Hydrogen storage
On the critical path to deliver ambitious hydrogen strategies

Storengy projects in France and Germany

Hydrogen and P2X

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Some key questions when talking about hydrogen storage

- What will be **the role** of large-scale hydrogen storage?
- What are the **available technologies**?
- What is the **underground potential**?
- Will **conversion of existing** sites be enough?
- What we need to do to succeed?

Quick reminder : the various roles of large-scale gas storage

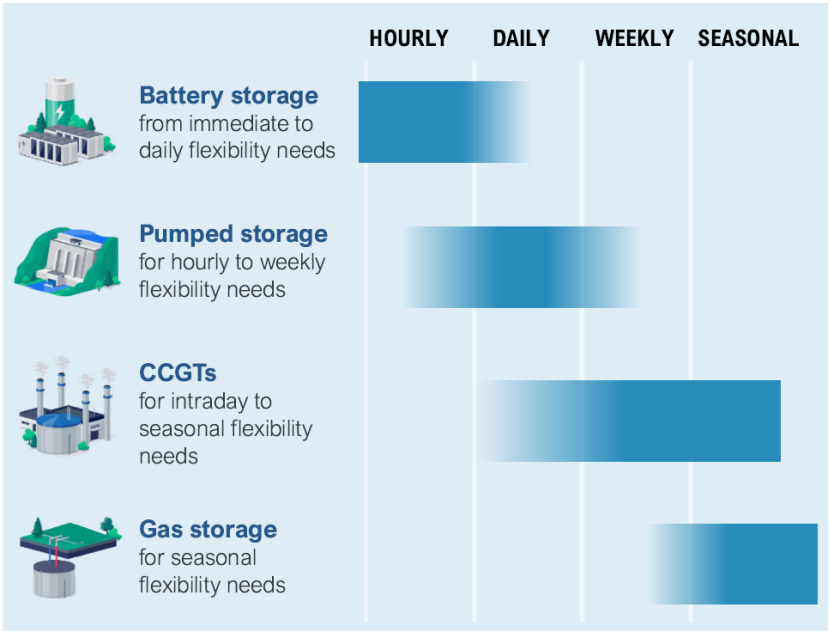
Volume risk management

- ✓ **Matching demand and supply:**
  - ✓ seasonal demand patterns
  - ✓ volatile demand of gas for power
  - ✓ Different supply profiles (pipe, LNG)
- ✓ Insurance against temporary **disruption** (production or transport)

Economic and financial role

- ✓ Reduce the overall **system cost**
- ✓ **Hedge** against price risk

Simplified representation of available gas and power flexibility sources :



Source: ENGIE, 2023 market update

Simplified comparison of methane and hydrogen offer and demand

Comparison of anticipated offer and demand patterns show a higher need for flexibility compared to today (in relative terms)

	Methane infrastructure		Hydrogen infrastructure	
	Consumption	Production	Consumption	Production (for electrolytic H2)
Drivers of hourly flexibility needs (and below)	Daytime vs nighttime activities (residential, tertiary)	Methane production and imports are largely constant over these timescales (except in cases of maintenance)	Daytime vs nighttime activities (residential, tertiary)	RES production variability (solar PV in particular), network congestions
Drivers of weekly flexibility needs	+ Weekday vs weekend activities (residential, tertiary)		Weekday vs weekend Activities (residential, tertiary)	RES production variability (wind power in particular) , network congestions
Drivers of seasonal flexibility needs (and higher)	++ Thermosentivity (mostly residential)		Thermosentivity (mostly residential) Residential consumption ?	RES production variability (hydro, wind and solar PV), network congestions

Additional drivers of flexibility needs, specific to electrolytic hydrogen

Artelys | SOLUTIONS EN OPTIMISATION

Study commissioned by GIE + personal notes

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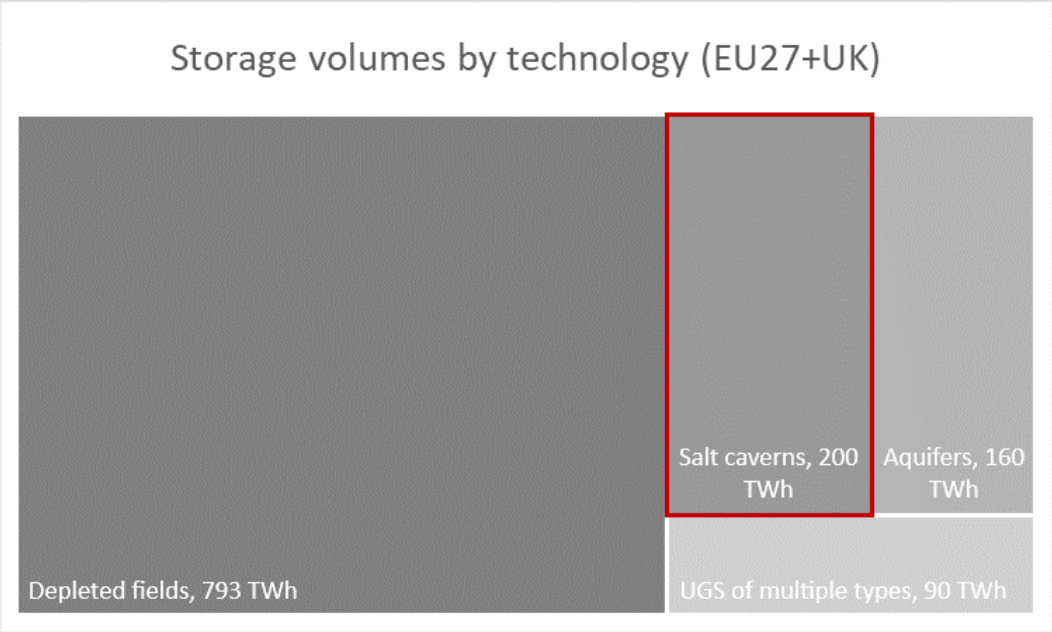
What are the technical solutions to store hydrogen?

Three technologies are used today to store natural gas underground :



Salt caverns are the best option to store hydrogen in the short term

Salt Caverns

TRL 9 (Commercial)

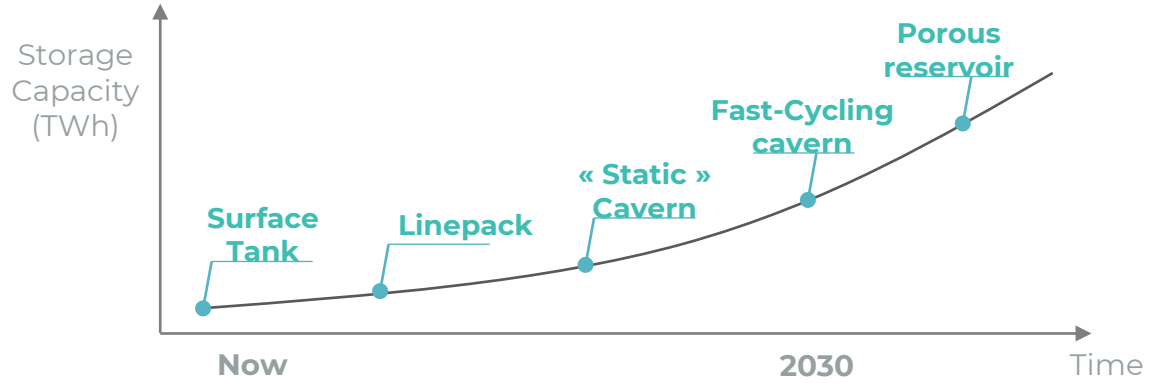
Fast Cycling Salt Caverns

TRL 7 (Pilot)

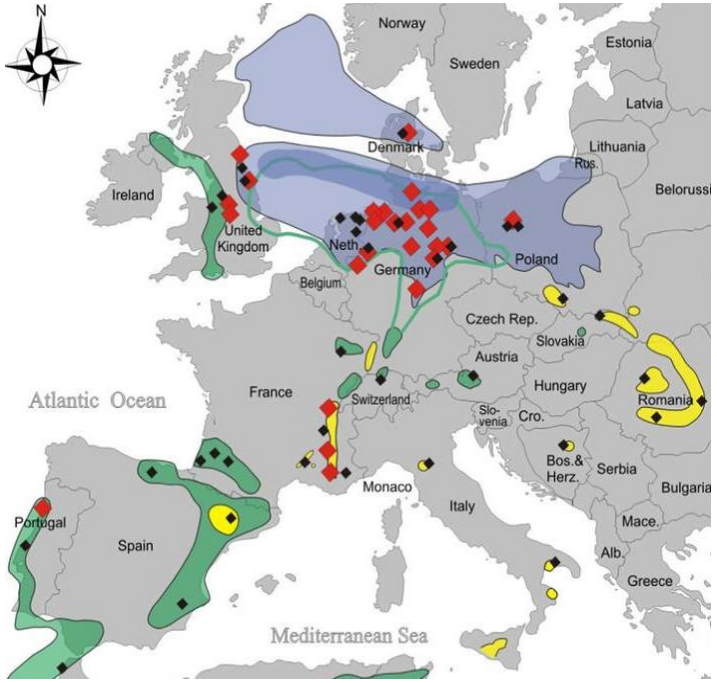
from 6 to 14 full cycles/year

Porous Reservoirs

TRL 2-3 (R&D)

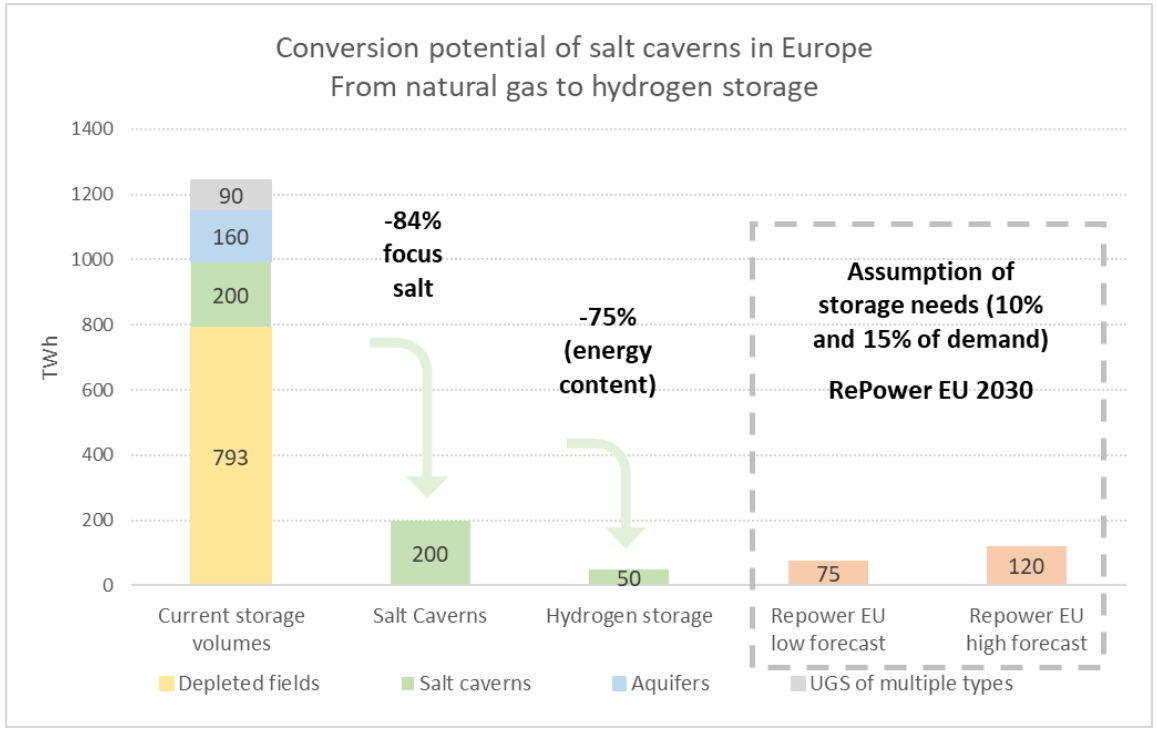


Europe’s underground storage potential



Gillhaus A. Natural gas storage in salt caverns - Present status, developments and future trends in Europe. Spring 2007 Conference:19; 2007.

- Hydrogen has a **lower energy content** than natural gas
- Conversion of all salt caverns represent **4% of actual capacity**



- RePowerEU 2030: H2 demand = 20 Mt = 780 TWh

Storengy hypster Hydrogen Storage project, France

2020 — Definition of the regulatory framework for the project & signature of the consortium agreement by all partners

2021 — Start of the engineering studies.

2022 — Construction of the electrolysis unit for on-site green hydrogen production.

2023 — Experimentation of hydrogen storage in a salt cavern and hydrogen production.

... — ...

H_2

1st demonstrator of Hydrogen green storage

13M€

Total budget:

5-million-euro granted by the Fuel Cells and Hydrogen Joint Undertaking FCH JU)

400 kg/day

Production of 400 kg of hydrogen per day

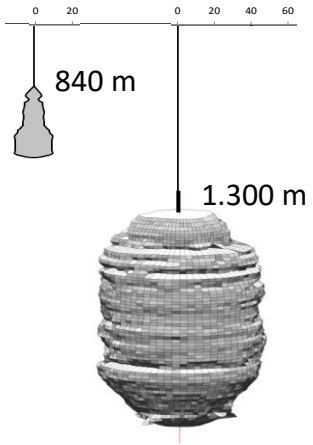
(the equivalent of the consumption of 16 hydrogen buses).

1MW

electrolyser

3 tons

of green hydrogen to be stored during the first stage



Typical cavern in Etrez

Geometric volume : 570 000 m3
Total gas: 4.75 Bcf
Equiv H2 : up to 6.3 ktons

HyPSTER cavern

Geometric volume : 7 000 m3
Total gas: 45,5 MMcf
Equiv H2 : up to 44 tons

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 — ENSEMBLE, CATALYSONS LES RÉUSSITES

Coordination

storengy, elementenergy

2 Strategic partnerships

Schneider Electric, TechnipFMC

Hypster is a project co-funded by the European Union's Horizon 2020 Programme through the Fuel Cells Hydrogen Joint Undertaking (FCH-JU) under grant agrement number 101006751

SaltHy project in Harsefeld, Germany

Hamburg / Stade region

At the crossroads of Germany, Denmark and the Netherlands

Phased project:

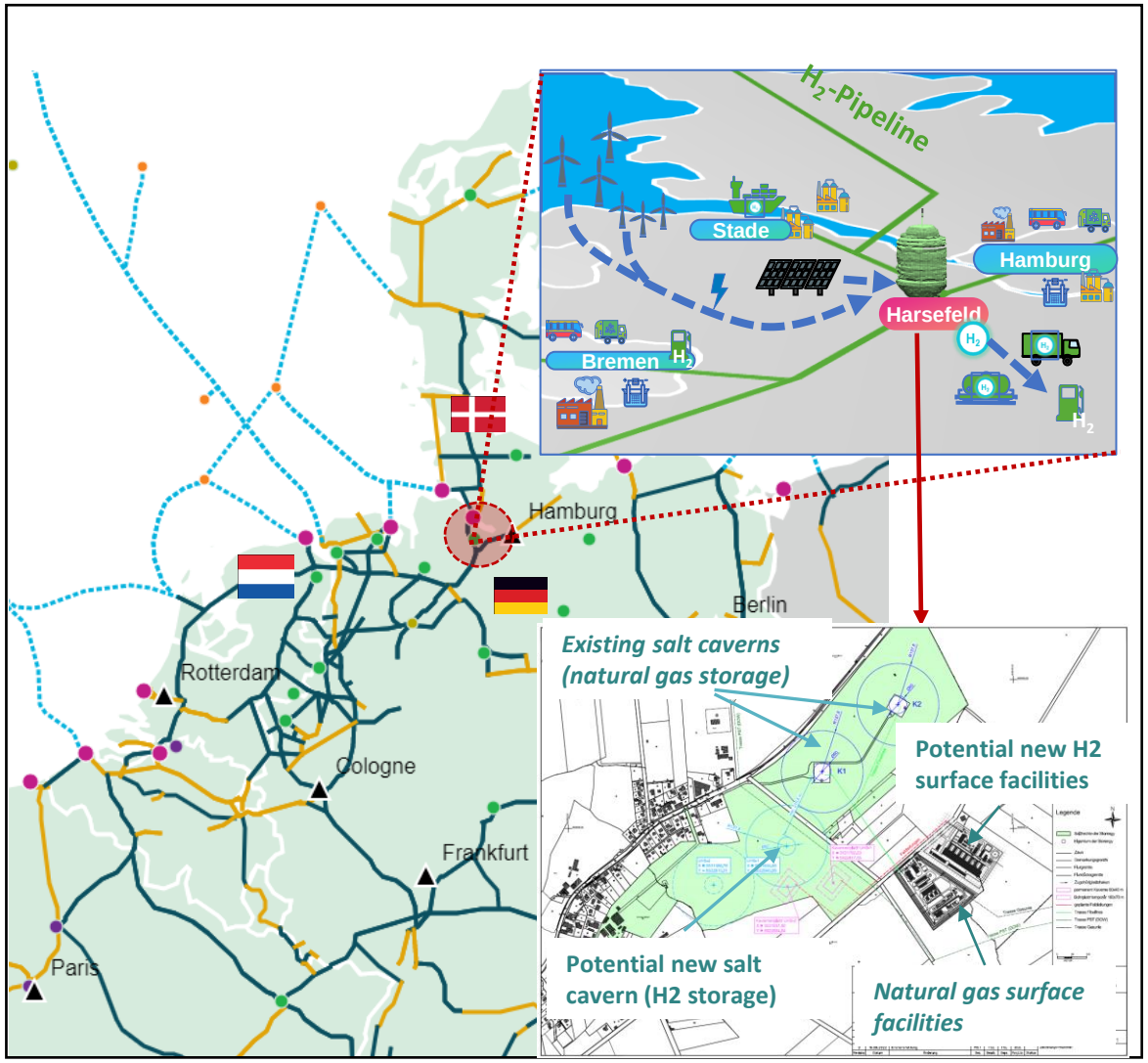
- 1st phase:

  one new salt cavern and dedicated surface facilities to store 100% H2

  Working Gas Volume: 5.200 t / 205 GWh, Maximum Inj. / With. rates: 17 GWh/d

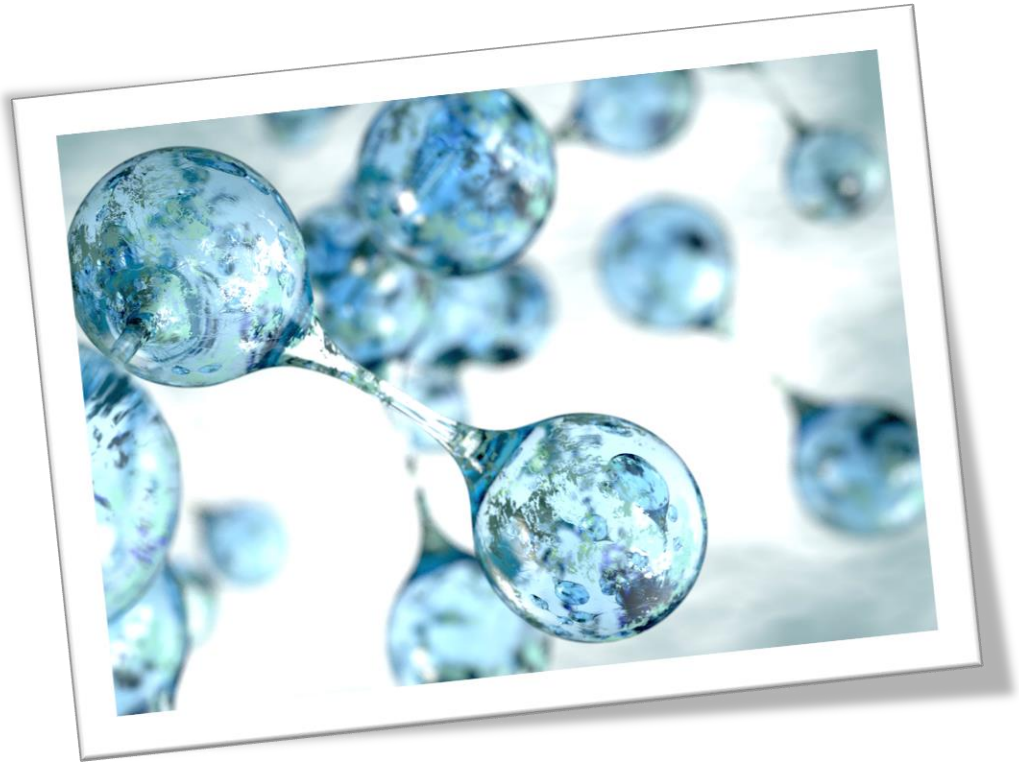
  Target date for 1st phase : 2030

- 2nd phase with another cavern and necessary surface equipment
- 3rd phase: repurposing of existing natural gas facilities (two caverns)



What we need to succeed

- Investment on predevelopment, pilot projects and R&D
- A **holistic power and “gas” infrastructure approach**
- A **clear and supportive regulatory context**
- **Adequate permitting processes**



Thank you!

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