Hydrogen Pilot STorage for large Ecosystem Replication

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Project start : January 2021
Location : Etrez (Ain) France
H2 Production : Electrolyzer 1MW
End of Pilot Phase : December 2023
Storage Capacity : 3 - 44 tons

Test industrial scale renewable hydrogen production and storage in salt caverns supported by technical and economic reproductibility of the process to other sites throughout Europe

Consortium Partners

H2 & Subsurface expertise

storengy, ESK, ARMINES, BROUARD CONSULTING

Regulation & Safety

INERIS

Storage replication potential

inovyn, storengy

Technical and economic assessments

elementenergy

Bacteriology Purification

equinor

Communication

axeLeRa

Coordination

storengy, elementenergy

9 partners, 4 countries

Project Overview

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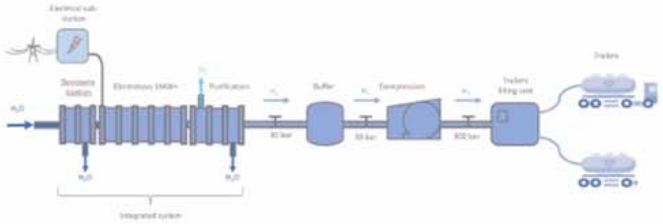
HyPSTER project is divided into two parts

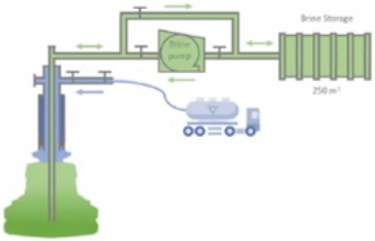
Renewable Hydrogen Production

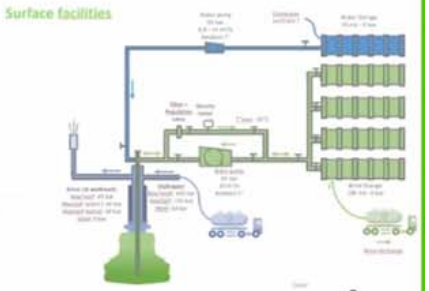
- Electrolyzer 1MW
- Hydrogen transportation by tube trailers



Pilot of Hydrogen Storage in salt cavern

- Use of an experimental existing cavern
- Tightness tests
- Pressure variation cycles





Project Objectives

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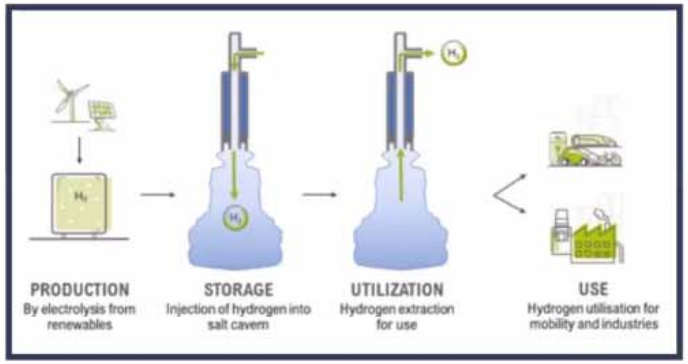

- ✓ Demonstration of the technical feasibility of H2 storage in salt caverns (safety of operations, environmental and geological impact)
- ✓ Adaptation of the equipment to hydrogen (piping, completion): grade of steel, elastomer, welds, etc.
- ✓ Hydrogen tightness of the salt cavity
- ✓ The thermodynamic behavior of hydrogen in the cavity
- ✓ The interaction of hydrogen in a salt cavity
- ✓ Feedback on the quality of the H2 leaving the storage facility

Adaption of EZ53 Cavern & Process for Tightness Test

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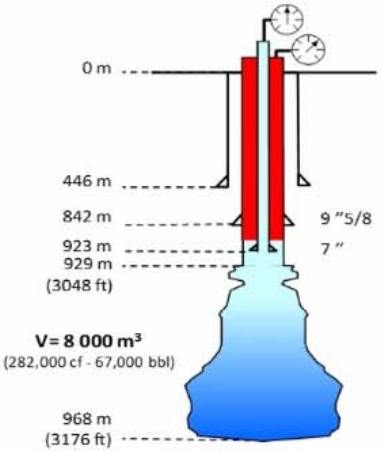
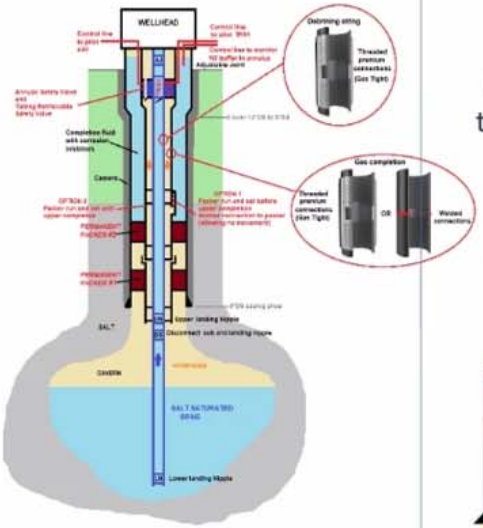
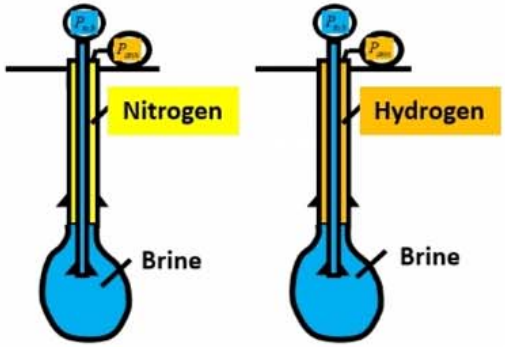


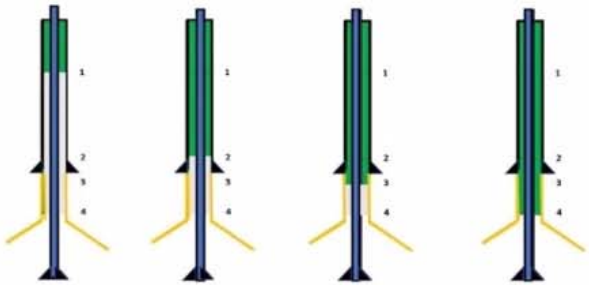
Current EZ53 installations



Cavern completion for H2 storage by brine compensation method

Perform a tightness test with N2 and H2, successively (for demonstration projects)

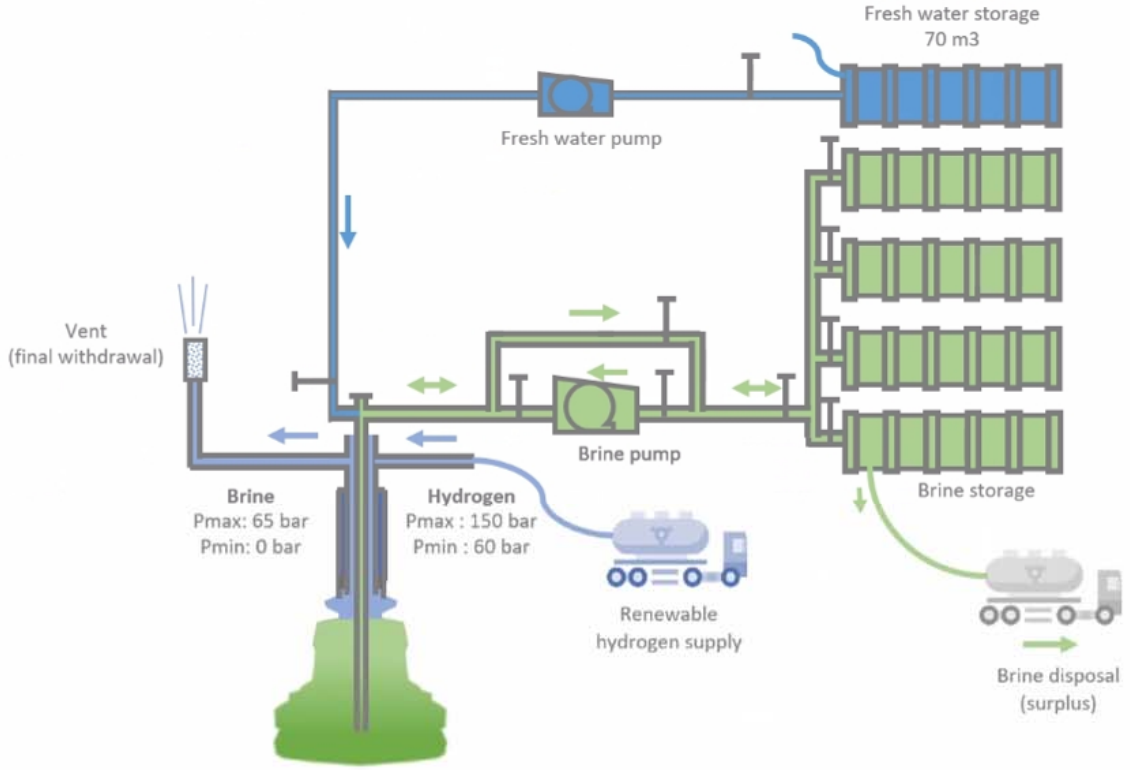




Set the interface at 4 different depths during the tests (for HyPSTER project)

Aim: Validate if standard method from natural gas storage is suited for hydrogen

HyPSTER – Cyclic Test Operation



HyPSTER – Test Cycle Definition

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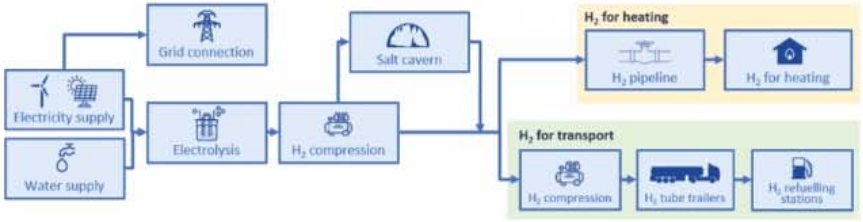
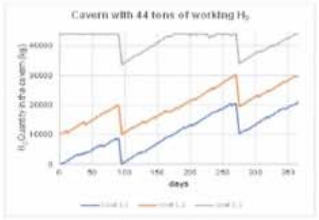
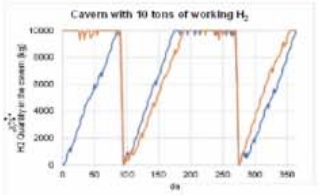
Modeling of exemplary hydrogen ecosystems

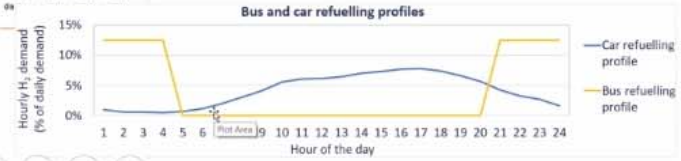






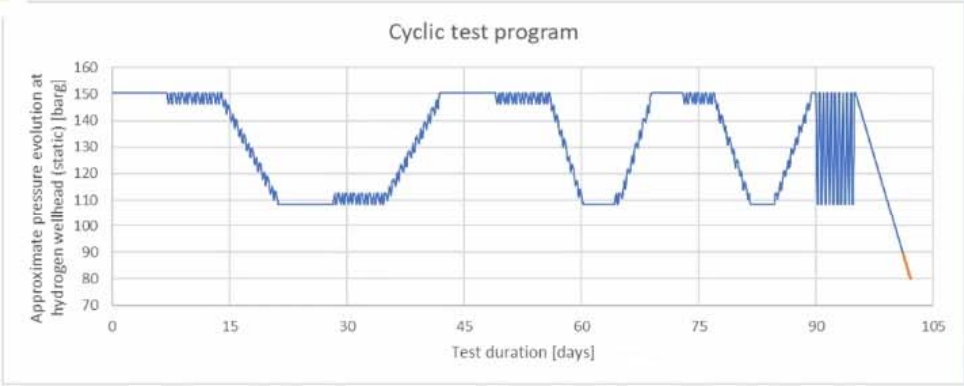
Scenarios investigated for Etrez storage:

- Electrolysis using wind/solar power or grid supply
- Usage for transport or heating
- Backup storage inculded



Planned cyclic testing program at EZ53 :

- ✓ Subject to technical limitations (pressure range)
- ✓ Relevant operating regime (idealized, but containing realistic features)
- ✓ Allowing calibration of software models
- ✓ Facilitating the monitoring of cavern tightness



Integrated test cycle with >100 intraday cycles, standstill periods for calibration and different pressure ramps to test various operation modes. A final hydrogen withdrawal can be added if possible.

HyPSTER – Adaption & Validation of Salt Cavern Models

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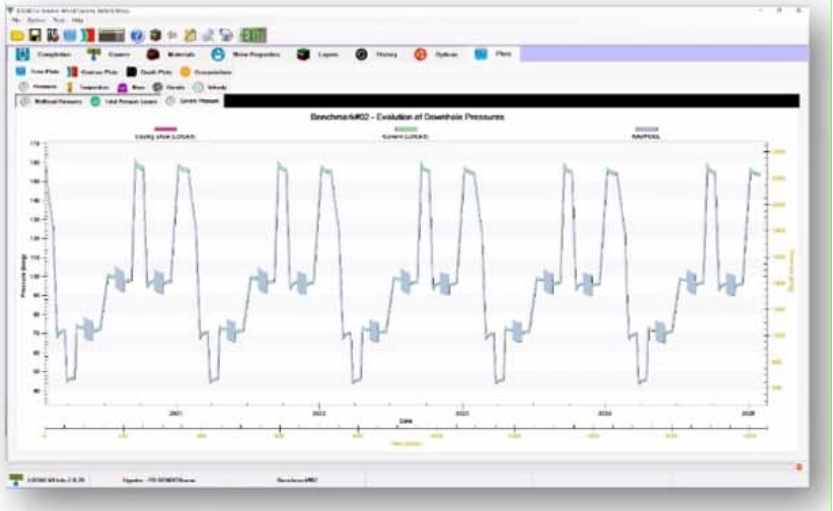
Thermodynamical & geomechanical models are **prerequisite** for storage design, approvability, safe operation
-> **commercial applicability!**



Comparison of software models **LOCAS** (Brouard Consulting) & **KAVPOOL/FLAC3D** (ESK/Itasca):

- ✓ Comprehensive benchmarking at relevant operating conditions
- ✓ **Agreement** for main model characteristics **confirmed** (e.g. cavern pressure development)
- ✓ Minor model differences identified, subject to model calibration

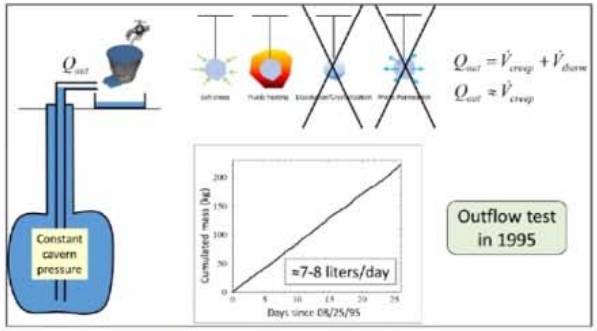
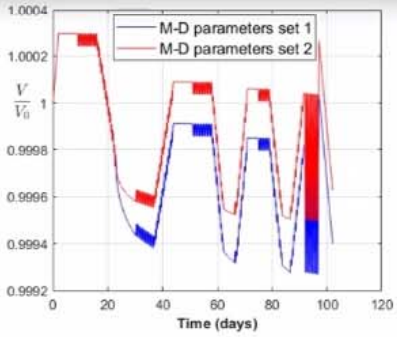


Figure 18. Example of a brine outflow test performed in 1995.

- ✓ Calibration of rock mechanical model on historical data
- ✓ First simulations of EZ53 cyclic tests



Modeled volume change during EZ53 cyclic test due to salt creep (computed using two different sets of parameters)

HyPSTER – Industrial Scale Modeling

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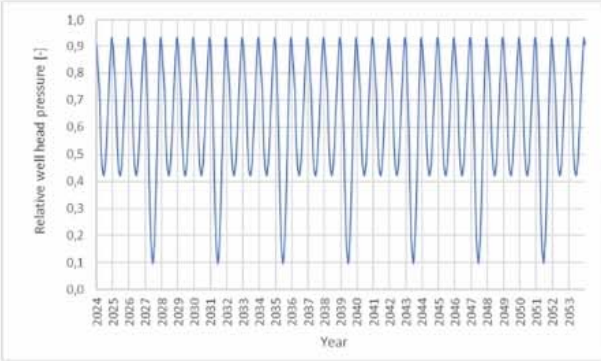
- ✓ Set of relevant cavern configurations for hydrogen storage in Europe defined
- ✓ Long-term schedule for industrial scale cavern operation defined

Parameter	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7
Depth of last cemented casing shoe [m]	600	900	900	900	1400	1400	1400
Geometrical cavern volume [m³]	350.000	200.000	500.000	800.000	200.000	500.000	800.000
Cavern height (roof to sump) [m]	70	70	140	300	70	140	300
Exemplary representations	UK	DE	DK, FR, DE, NL, PT	DE, NL	DE	FR, DE	DE



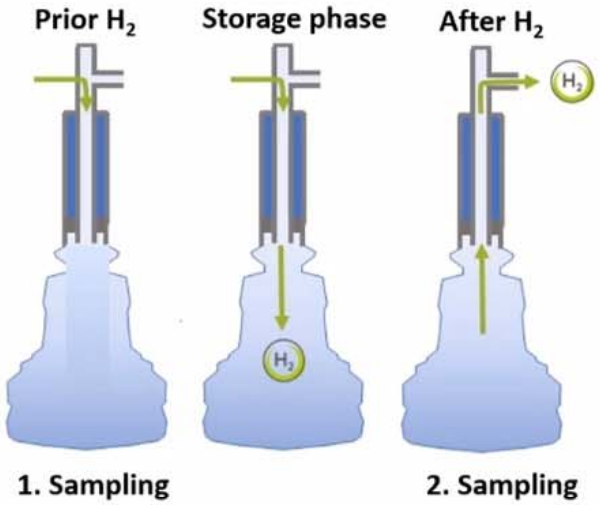
Operating schedule for comparison of industrial scale caverns

Sensitivity analysis (including additional geomechanical parameters)

HyPSTER – Microbiological Assessment

Microbial growth and consumption:

Investigate possible H_2 utilizing bacteria and the risk of H2 loss and ability generating toxic compounds. How to boost or inhibit bacterial growth ?



HyPSTER – Microbiological Assessment

Brine analysis:

Chemical analysis: total organic carbon (TOC), volatile fatty acids, pH, sulphate

DNA analysis: cell numbers of several key groups, community structure

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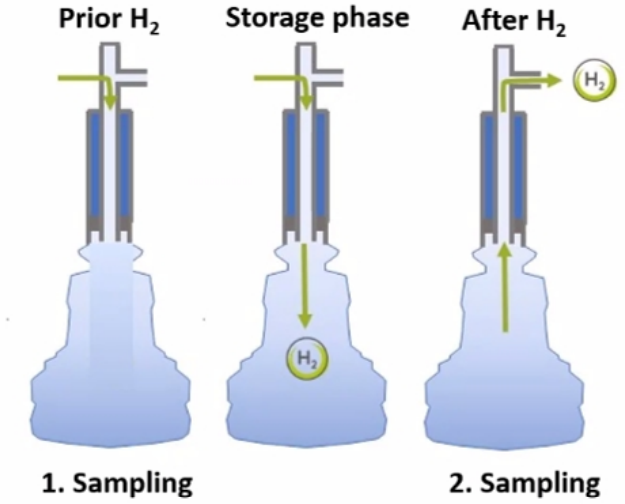

2 samplings planned:

1. before H_2 injection
   (2-4 samples during wireline operation)
2. after H_2 storage phase
   (~10 samples during emptying of cavern)

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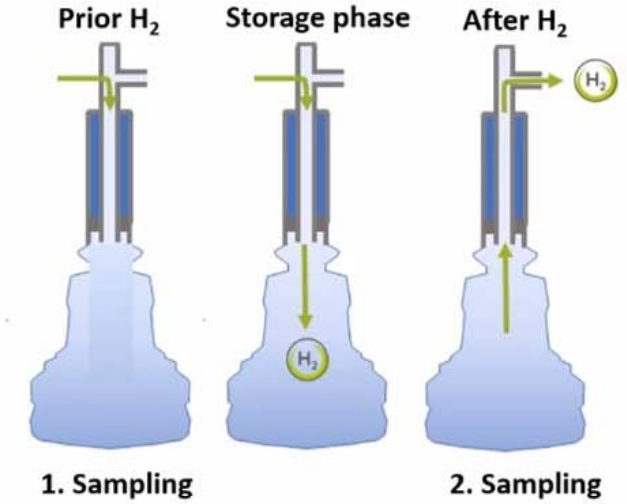
Effects of pressure changes:

Growth of brine/enrichment under higher pressure (specific for HyPSTER cavern)

Simulating cyclic pressure and temperature changes over time

→ **How will the community react? Changes in consumption rates?**



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Hydrogen Pilot STorage for large Ecosystem Replication

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Summary:

- Project is on track & within budget
- Approvals have been granted
- Groundwork started
- EZ53 suited for demand scenario
- Models successfully cross-checked
- Website & podcasts available online
- Workshop with stakeholders held

Next steps (extract):

- Continue on-site work (H2 production & cavern platforms)
- Perform tightness test & cyclic test
- Confirm applicability of tightness test method & cavern models
- Analyze delivered hydrogen purity & microbiological activity
- Provide lessons learned on safety & environmental impact
- Model industrial scale storage application
- Assess techno-economic replicability & develop roadmap
- Engage with other potential storage operators & partners
- Develop recommendations for national & EU policy makers
- Publish scientific project results

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Thank you for your attention!

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Project information:
https://hypster-project.eu

Co-funded by the European Union
Clean Hydrogen Partnership

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101006751. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation programme, Hydrogen Europe and Hydrogen Europe Research.