Capacity estimation of the European porous media traps

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Geostock

hystories
Hydrogen Storage in European Subsurface

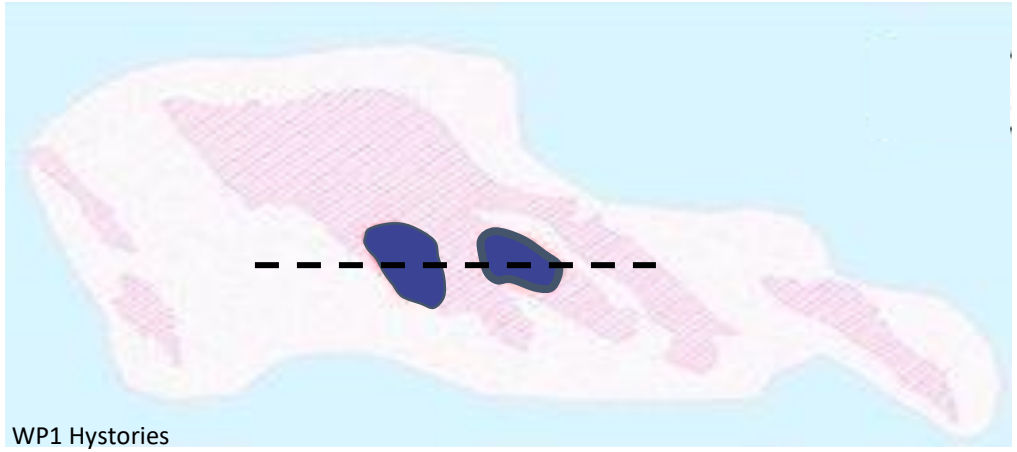
Acknowledgment

The Project Is co-founded by European Union

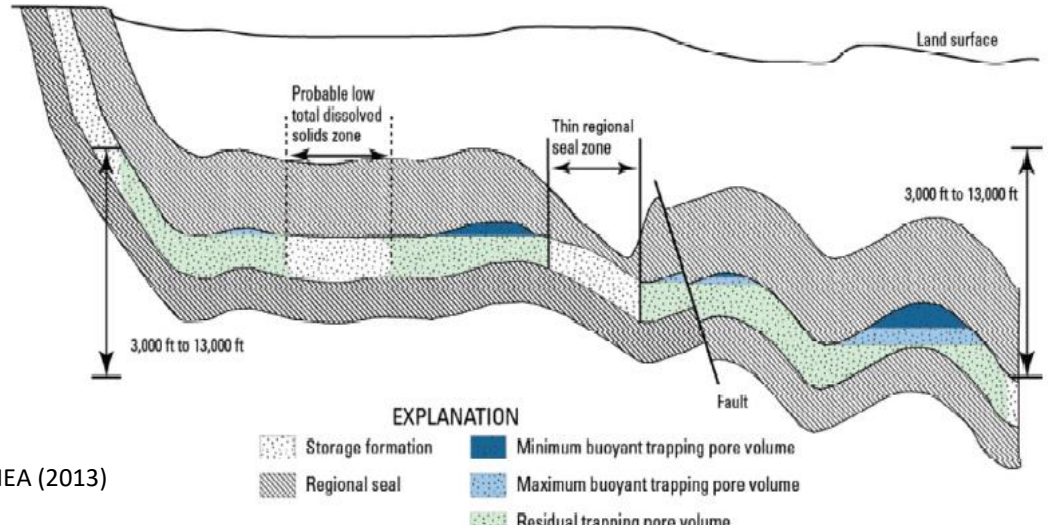
Clean Hydrogen Partnership

Hierarchy of information and focus of the work

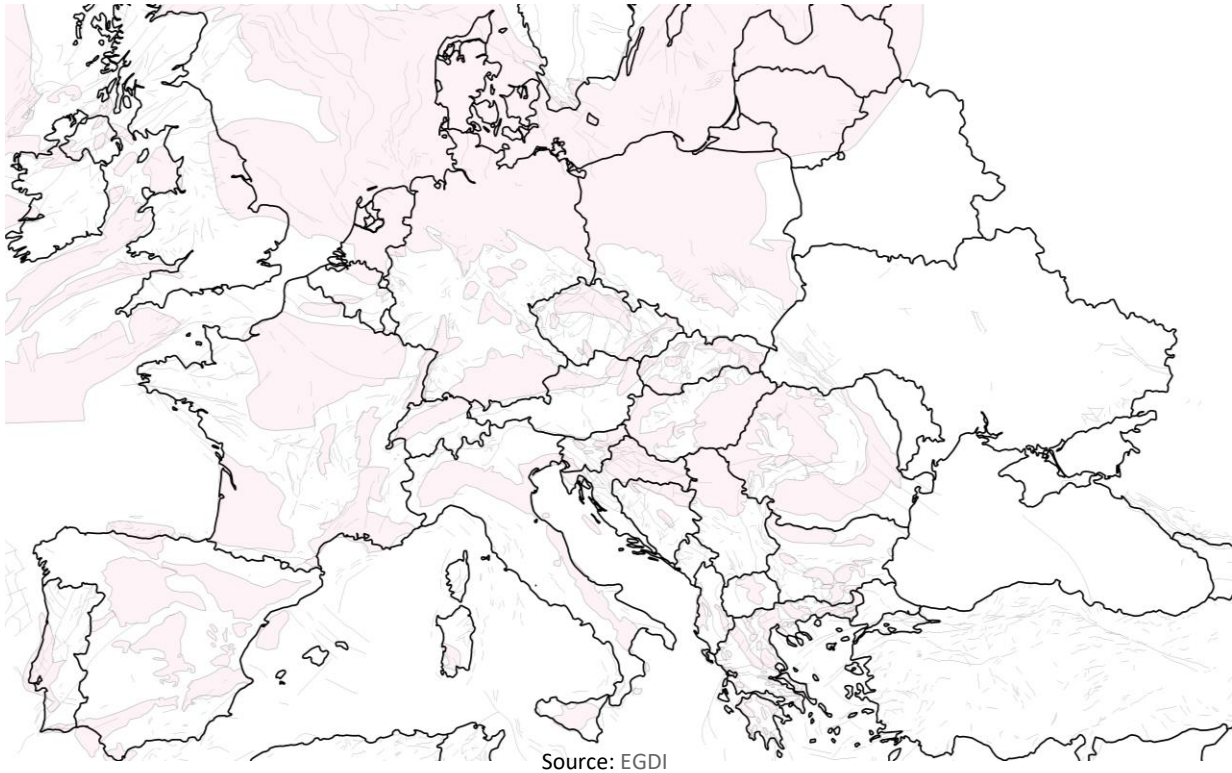
Porous and permeable **structures** for lateral containment
Overlaying **impermeable cap-rock** for vertical containment



WP1 Hystories

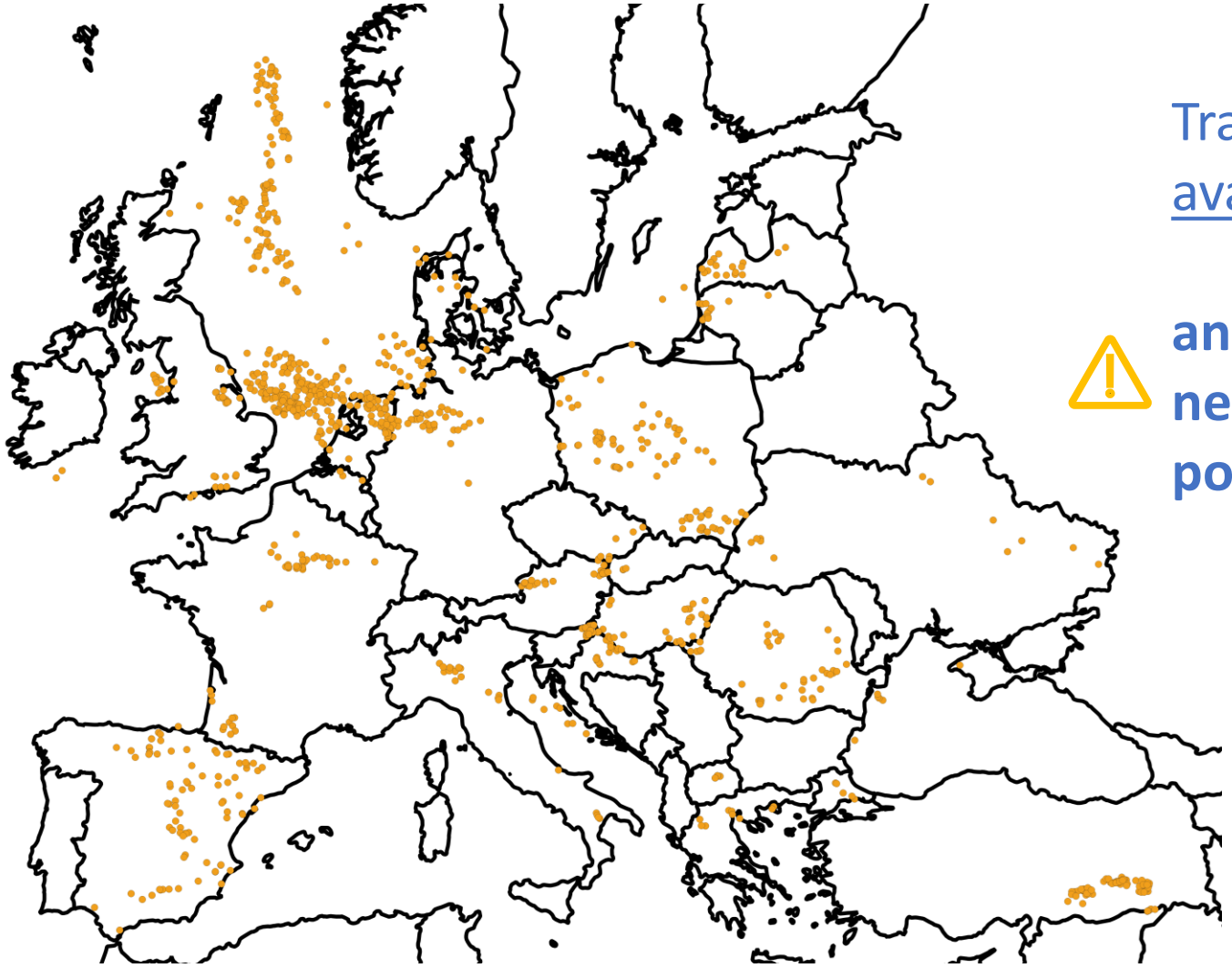


IEA (2013)



Source: EGDI

Results of data collection for traps



Identified storage traps in the Hystories database that may be suitable for hydrogen storage

Traps identified in WP1 from **publicly** available data

⚠ **an absence of identified traps does not necessarily indicate an absence of storage potential**

Storage options in porous media

- **Underground Gas Storages**: conversion to hydrogen storage, potentially readily available
- **Depleted Oil & Gas Fields**: potentially interesting in some countries
- **Deep Saline Formations**: potentially large and available in most countries but generally poorly characterized

Different issues

Technical

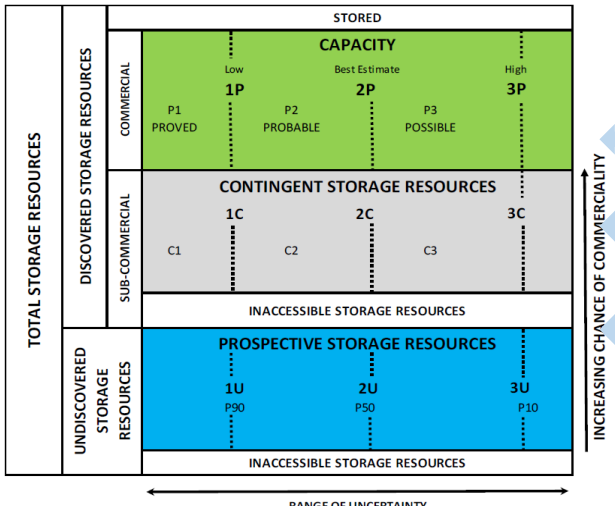
Hydrogen physical behavior in reservoir (fingering, diffusion, mixing) and quality

Cap-rock tightness

Reactivity with indigenous rock minerals and fluids

Well integrity (cement, material, equipment) and deliverability

Maturity

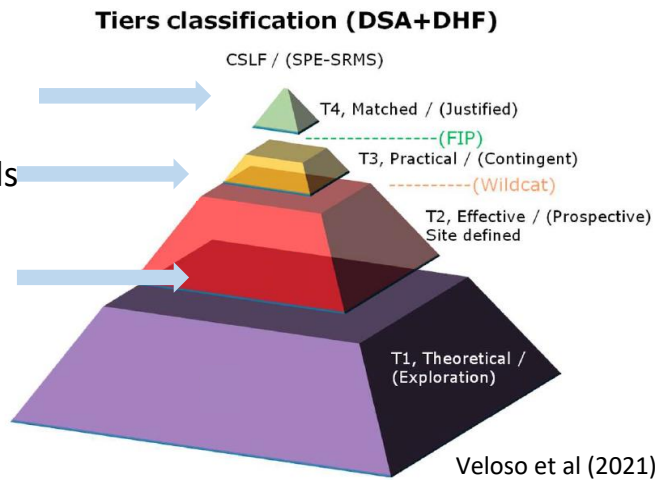


SPE (2018)

Underground Gas Storage

Depleted Hydrocarbon Fields

Deep Saline Formations



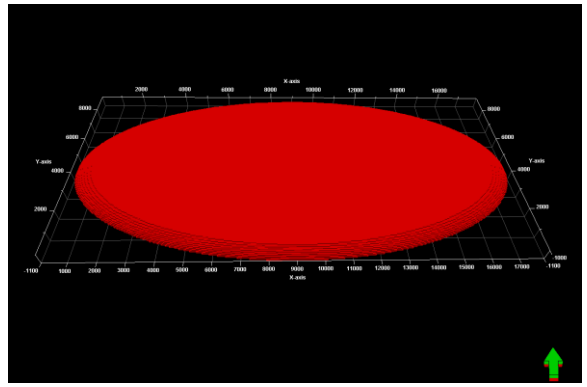
Veloso et al (2021)

Methodology for capacity assessment

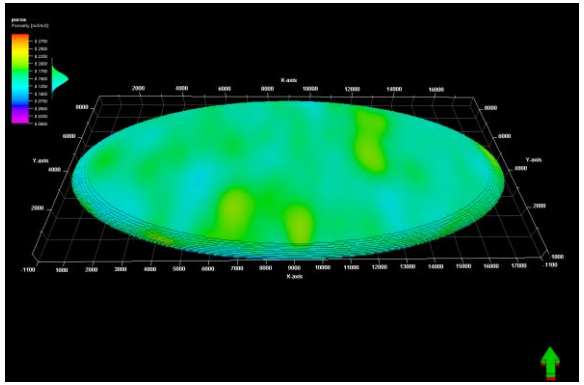
Synthetic modeling approach for **each traps** based upon publicly available data at the European Scale

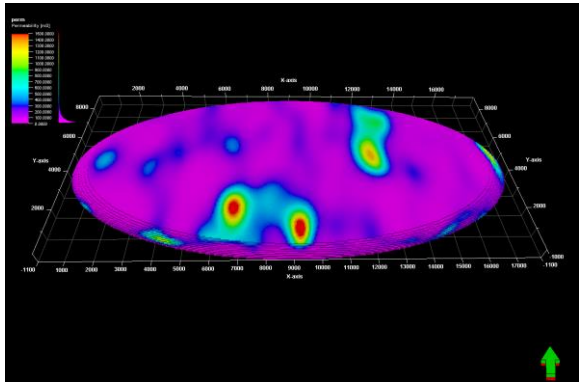
Minimal trap dataset: area, depth, thickness, porosity
805 out of +1150 traps identified from publicly available data

Simplified structural model



Simplified petrophysical model
from available database information to compute the **pore volume** V_p





Volumetric storage capacity

From the porous volume $V_p = A * GT * NtG * \emptyset$

It is possible to derive the hydrogen storage capacity

$$V_{H_2} = V_p * E_{H_2} / B_{H_2}(P,T)$$

Where :

$B_{H_2}(P,T)$ is the hydrogen volume factor which accounts for density evolution with depth

E_{H_2} is the hydrogen storage efficiency factor computed :

- Depleted hydrocarbon fields based upon gas/oil recovery factor
- Underground Gas Storages based upon working gas
- Deep Saline Formations based upon CO_2 storage efficiency analytical model

Storage efficiency for Deep Saline Formations

Neglecting solubility trapping : H_2 dissolution ~ CH_4 dissolution << CO_2 dissolution

$$E = 2(1 - S_{wc})M\frac{\Gamma^2}{\Gamma^2 + (2 - \Gamma)\left(1 - M(1 - \Gamma)\right)}$$

Juanes et al (2010)

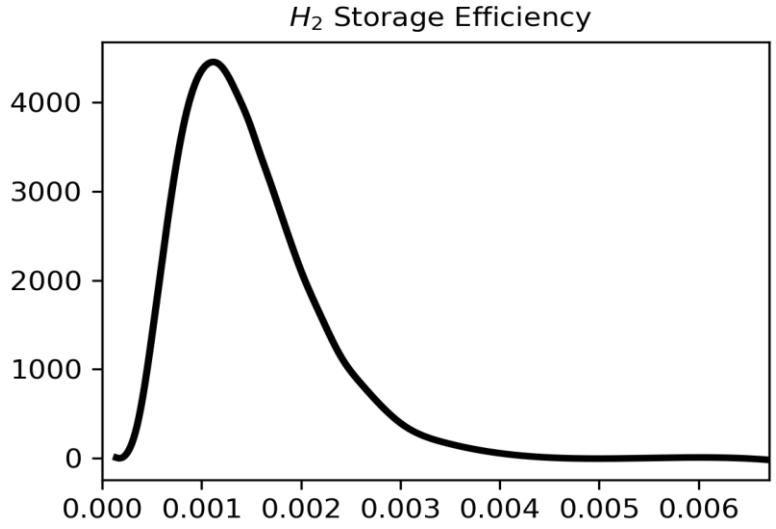
Capillary trapping coefficient

$$\Gamma = \frac{S_{gr}}{1 - S_{wc}}$$

Mobility ratio

$$\mathrm{M} = \frac{1/\mu_w}{K_{rg}/\boldsymbol{\mu_g}}$$

Gas viscosity obtained from tabulated H_2 PVT (NIST) [7-450bar/40-150°C]
Water viscosity obtained from correlation (Batzle & Wang , 1992)



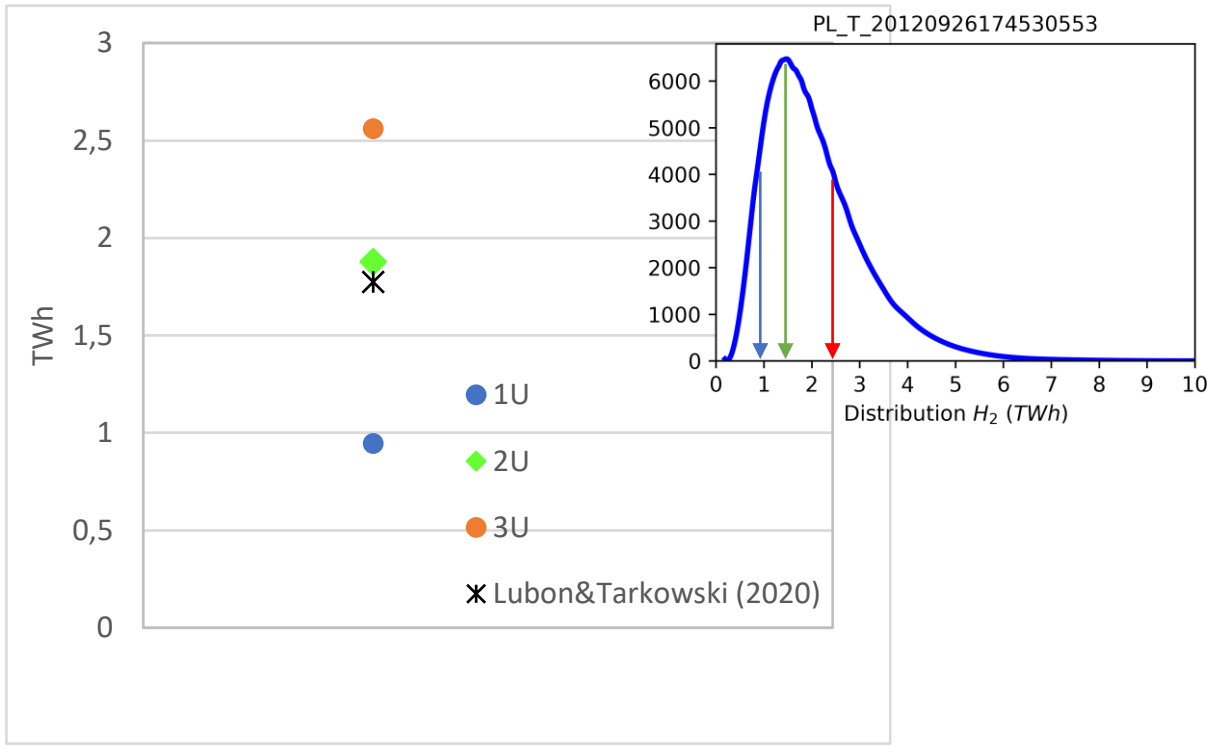
H_2 Storage Efficiency ~ 1/30th CO_2 Storage Efficiency

CO_2 in saline formation: 0.5% - 2% - 5.5%
US DOE (2015)

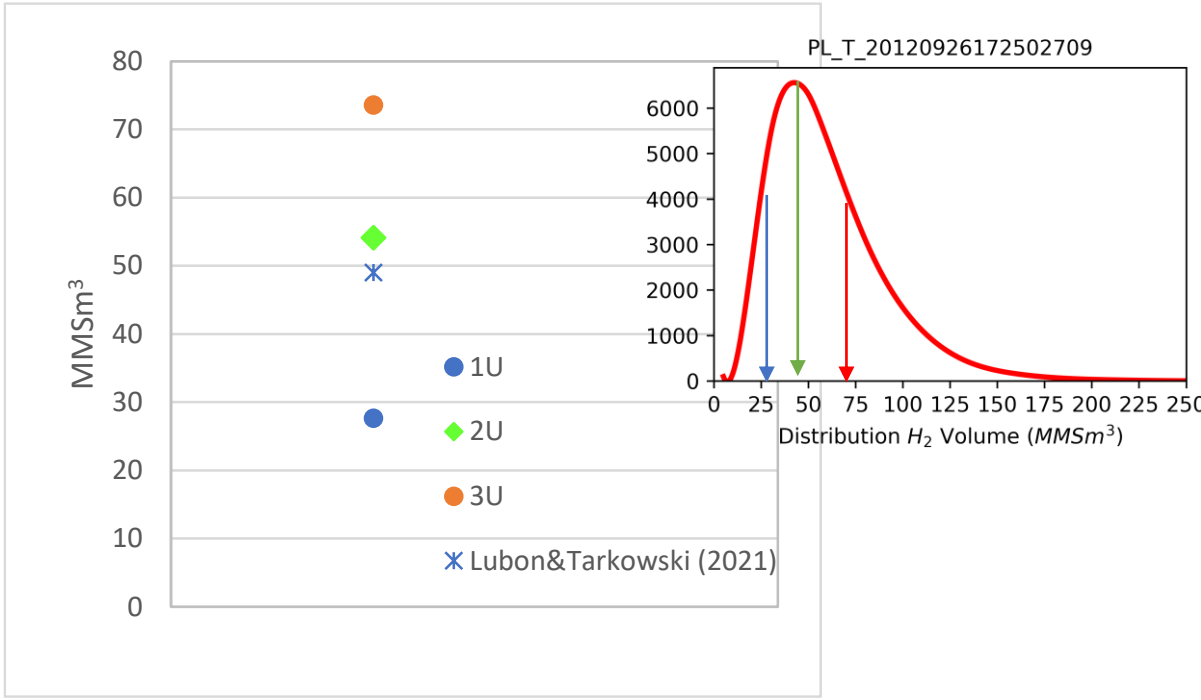
Deep Saline Formations capacities on published cases

Comparison of **volumetric** storage capacities with published **dynamic** storage capacities

~6% w.r.t. mean estimate (2U)

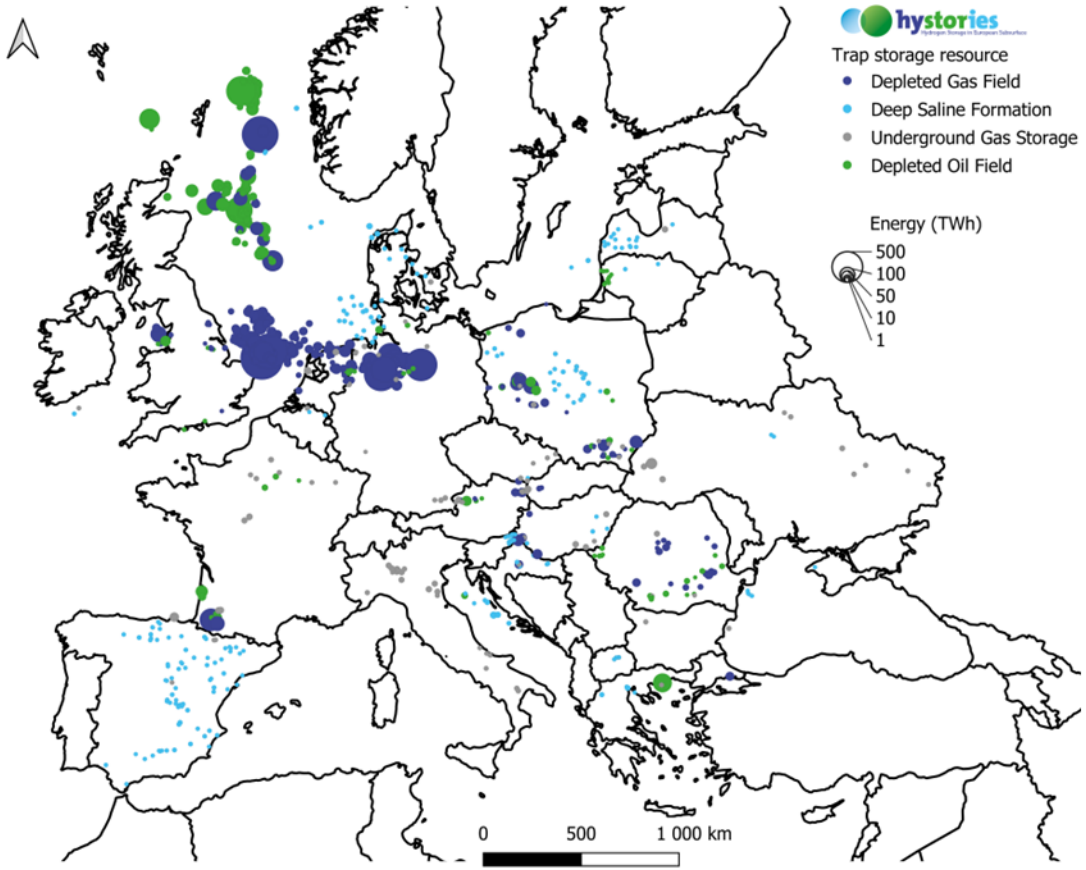


~2% w.r.t. mean estimate (2U)

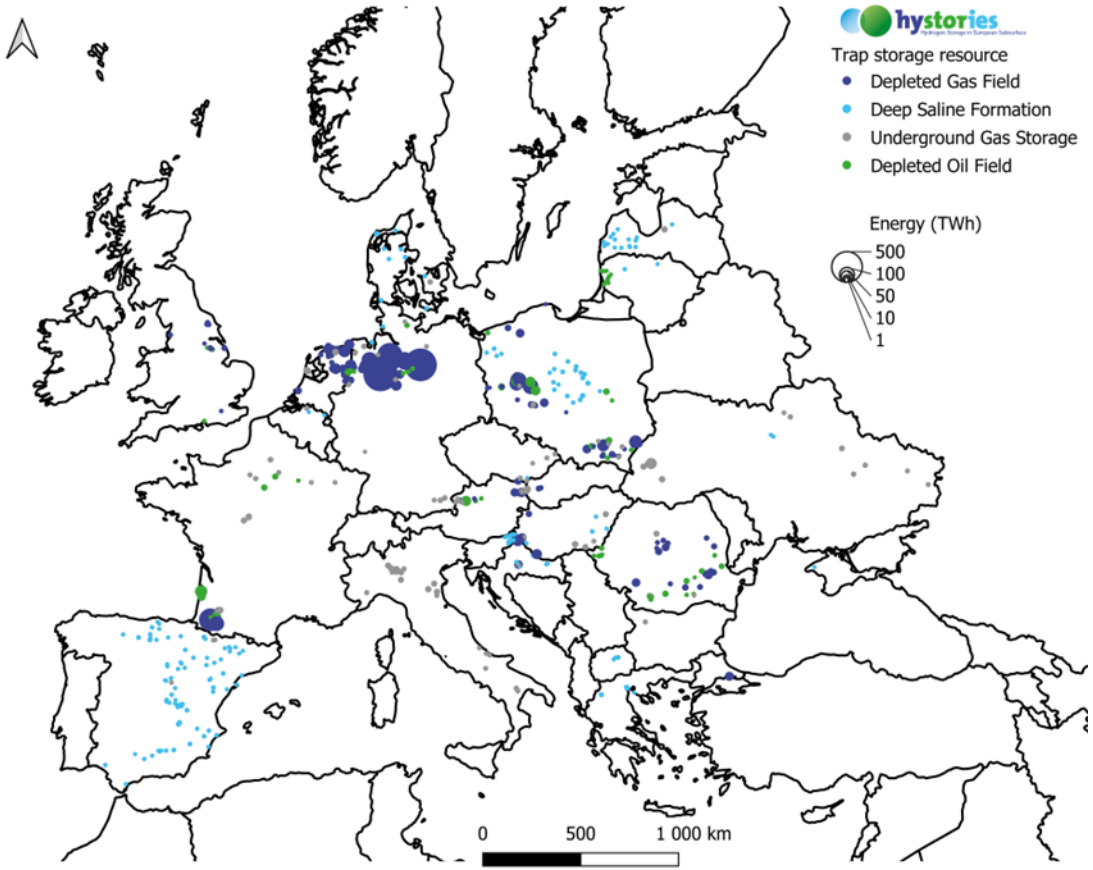


Heating Value: 3 KWh/Nm³

Traps volumetric capacities



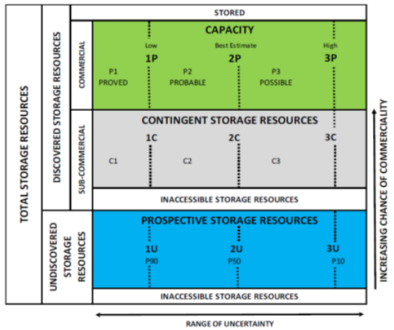
Onshore + Offshore

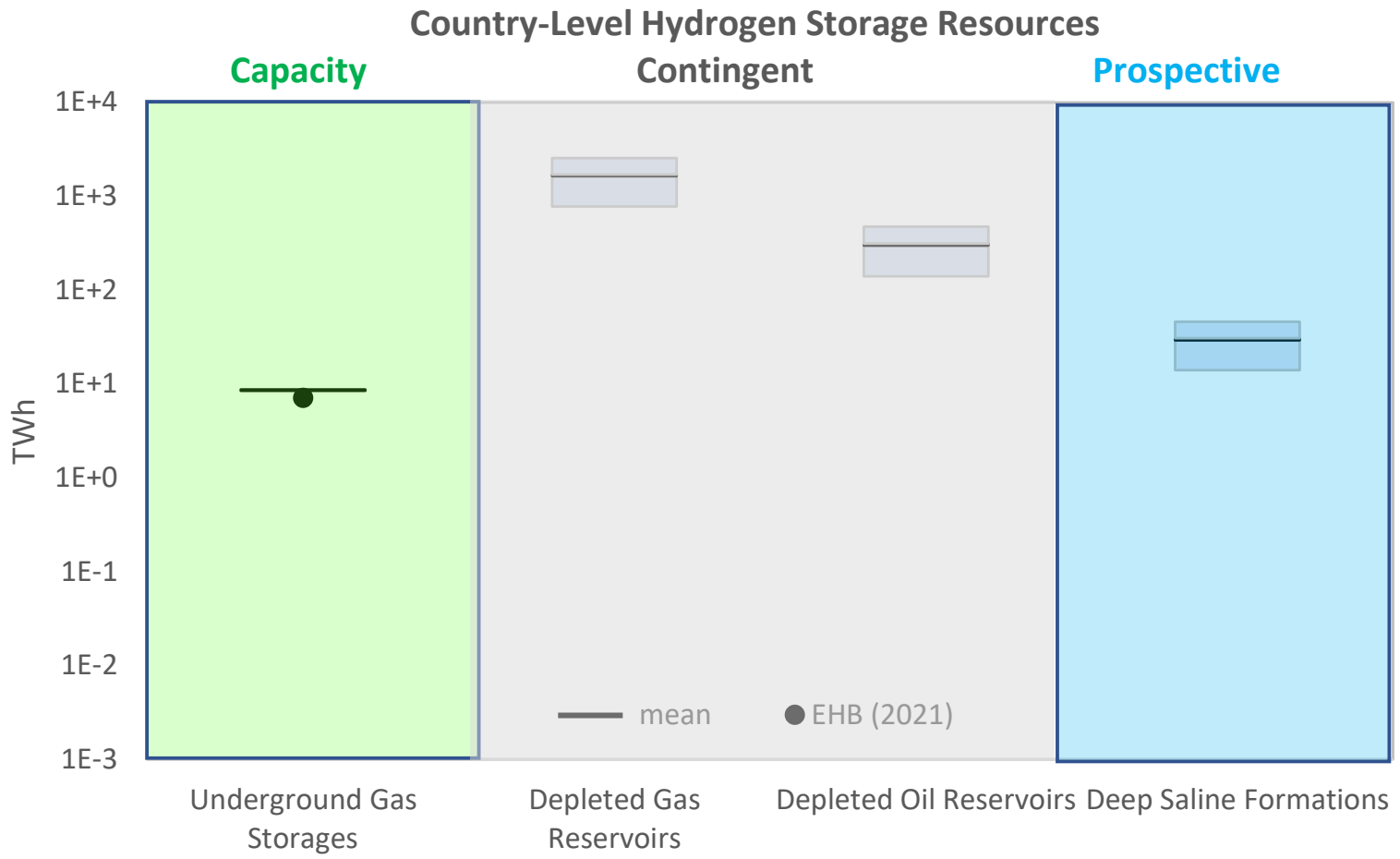


Onshore

Country storage resources

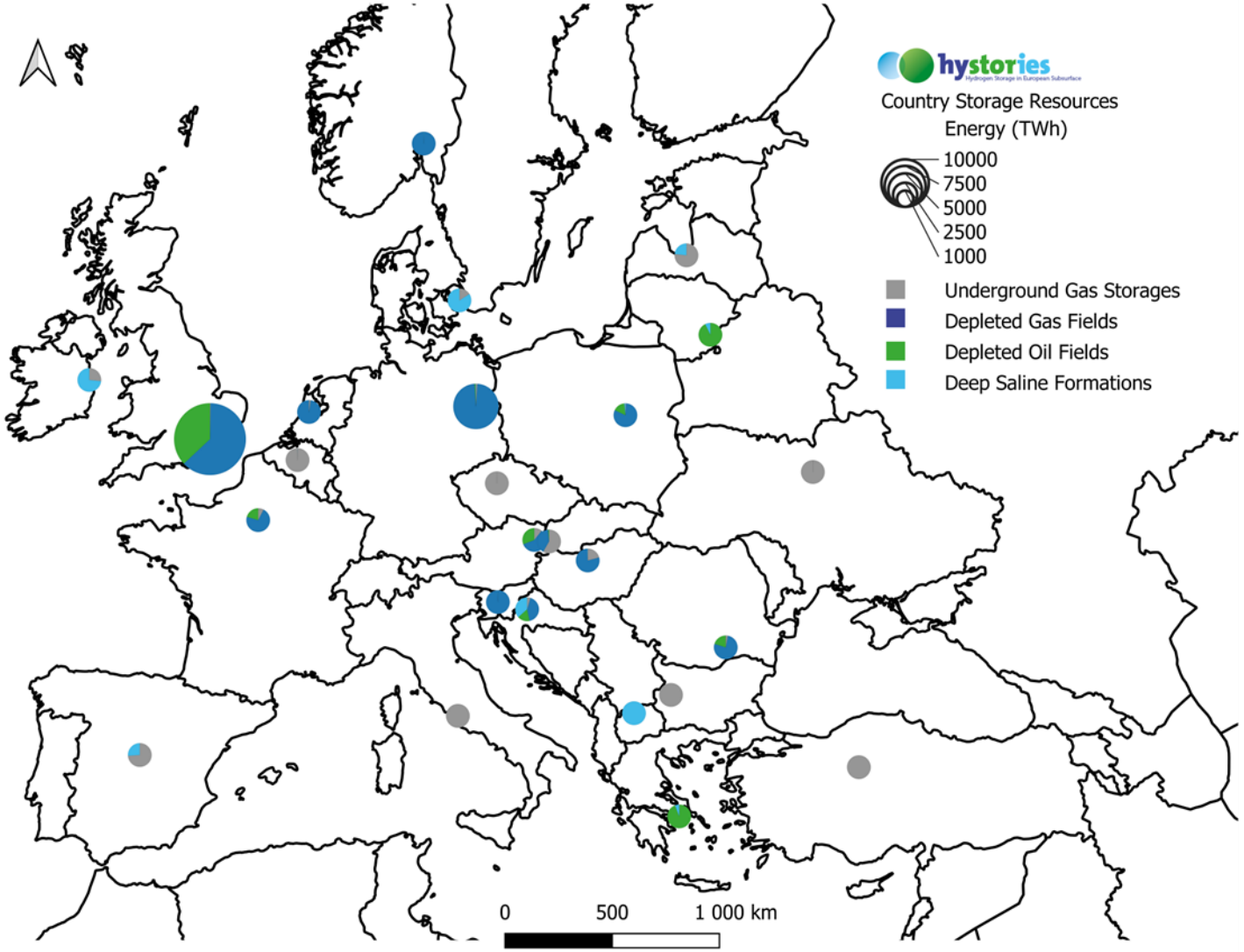
Combining the distributions for the different traps enable to estimate the potential hydrogen storage resource of each country





Available for each country in Hystories report D2.2

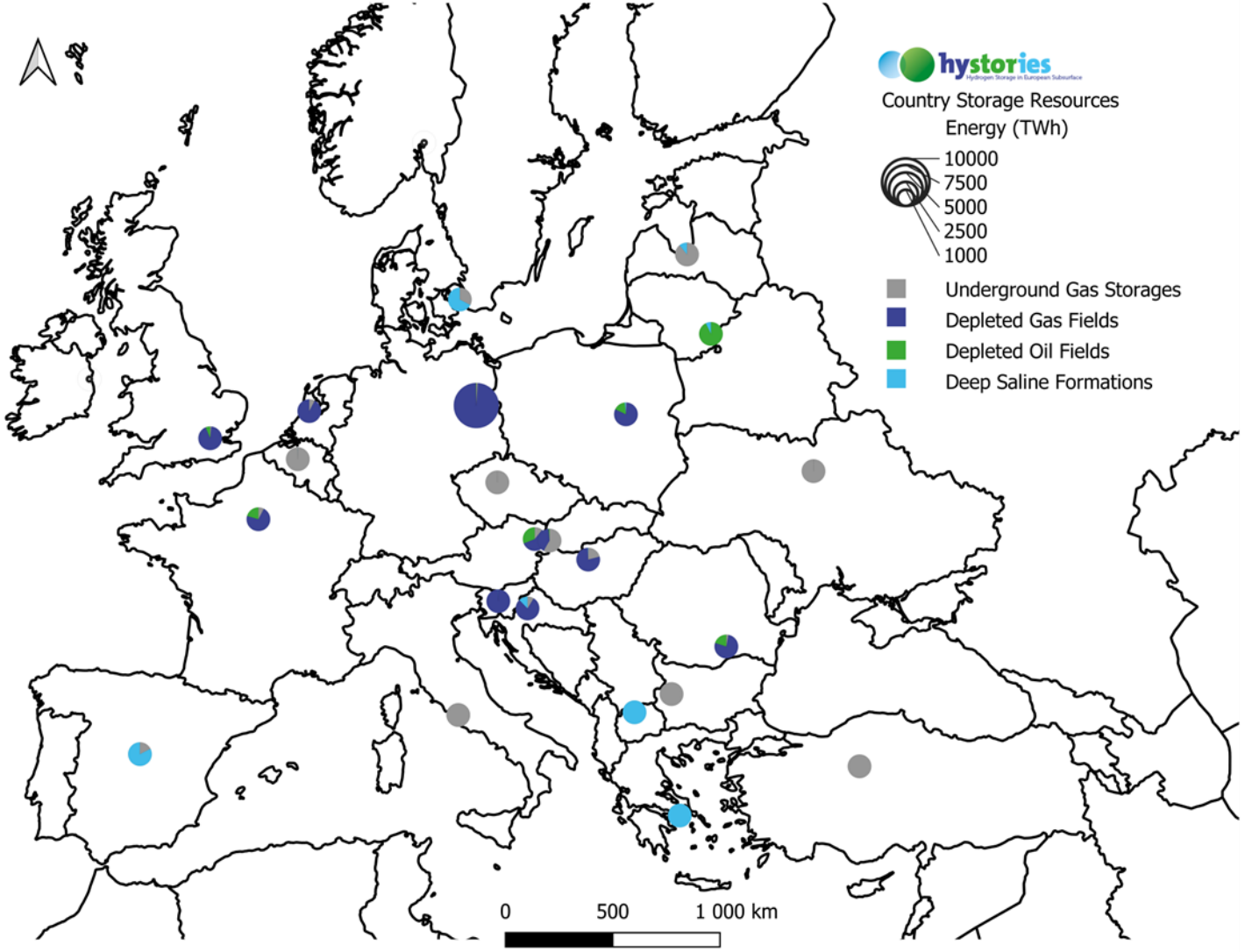
Onshore & Offshore hydrogen storage resources



EU27 + UK+ NO + TK + UA
Storage resources (TWh)

Underground Gas Storages	455
Depleted Gas Fields	14150
Depleted Oil Fields	4405
Deep Saline Formations	105

Onshore hydrogen storage resources



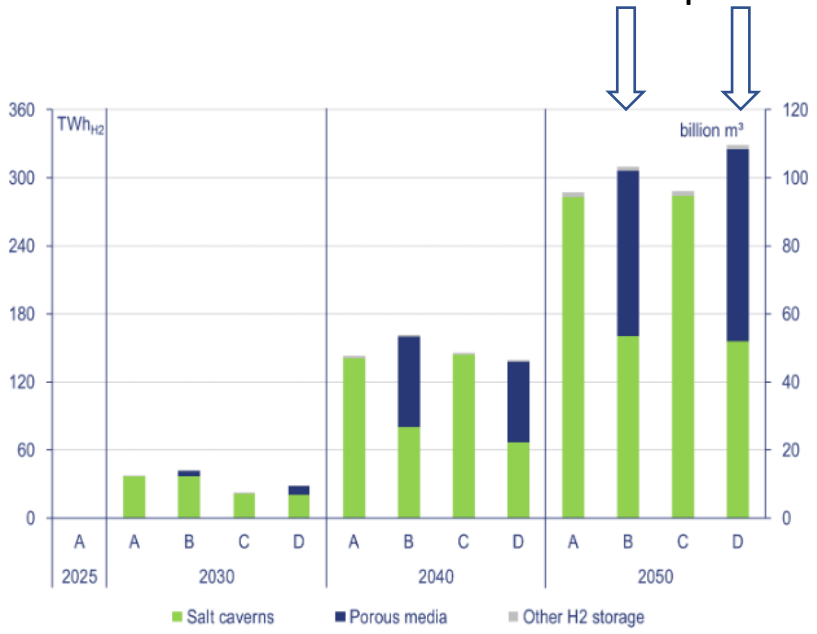
EU27 + UK+ NO + TK + UA
Storage resources (TWh)

Underground Gas Storages	390
Depleted Gas Fields	6015
Depleted Oil Fields	390
Deep Saline Formations	50

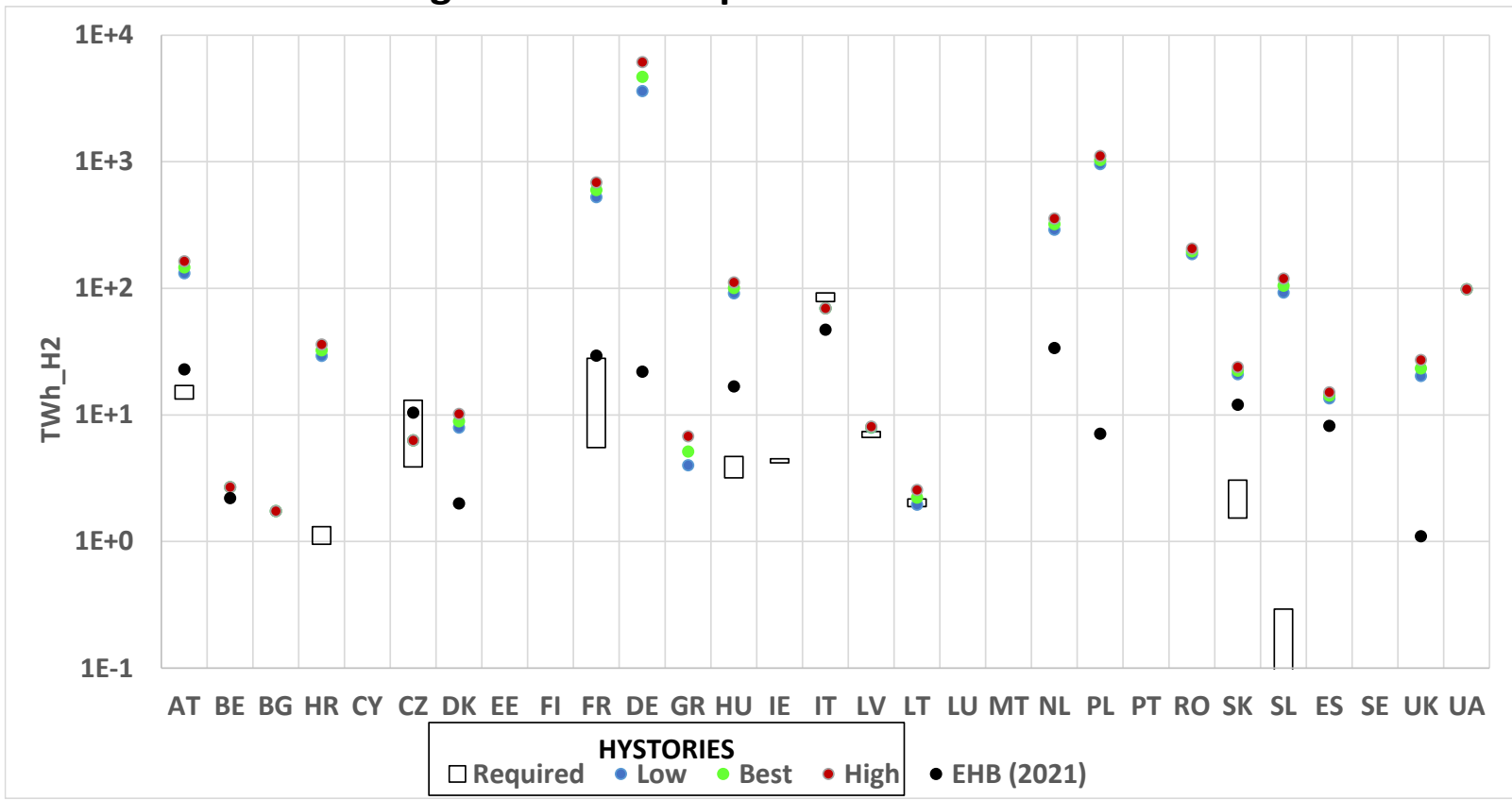
Country level storage requirements vs available capacity in porous media in 2050

WP5 Hydrogen Scenarios

salt cavern + porous media



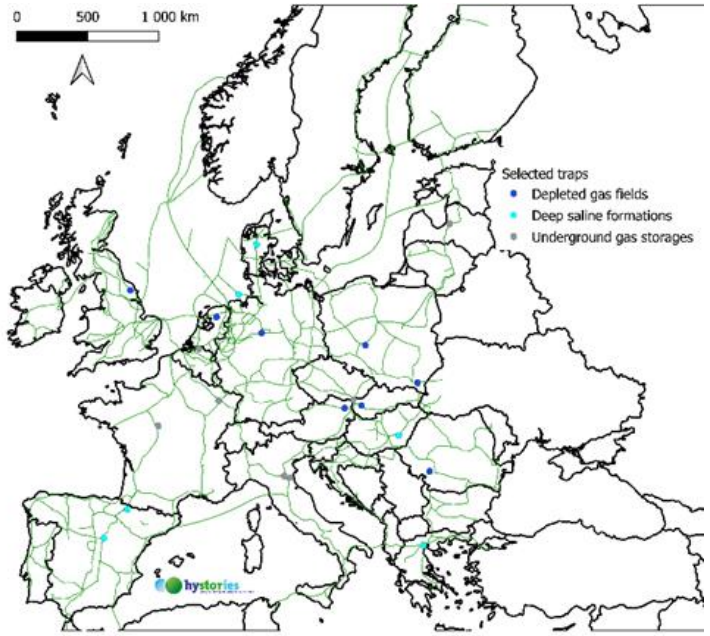
Country level storage requirements vs available onshore storage resources in porous media in 2050



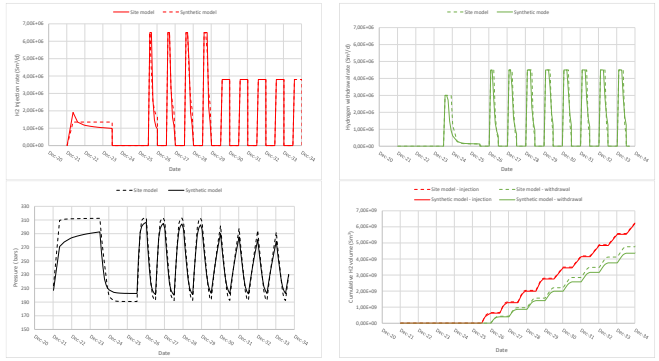
Countries without porous media requirement in WP5 scenarios may have sufficient salt deposit capacity to cover their needs (e.g. United Kingdom, Poland) or unsuitable geological conditions (e.g. Sweden, Estonia)

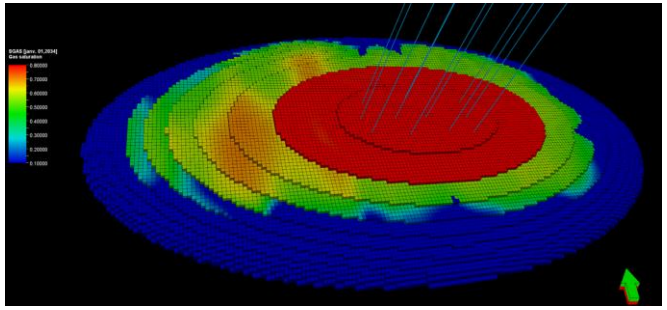
From potential resource to capacity…

For 22 onshore traps in EU27+UK

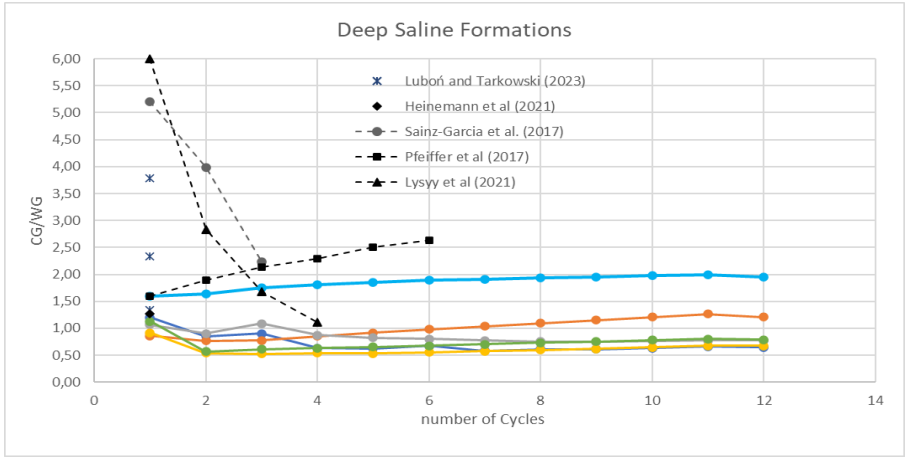


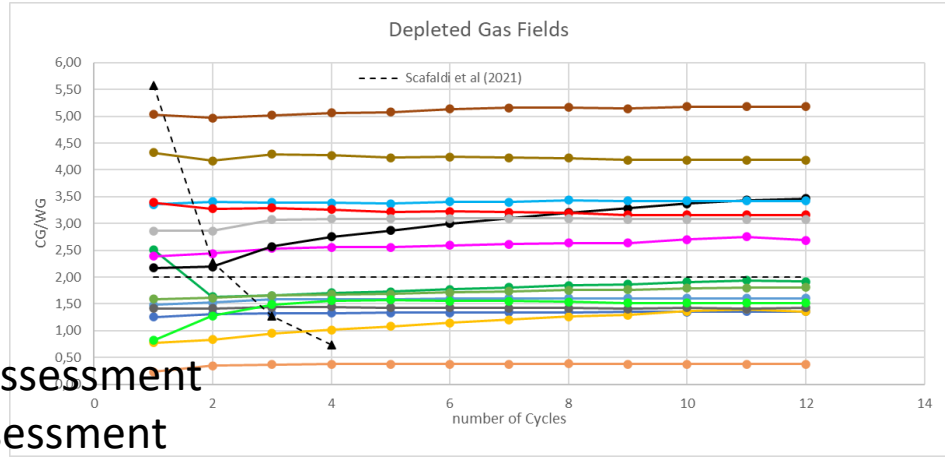
Synthetic
3-D dynamic simulations

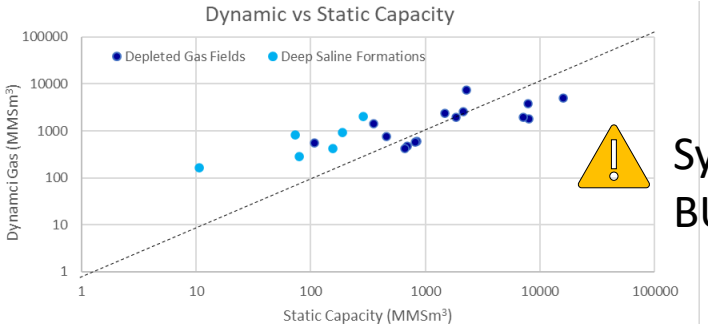




Cushion Gas/Working Gas ratio







Synthetic models are suitable for resource assessment
BUT not satisfactory for storage capacity assessment

Site specific models must be considered

Bouteldja & Le Gallo (EAGE 2023)

Synthesis

Volumetric storage resource (Total Gas) is significant enough in EU when solely considering the conversions of Underground Gas Storages and Depleted Gas Fields.

Commercial capacity (Working Gas) may be much smaller due to site specific development and constraints

Capacity may not be aligned with the market requirements (production/consumption) or the country needs (security, strategy and competing activity)

Development times and investments may vary greatly between storage types.

Report on storage resource assessment (D2.2) is available on Hystories web site
https://hystories.eu/publications-hystories/

Hystories project consortium

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