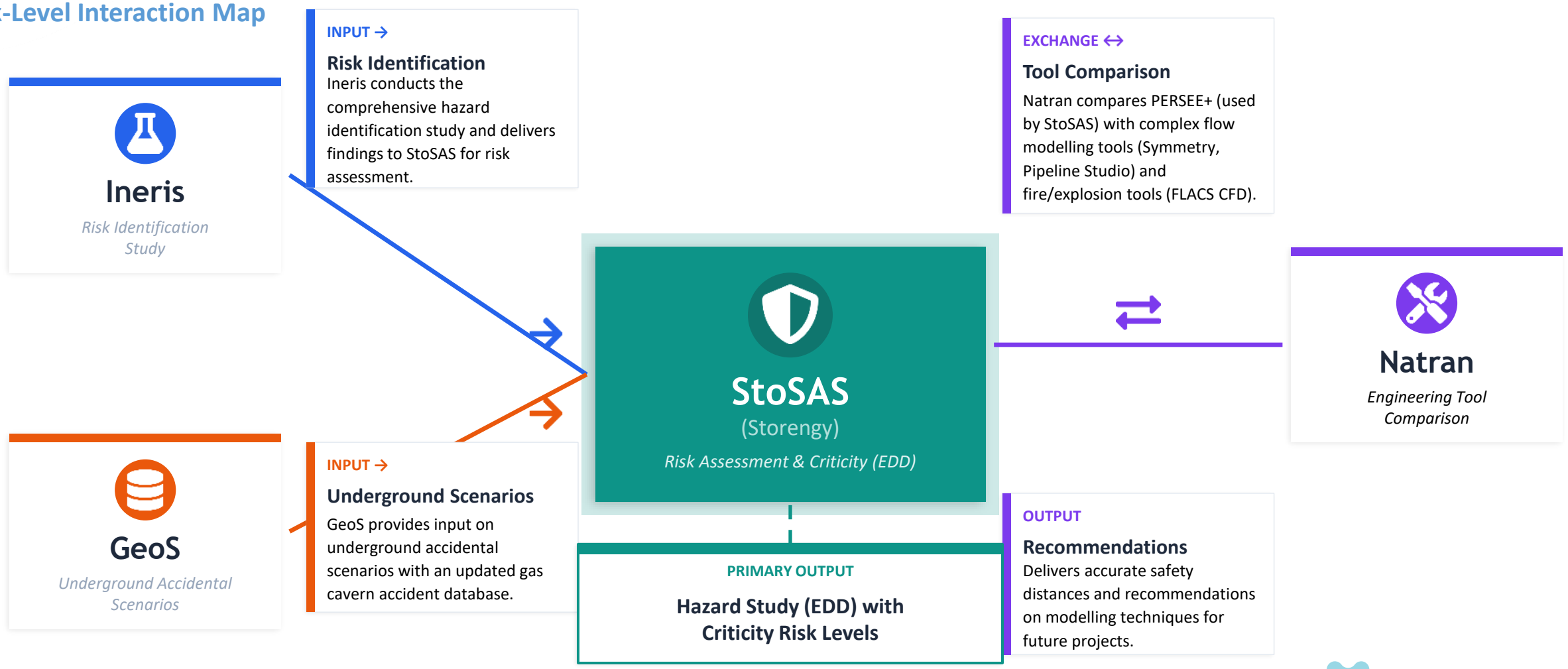
Implementation of safety distances regarding the current plot plan.

Comparison: PERSEE+ vs Symmetry / Pipeline Studio / FLACS CFD — for accurate safety distances in future projects

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Stakeholder Interactions — Manosque Demonstrator

Task-Level Interaction Map



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WP5 — Plot Plan Acceptability & Initial Safety Results

Progress on Modelling — Key Results to Date

Key Result: Thermal effects and overpressure distances from major scenarios (e.g. total rupture of GA/GB swan neck) do not exceed the existing PPRT perimeter at the Manosque site.

Plot Plan Acceptability Study

COMPLETED

- Compatibility assessment of surface facilities with regulatory & technical constraints
- Internal and external domino effects studies within site perimeter
- Safety distances evaluation for major scenarios

Results Under Review & Update

IN PROGRESS

- Discussions on first compliant plot plan integrating safety distances
- Integration of updated FEED data (FEED updates)
- Dispersion study results and safety distances recalculations

NEXT STEPS

- Finalize plot plan incorporating all safety distances
- Integrate dispersion study outcomes

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WP6's main tasks

Communication, dissemination, exploitation

Task 6.1 – Communication and dissemination tools

Task 6.2 – Knowledge sharing with external stakeholders

Task 6.3 – Participation to dissemination events

Task 6.4 – IPR and Innovation Management

Task 6.5 – Elaboration of the final report

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Objectives of WP6

COMMUNICATE	NETWORKING	FACILITATE REPLICATION	EXPLOITATION OF RESULTS
Coordinate and execute necessary communication and dissemination activities in order to massively share the project results at EU level	Bridge with other EU projects and relevant stakeholders	Elaborate recommendations about the technical and economic reproducibility of the process to other sites in EU	Manage IPR and innovation process



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WWW.FRHYGE-PROJECT.EU

Your source for updates on the European hydrogen storage project in salt caverns, featuring research progress, partner collaborations, and industry events

A European Intiative



Learn about the FrHyGe partners, their roles, and their collaboration in making underground storage in salt caverns a reality

Scientific Publications



Throughout the project, results from work packages and academic research will be published

News and Events



Stay informed with updates on events, conferences, and new insights through our website and newsletters

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