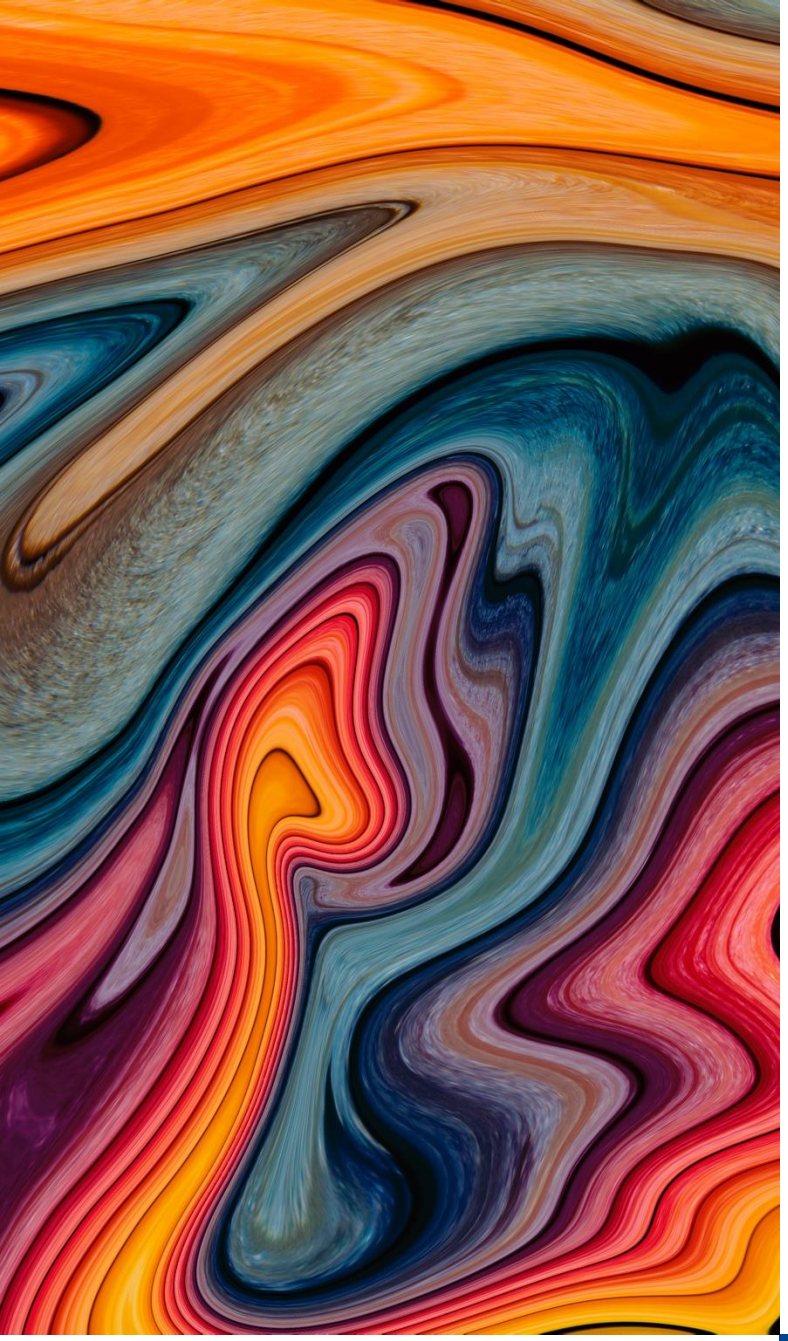
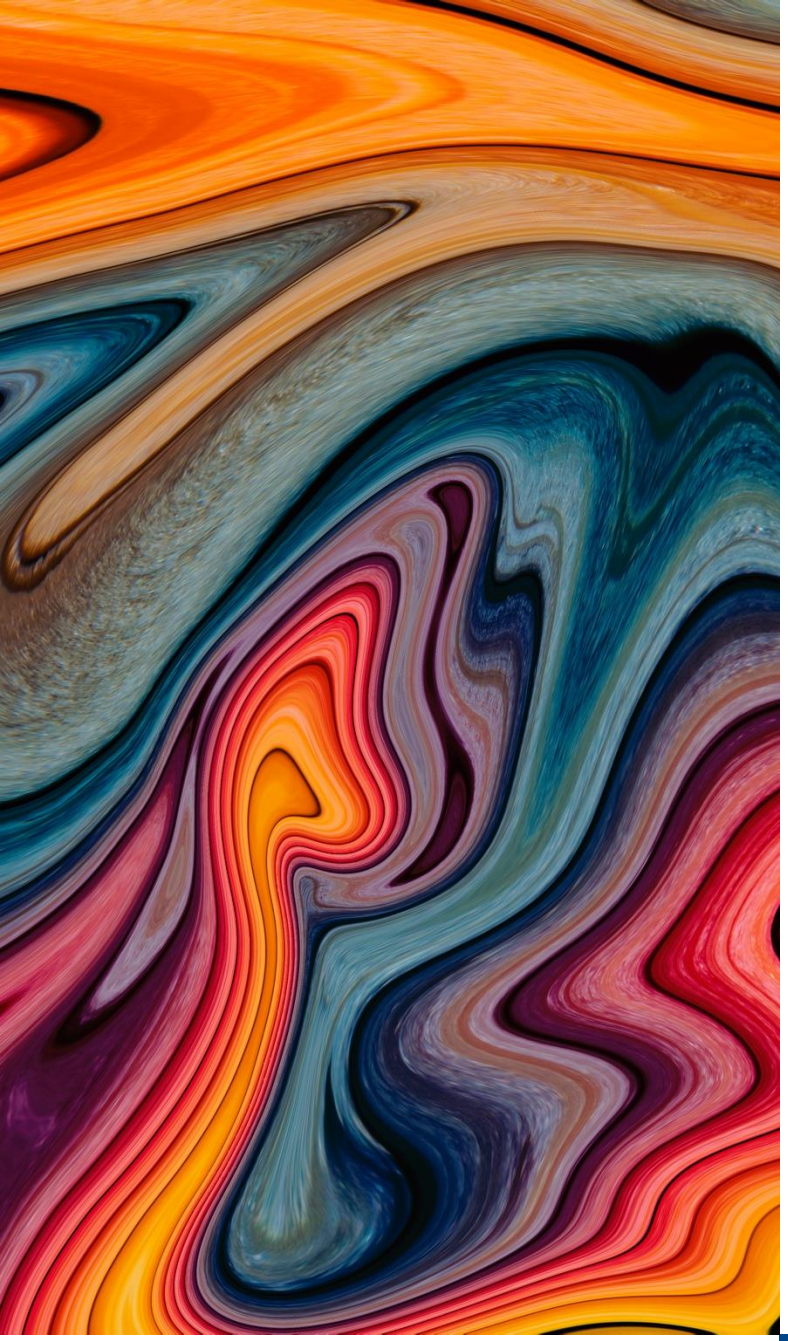


Geostock

WE MAKE THE EARTH THE BEST PLACE
FOR STORING ALL ENERGIES

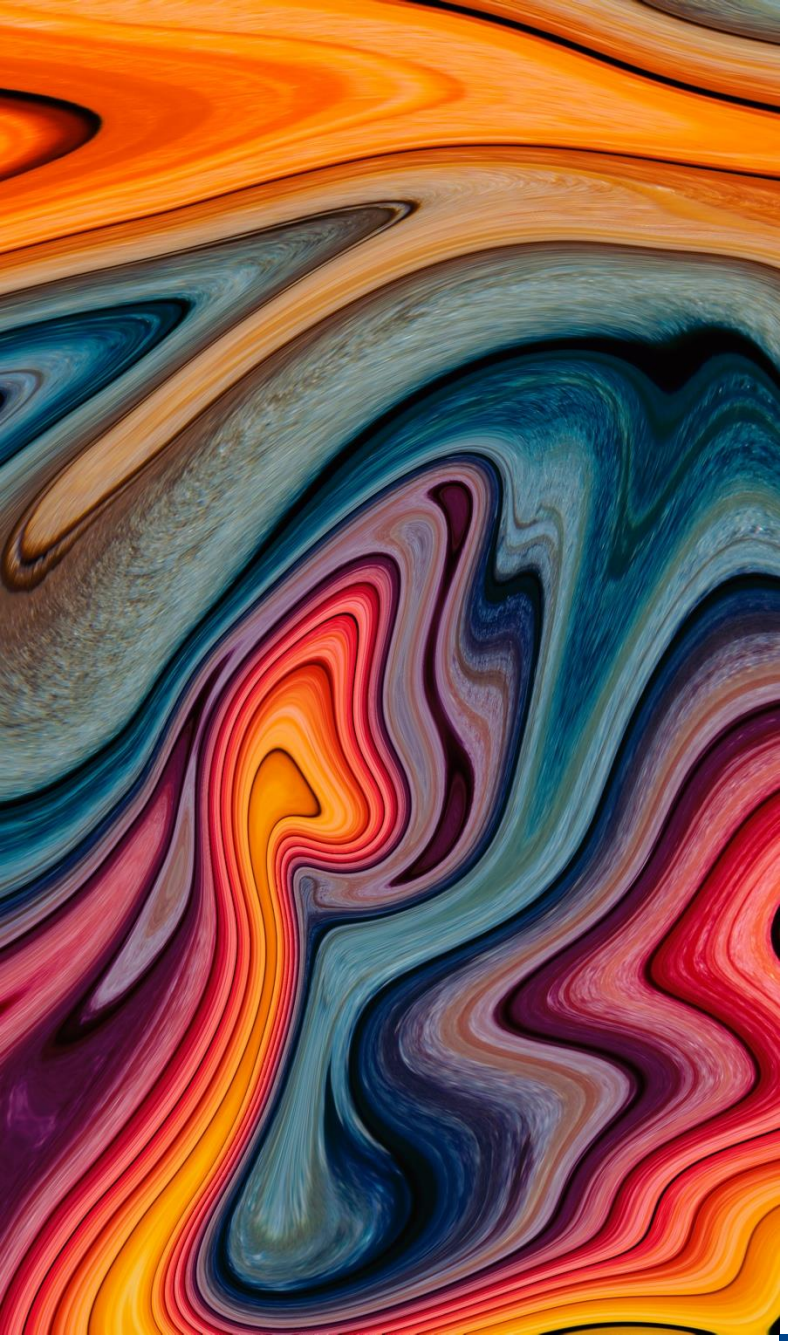
# Different ways to store $H_2$ underground & Why the Lined Rock Cavern solution ?

**Elodie ZAUSA, GEOSTOCK, Development & Sales Manager**



# Content

- 1- Introduction of Geostock
- 2- Role of $H_2$
- 3- What is the potential market ?
- 4- Different ways to store $H_2$
- 5- Why the LRC solution ?



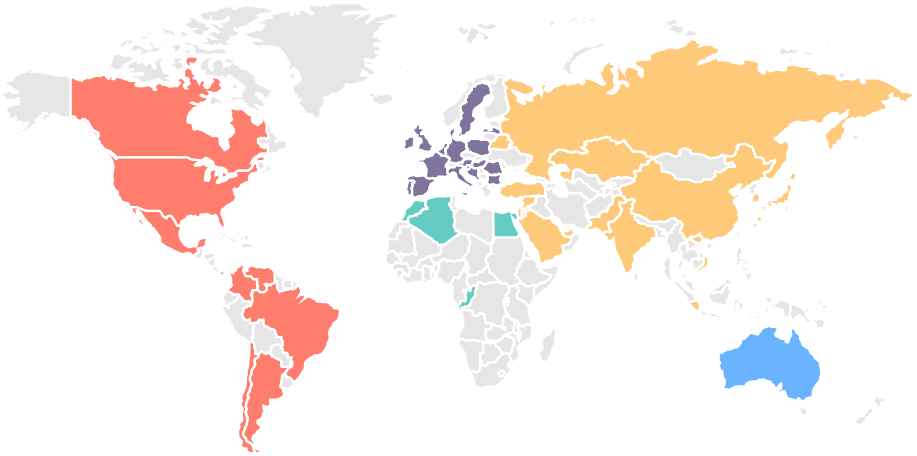
# 1- GEOSTOCK Introduction

# Geostock group organization

## A global presence

VINCI CONSTRUCTION | GRANDS PROJETS

Geostock



* **Geostock** owns minority shareholdings in underground storage assets operated by or in association with us.

**ASIA MIDDLE EAST**

| | |
|---|---|
| **SINGAPORE** GEOSTOCK ASIA | 100% |
| BANYAN CAVERN STORAGE SERVICES | 100% |
| **UEA** - BRANCH GEOSTOCK FUJAIRAH | 100% |
| GEOSTOCK ABU DHABI | 100% |
| **TURKEY** - BRANCH GEOSTOCK ANKARA | 100% |

**EUROPE**

| | |
|---|---|
| **FRANCE** GEOSTOCK | 100% |
| GEOMÉTHANE* | 1% CNP ASSURANCES 49% STORENGY 50% |
| **GERMANY** UGS | 60% |

**AMERICAS**

| | |
|---|---|
| **USA** GEOSTOCK SANDIA | 100% |
| **BRASIL** GEOSTOCK DO BRASIL | 100% |
| **MEXICO** GEOSTOCK MEXICO | 100% |
| GEOSTOCK OPERACIÓN | 100% |
| SHALAPA LPG STORAGE* | 5% CYDSA 95% |

# Our Fundamental Commitments (QHSE)

## Our SAFETY Objectives

**0** ***ZERO***
*Severe Accident*

**0** ***ZERO***
*HIPO 1 or 2*

## Certification

ISO 9001 (QMS),
14001 Environmental
& 45001 (OH&S MS)

## GEOSTOCK Green Storage Transformation Plan in 3 parts

1

### OUR COMMITMENT

reduce by 40% our direct $CO_2$ emissions in 2030

2

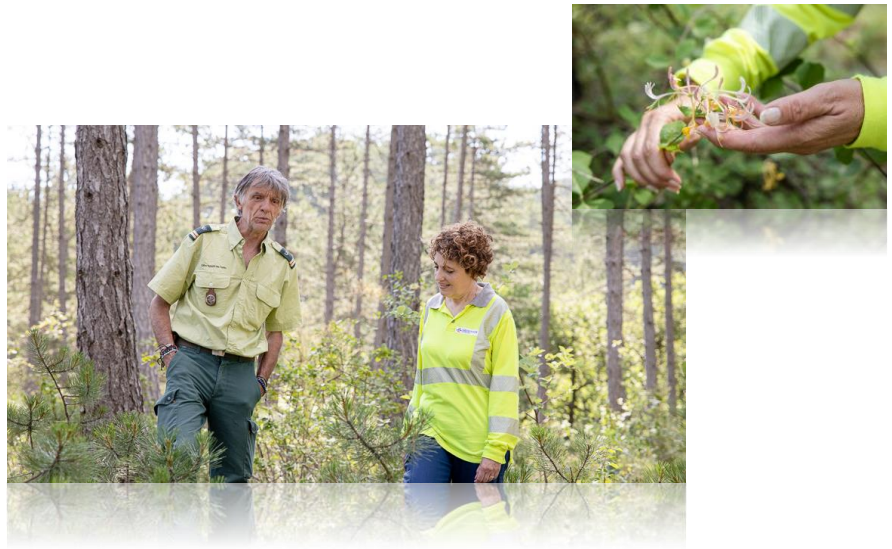
### SUSTAINABLE SOLUTIONS

Support our customers improving their Environmental Footprint

3

### NET-ZERO SOLUTIONS

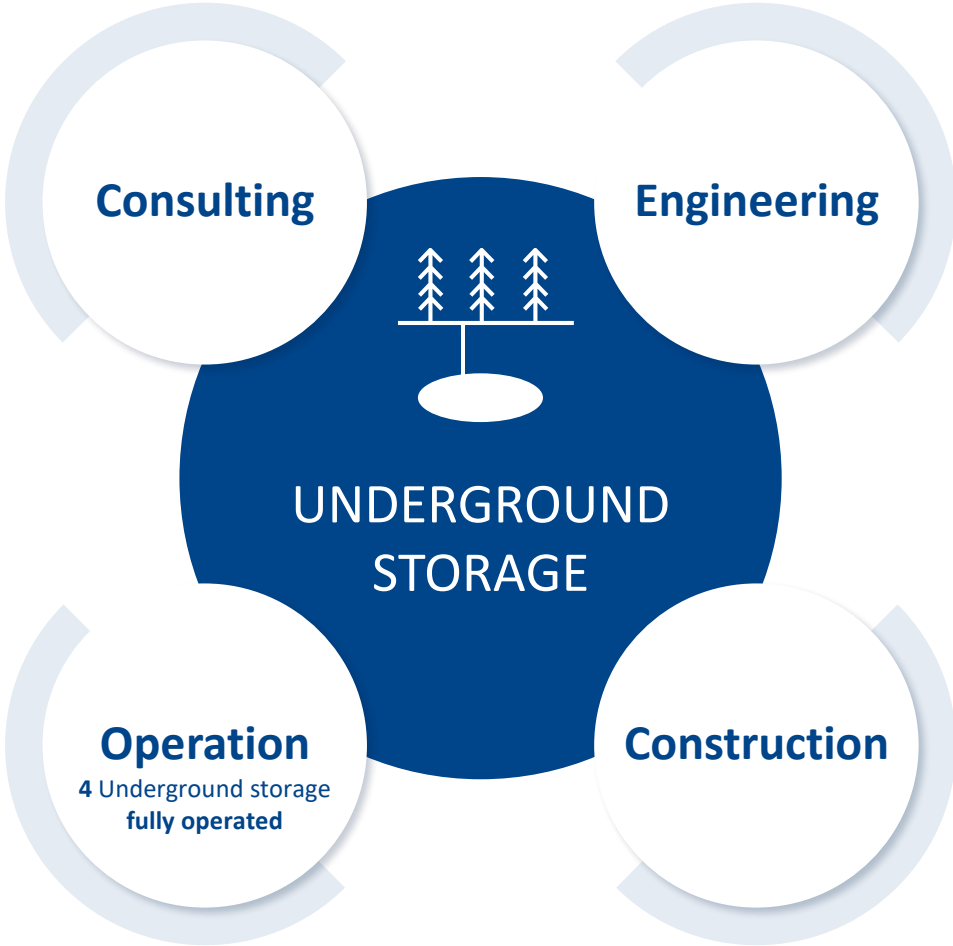
Promote Energy Transition through Decarbonized Energy Storage & CCUS



# Underground Storage Excellence

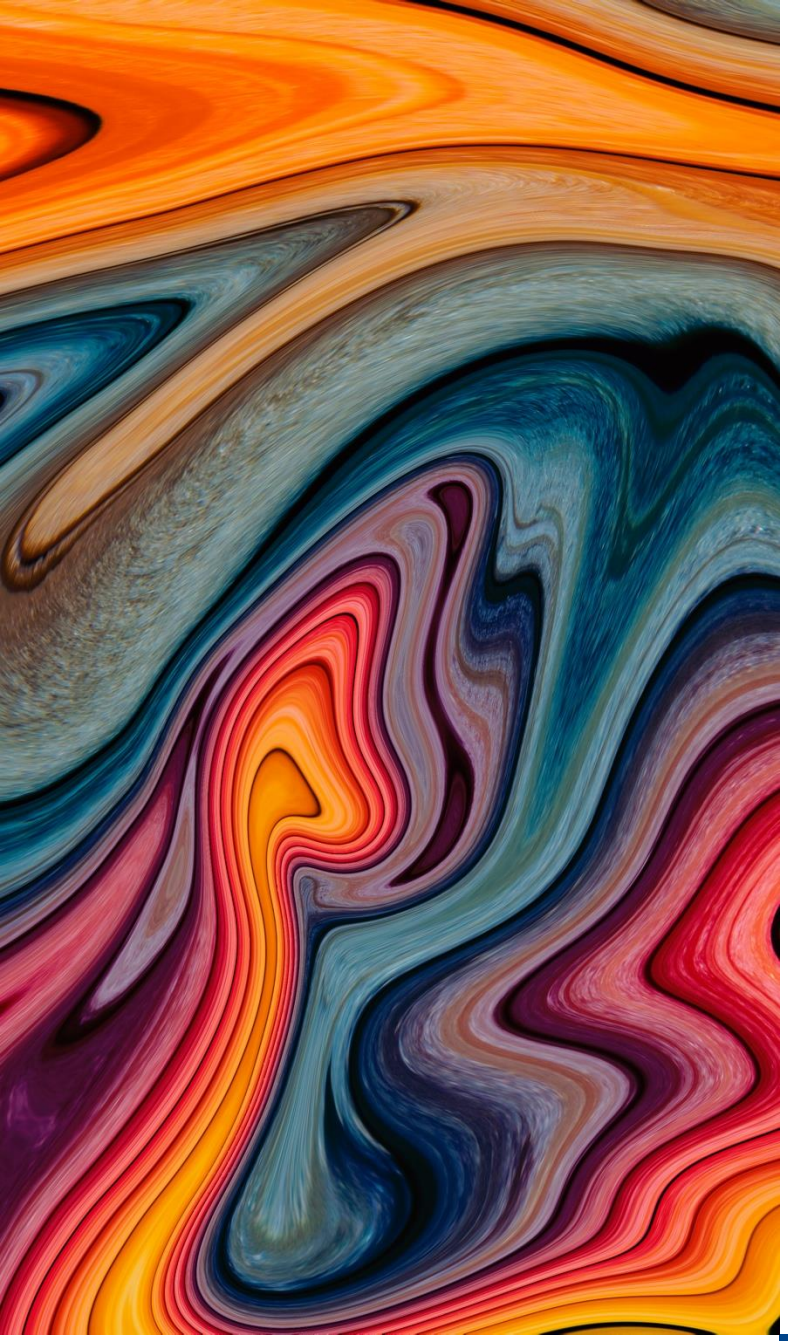
- An **international Group,** more than 55 years of experience, nearly 500 employees
- We do: **Consulting, Engineering, Construction management, Operation & Maintenance**
- On **all Underground Storage Techniques** (Porous reservoir, Salt & Mined rock caverns)
- **For all energies** (Liquid, Liquefied and Gaseous Hydrocarbons, $H_2$, $NH_3$, Compressed air and $CO_2$)

A **key player for Underground Storages** for all energies




**…BY RELYING**

on the synergies between our services

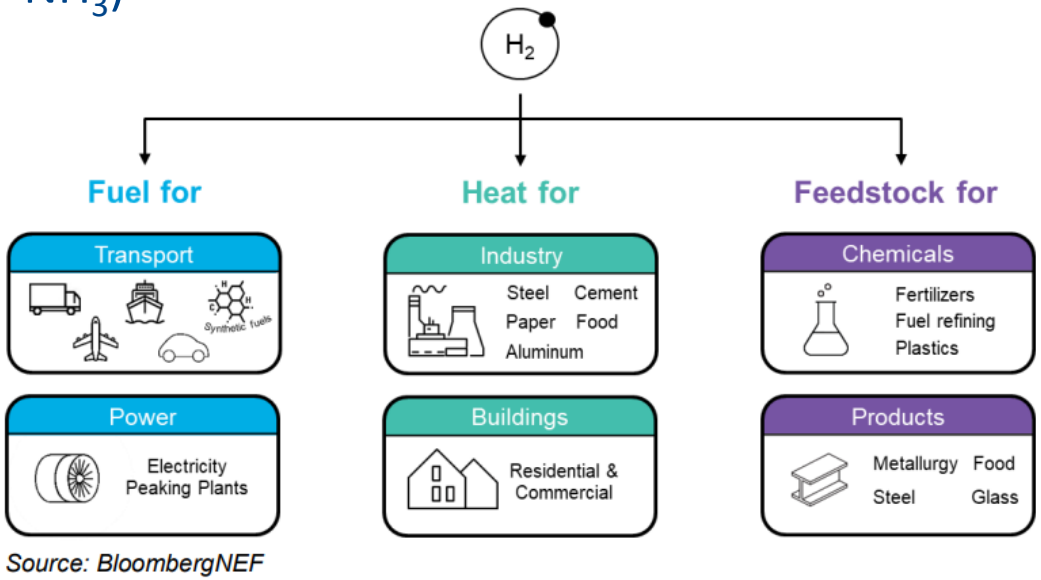


# 2- Role to be played by Hydrogen tomorrow

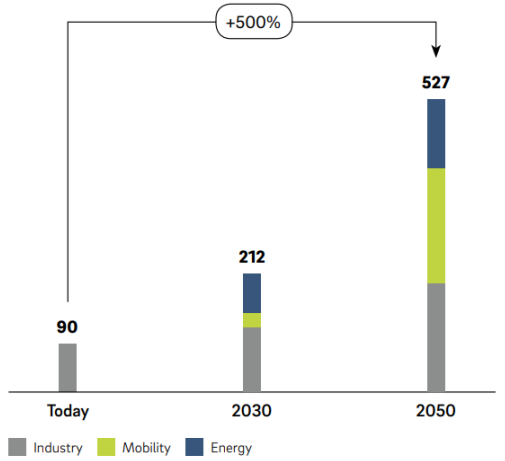
# Today,
# The uses of many sources of Energy



# Tomorrow,
# the many uses of $H_2$ (and its derivatives $NH_3$)




*Source: BloombergNEF*

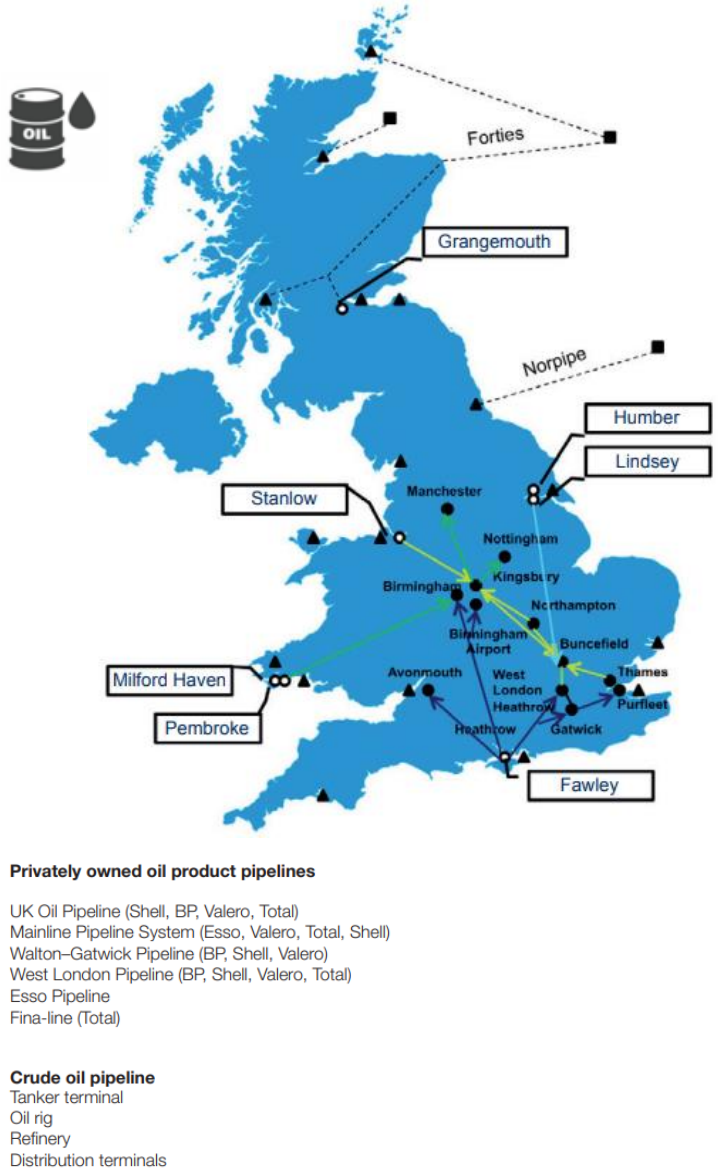


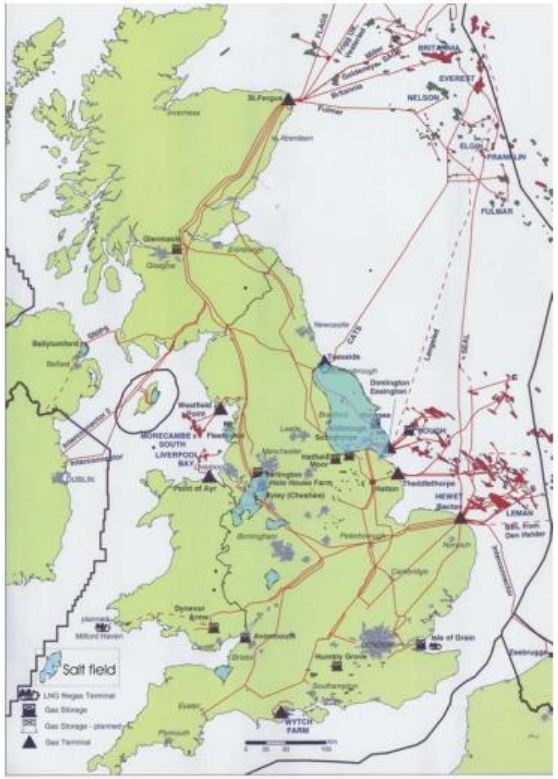

Source: IEA. Roland Berger

**$H_2$ consumption in the IEA's Net Zero Emission Scenario [Mt]**

Other solutions to support the net zero transition : biofuels, e-fuels, green electricity, etc.
⇒ Focus on $H_2$ in the presentation

# UK: Location of the current storages (Oil & Gas)



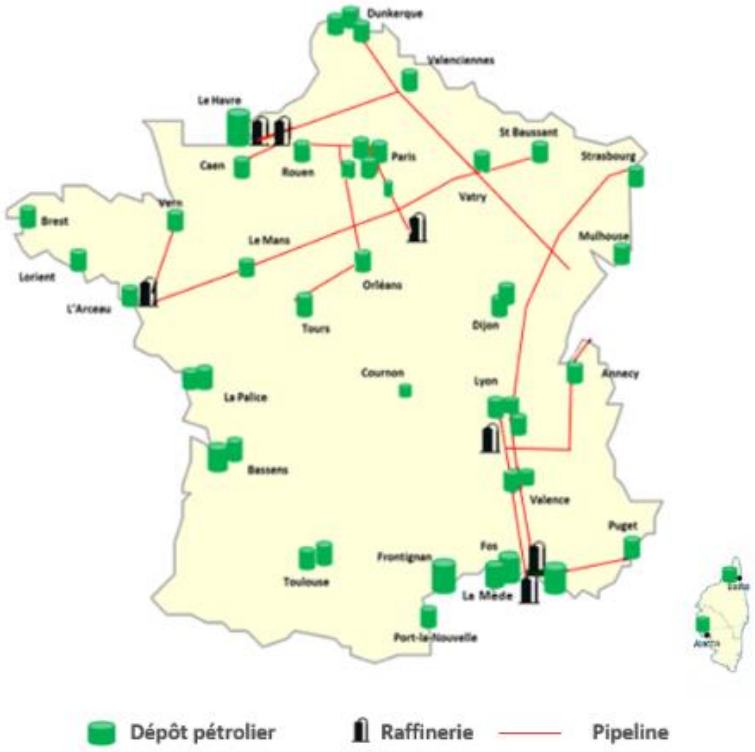

Underground storage

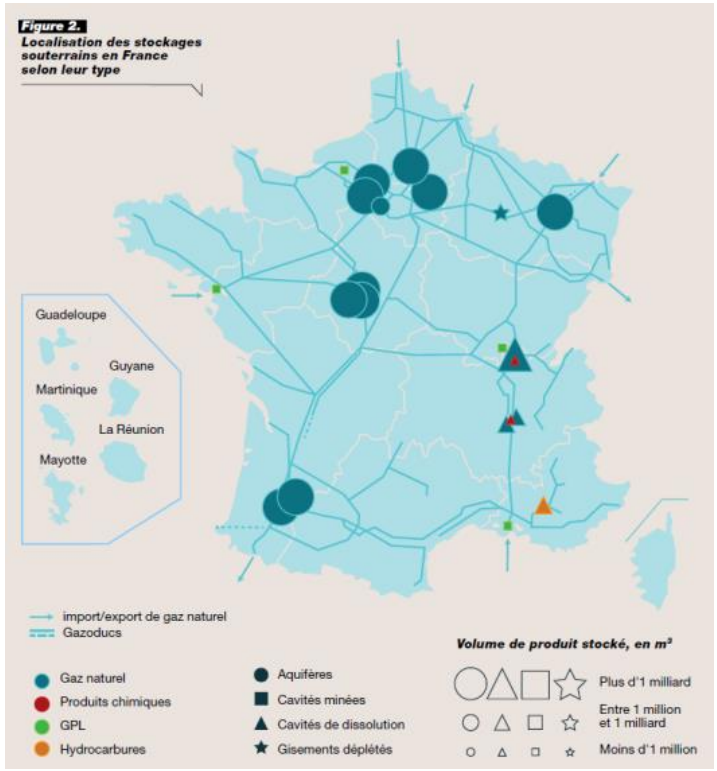
**TODAY**
Underground storage and above ground storage provide comprehensive national coverage

**TOMORROW** with $H_2$ ?

*Source: Deloitte based on UK PIA Statistical Review 2012 (p. 9) and Finding an unusual suspect (p. 34) by BP*

# Location of the current storages (Oil & Gas)



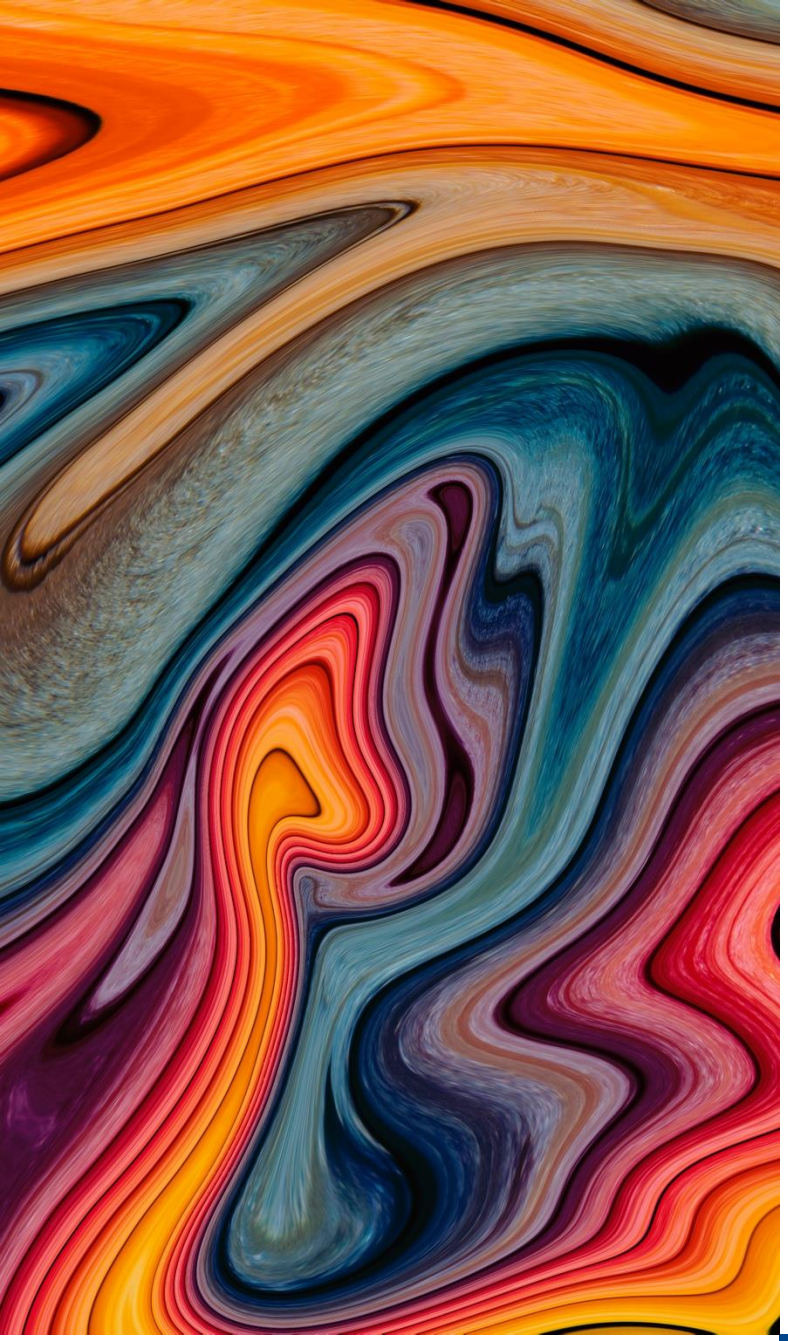




Above ground storage

Underground storage

**TODAY**
Underground storage and above ground storage provide comprehensive national coverage

**TOMORROW** with $H_2$ ?



# 3- Différents drivers for storage $H_2$ & $H_2$ market

# Differents drivers for hydrogen storage

| | |
|---|---|
| Robust supply chain | Continuity of supply in the event of failure/maintenance of $H_2$ production equipment – especially for sales to industries |
| Balance energy supply | To meet the daily & seasonal fluctuating needs (domestic - heating, industry, etc..) |
| Energy resilience | Strategic stocks to provide national energy security & resilience |
| Energy security | To balance $H_2$ produced with intermittent renewables<br>Vital in a world of ever-increasing EnR capcity |
| Power generation | Renewable electricity generation is intermittent. During low generation supplied maintain by CCGT with the use of H2 instead of NG |
| Arbitrage | Optimisation of production according to the cost and availability of electricity (erasure or resale surplus) |
| Efficiency of CCUS | With $H_2$ storage, CCUS enabled $H_2$ plants can operate at a constant high load capacity |

# Massive storage infrastructure will be needed to deliver $H_2$ at scale
# VISION by 2030

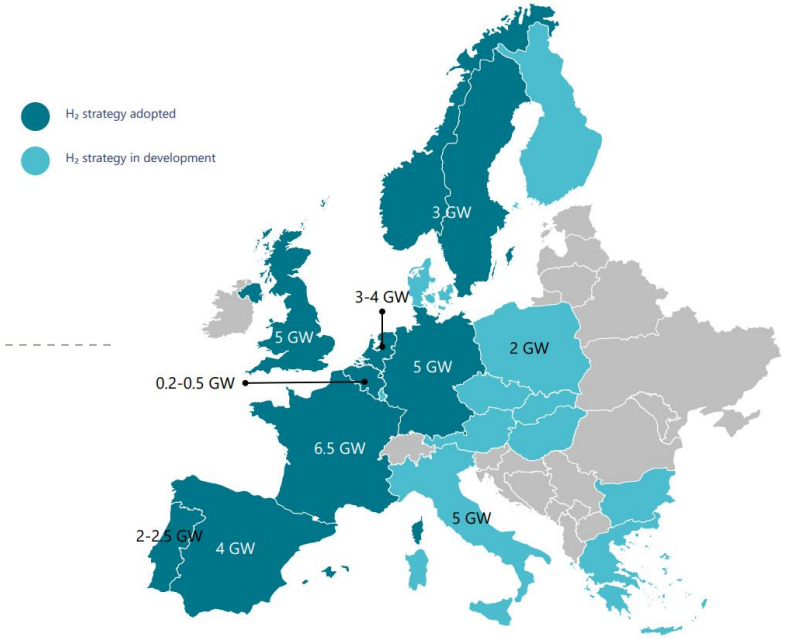
**Assumption : 5%** Storage Capacity

PRODUCTION CAPACITY
**10 GW** of Electrolysers
(British Energy Security Strategy, 2022)

STORAGE CAPACITY
**20** to **40** Caverns


PRODUCTION CAPACITY
**40 GW** of Electrolysers
(European Commission, 2020)

STORAGE CAPACITY
**125** to **250** Caverns

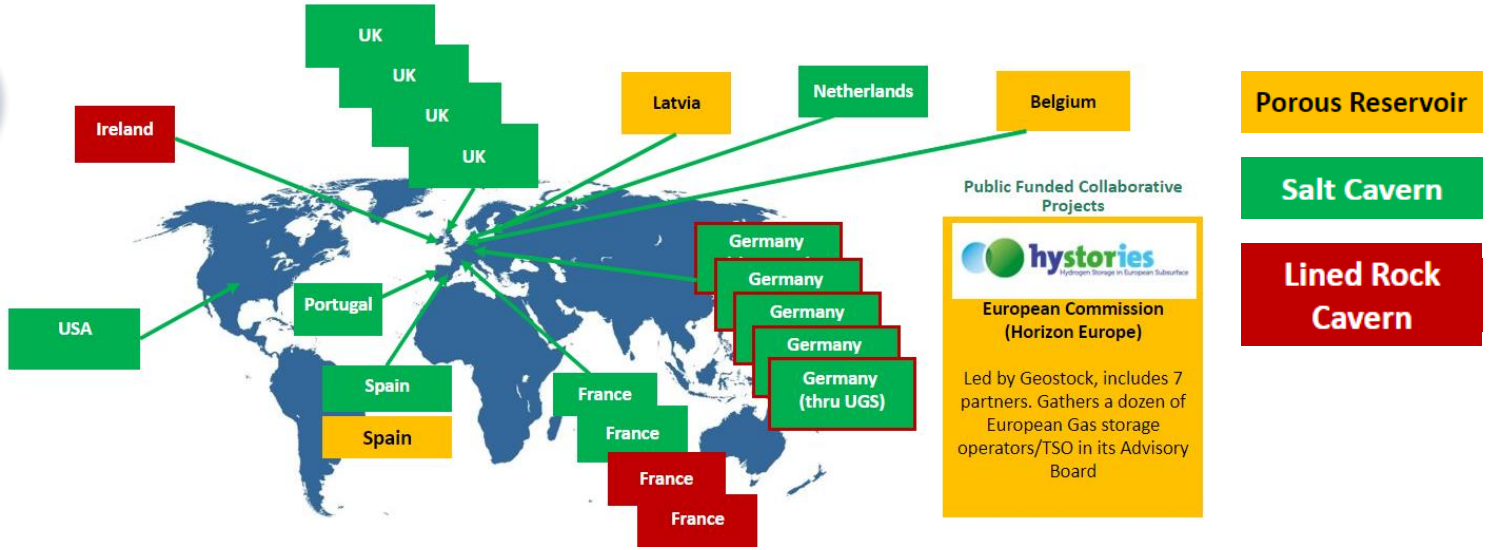



PRODUCTION CAPACITY
(Hydrogen Council, 2021)

STORAGE CAPACITY
**> 400** Caverns

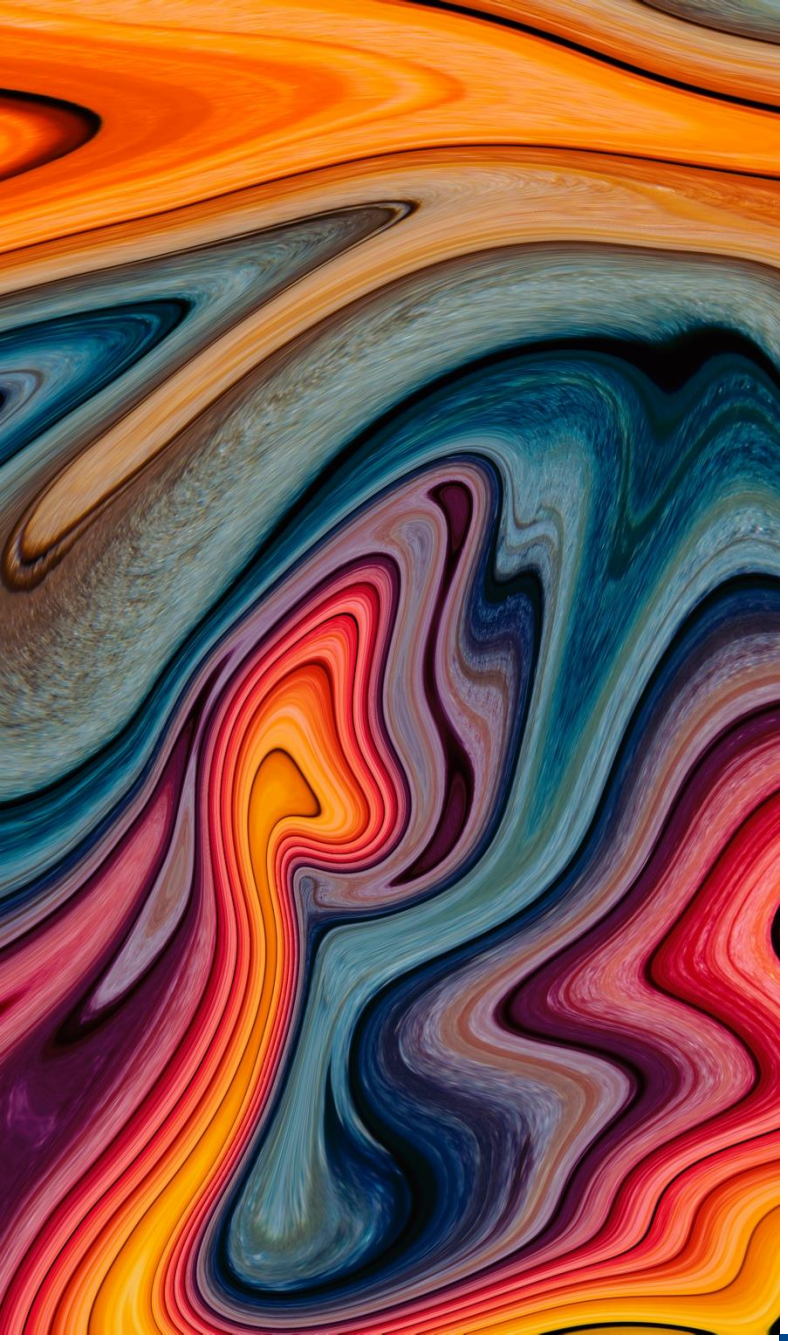
# Acceleration in demand for $H_2$ underground storage & CCS

**Hydrogen Contracts since 2020**



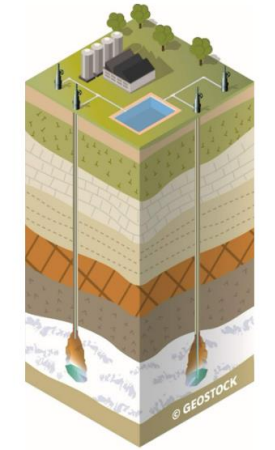

## Knowledge Management actions taken to develop NZS

- Liner for Lined Rock Cavern ($H_2$, $NH_3$, $CO_2$)
- $H_2$ impact on well casings/completions, microbio activity
- Surface Equipment (Compression, Hydrogen-methane separation, Hydrogen purification, etc.)
- Increase the number of people working for NZS (70% today)



# 4- Different ways to store massive quantities of $H_2$

# Solution 1: Salt cavern – Existing $H_2$ storage




**SALT CAVERNS**

- Liquid & Liquefied Hydrocarbons
- Natural Gas
- **HYDROGEN**
- Compressed Air & Effluents

MOST COMMON TECHNIC FOR **$H_2$ UNDERGROUND STORAGE**

- No Technical Show Stopper
- Nearly 2 000 existing storage Salt Caverns Worldwide
- 50 years industrial experience with up to 6 Hydrogen Caverns (incl. 3 in the UK)

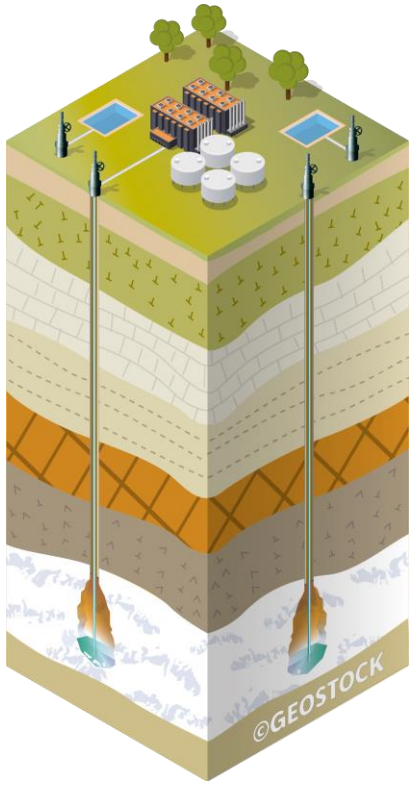
Participation in several **R&D projects for more than 10 years**: ROSTOCK H, STOPIL $H_2$…

2019-2023, GK has done numerous studies in:

- **Reconversion of existing underground** storage to $H_2$ or a mix $H_2/CH_4$ for asset owners (UK, France, Spain, Germany, Netherland, USA, UAE, Morroco…)
- **Creation of new caverns**

# Solution 1 – Salt Cavern: main characteristics, pros and cons

- Large volume, up to 1 000 000 m3
- Working gas up to 10 000t
- High flowrate
- Cost
- Conversion of existing salt cavern storage can be studied case by case




- Required geology not available everywhere
- Water for salt leaching
- Brine disposal
- Cushion gas (but potentially recoverable)

# Solution 2: Porous media for hydrogen storage


**DEPLETED FIELD & AQUIFERS**

- Natural Gas
- Compressed Air, $CO_2$
- **HYDROGEN**

**SOLUTION TO STORE MASSIVE VOLUME OF HYDROGENE**

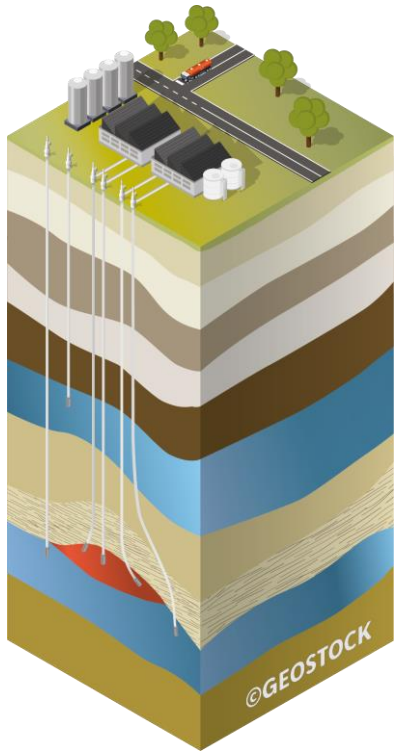
- Very common technique for Natural Gas storage
- Could be in depleted Oil/Gas fields or in saline aquifers
- Operated between 60 bar and 200 bar

Geostock is involved in the **HYSTORIES** (Project Leader).

Recently 2019-2023, numerous studies in **reconversion of existing underground** storage to mix $H_2/CH_4$ for asset owners (Belgium, Latvia, Spain, Germany, USA…) and new pure $H_2$ storage development feasibility assessments (microbiological activity)

# Solution 2 – Porous Media: main characteristics, pros and cons

- Very large volume, average 500 millions Sm3
- Working gas capacity around 45 000t
- Cost




- Required geology not available everywhere
- High cushion gas, not recoverable
- Integrity of product quality (microbioligical activity) to be checked on case by case basis

# Lined Rock Caverns for hydrogen storage

**LINED ROCK CAVERN**

- Natural Gas
- Liquid & Liquefied Hydrocarbons
- **HYDROGEN**

**UNDERGROUND STORAGE IN THE HEART OF THE INDUSTRIAL CLUSTER**

- More flexible from a geological point of view to be located in the heart of industrial clusters
- Agile, highly responsive and accurate

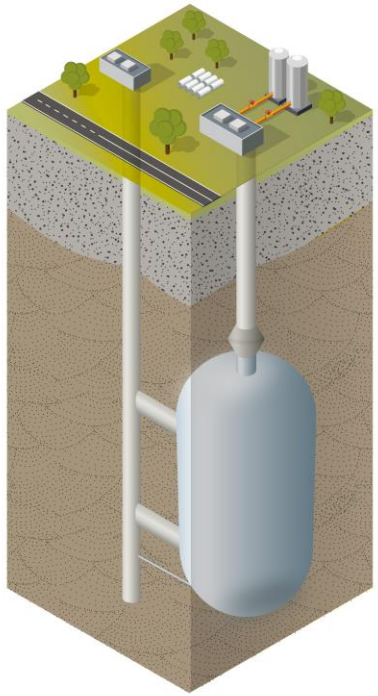
**A unique know how in Rock Cavern** : For more than 50 years, Geostock has been involved in 30% caverns commissioned or under construction, worldwide.

**Construction of a LRC pilote for LNG** : 2004-2006, in South Korea. Partnership between Geostock, Saipem and SKEC.

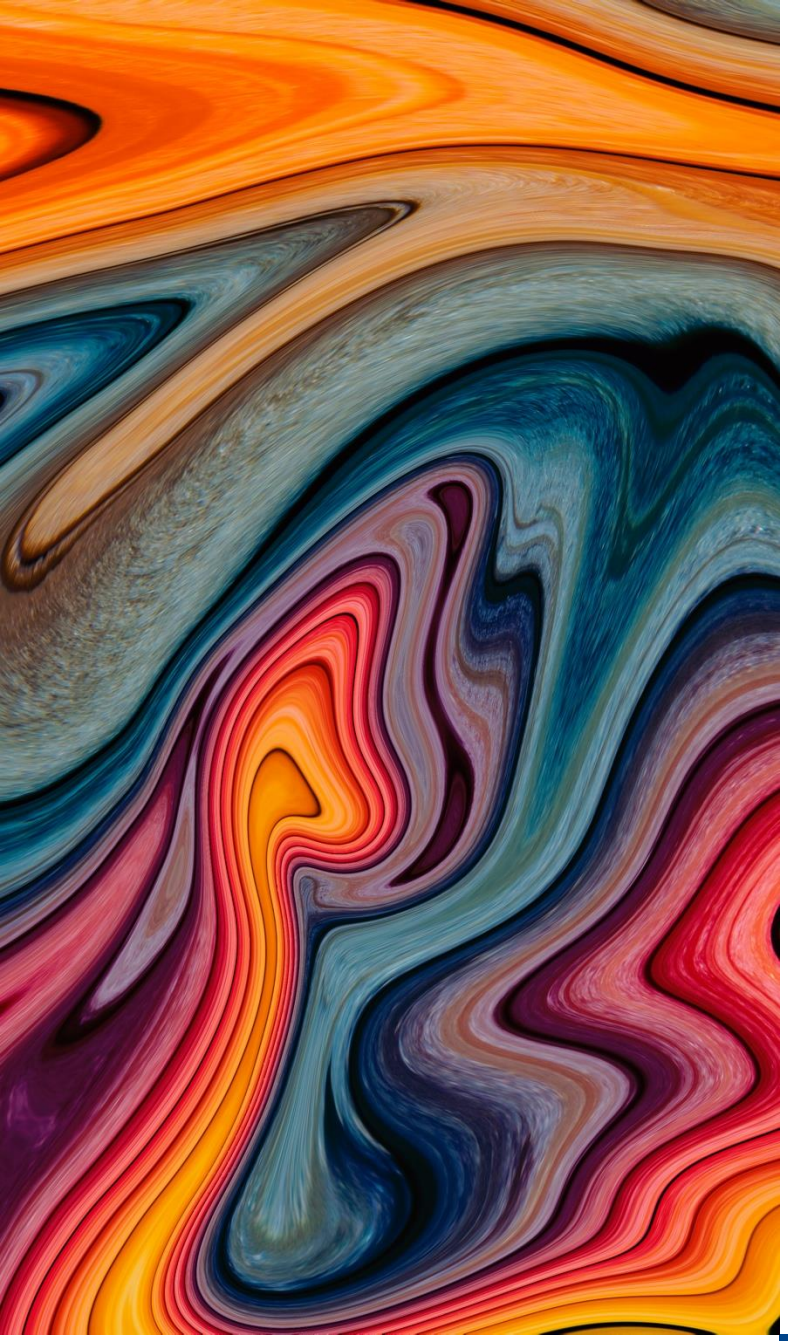
**Suitable technology for $NH_3$, $CO_2$**

# Solution 3 – Lined Rock Cavern: main characteristics, pro and cons

- Can be done almost everywhere
- High flowrate
- Flexible storage, possibility to import and export at the same time
- Low volume of cushion gas
- Suitable for $NH_3$, $CO_2$

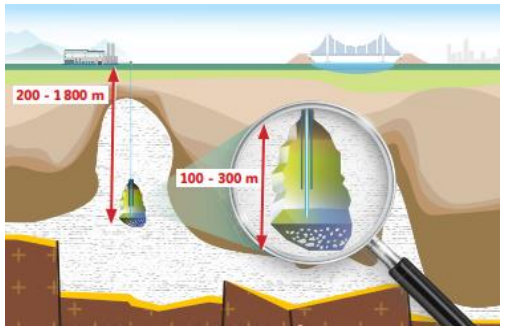


- Cost
- Liner choice to be optimised



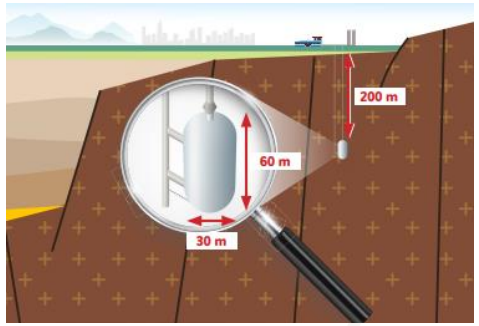
# 3- Why the LRC solution ?

# Why developping the Lined Mined Rock Cavern ?




**Low**
**Cost / m³**

**> 3 000 t**




**Medium**
**Cost / m³**

**500 – 2000 t**

- **Proximity needs**
  - Near industrial clusters ($H_2$ part of decarbonation solutions)
  - Near ports (**import** / export)
  - Near airports (Ex. Roissy CdG : 15% of the air traffic by 2035 = 3 to 5000 t $H_2$
  - Near wind / solar farms & power generation

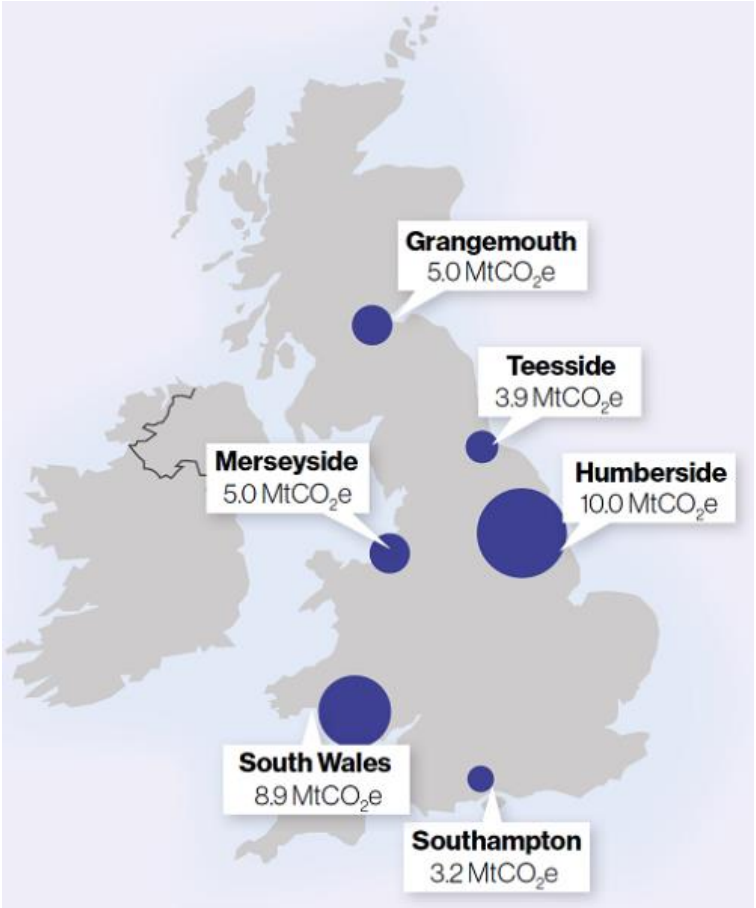
- **Buffer** for other products : $NH_3$ & $CO_2$

**SALT is not everywhere**

# Few examples - UK

## Location of industrial clusters

LRC Potential

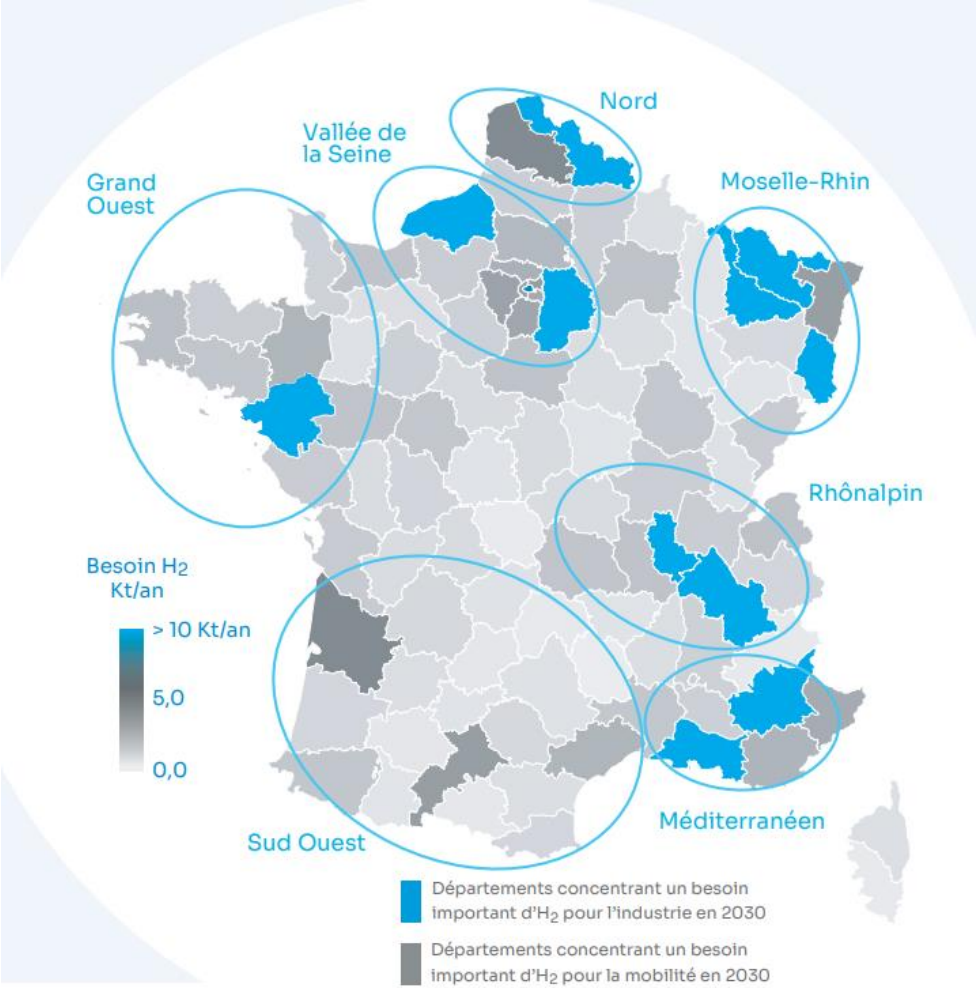




Studies

Prospects

# Few examples - France
## Location of industrial clusters

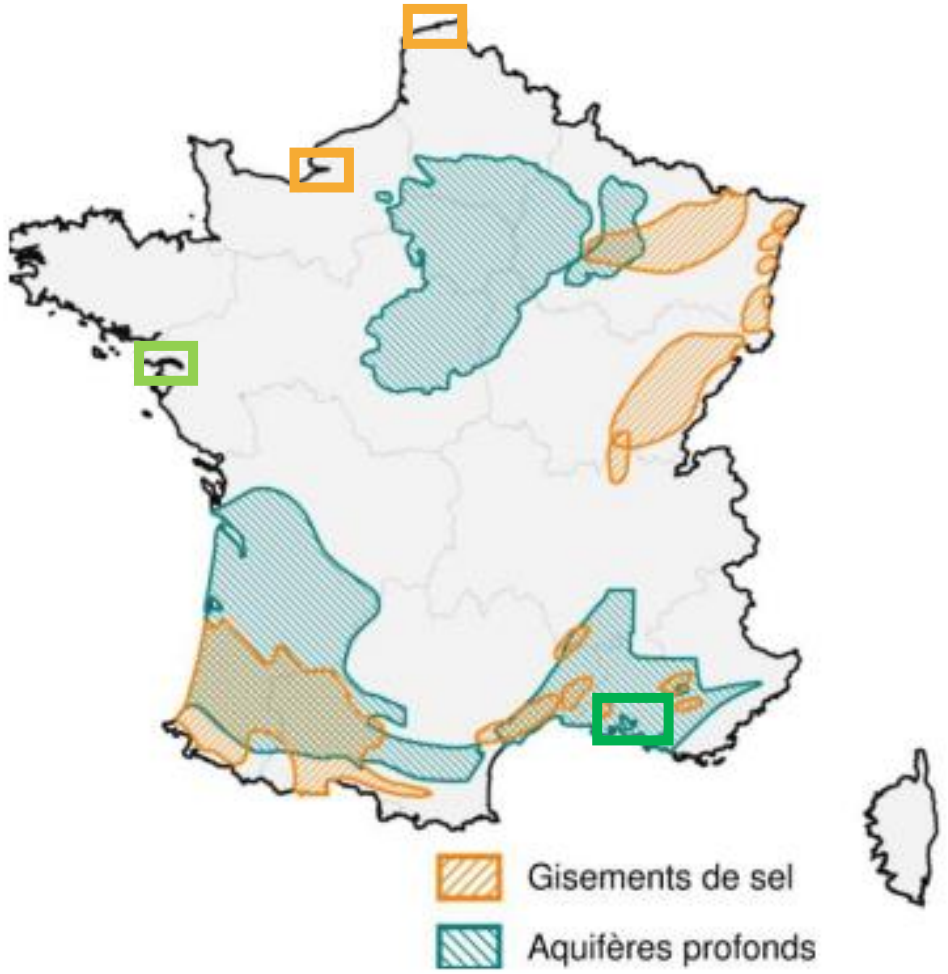



Project : **GEOGAZ $H_2$**
800 T $H_2$ - 100 bars
**Commissionning 2028**

Study :
Storage repurposing
Capacity 80 000 $m^3$
Products : $H_2$g, $NH_3$, $CO_2$

**LRC Potential**

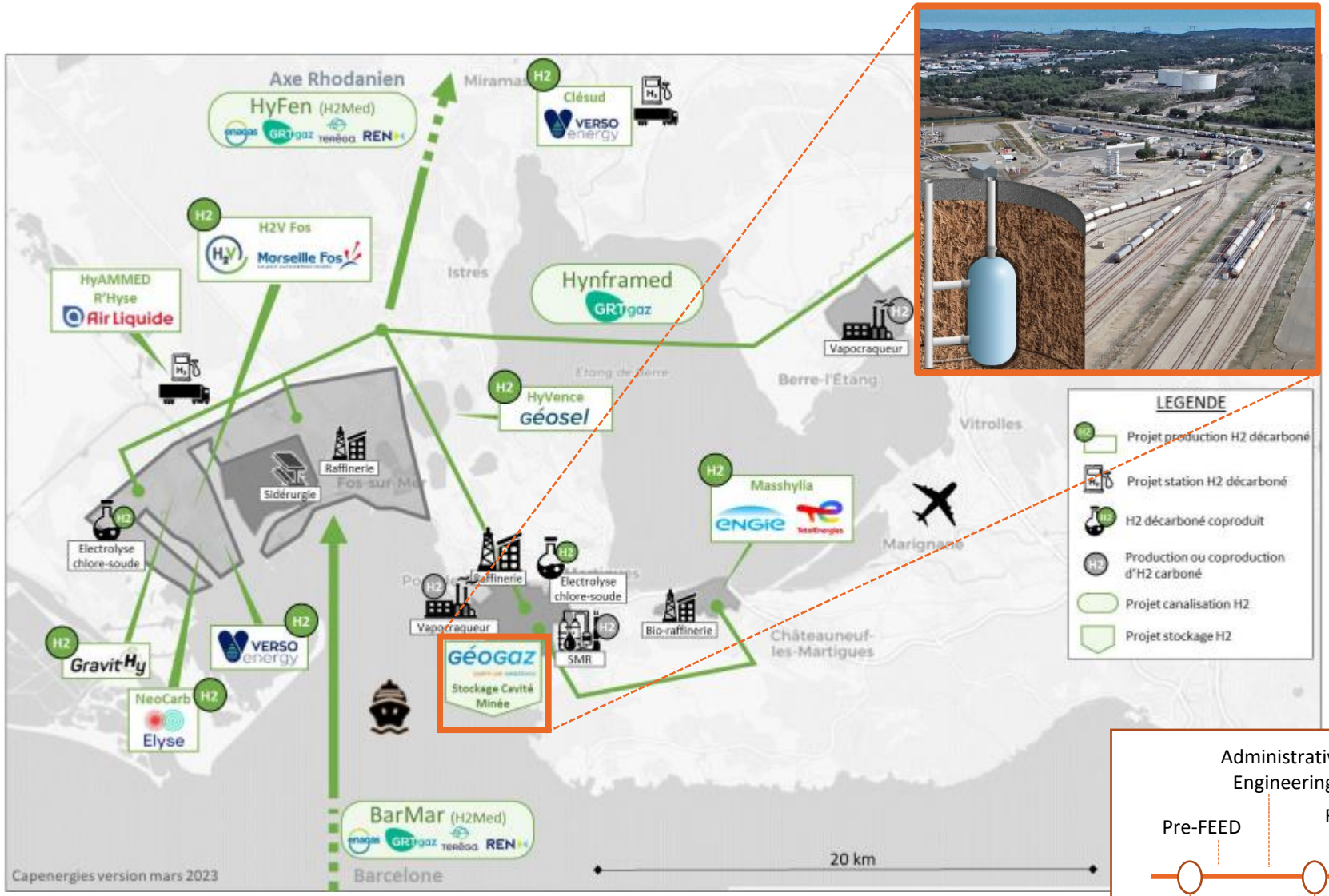
Prospects **Dunkerque** & **Normandie**



# FOCUS on Marseille-Fos H2 Cluster

## GEOGAZ Lavéra Project - $H_2$ STORAGE

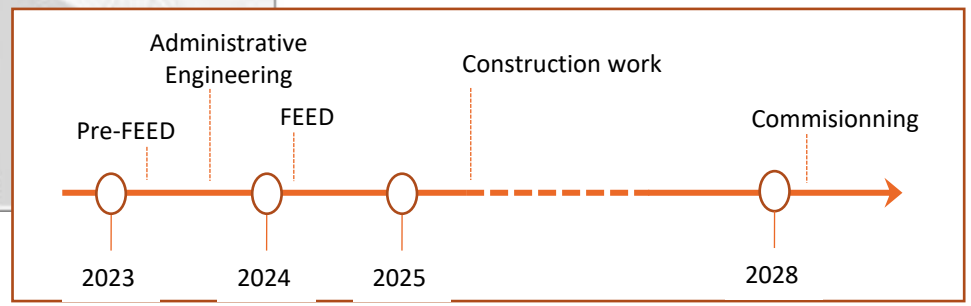
From 400t to 800t of gaseous $H_2$






## Why storing Hydrogen at Geogaz Lavera?

- 3 existing mined rock caverns (SEVESO site): biggest multi-modal storage site for LPG in France
- Storage shared by the main local petro-chemical actors, with pipelines connection
- Loading bays for trucks and railcar & connected to the GPMM: import & export



# Take away message

- As an order of magnitude → between **200 and 400 medium size underground storage might be needed by 2030-2035** to store hydrogen worldwide.
- **Salt Cavern are a proven technology commercially available today**
- **Lined mined rock caverns is a** solution to be considered for **massive storage of hydrogen where there is no salt**.
- Porous rock reservoirs is getting ready for commercialisation as well (Demonstrators may be required)

# Thank you

Geostock

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