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Injection Projects

Insights and Challenges Regarding the Positioning of Injection Projects in the UNFC context

RESOURCE MANAGEMENT WEEK 2023

ASSURING SUSTAINABILITY IN RESOURCE MANAGEMENT

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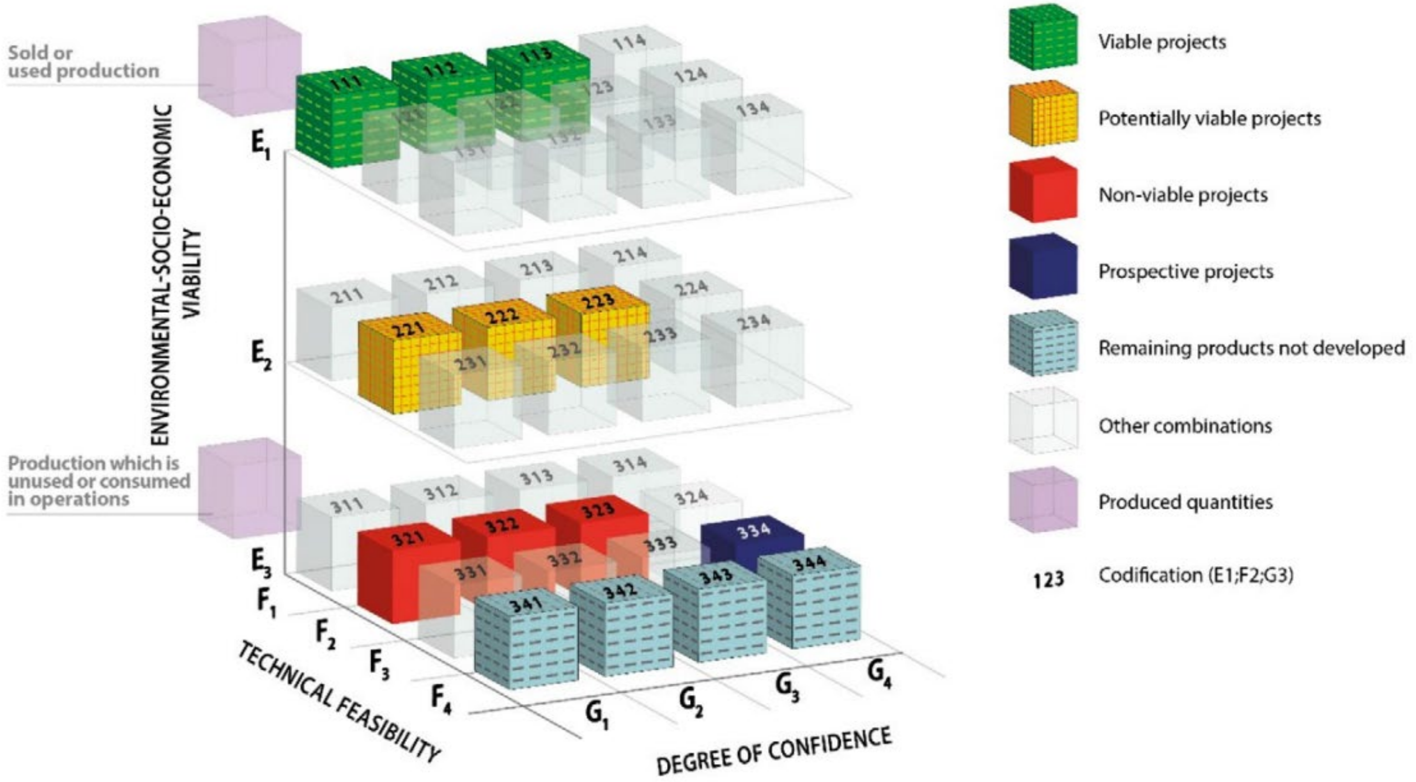
Technical maturity and developments

CCS global facilities/capacities (1)
- 30 operational (42.6 Mt/a)
- 11 under construction (9.6 Mt/a)
- 78 advanced development (97.6 Mt/a)
- 75 early development (91.9 Mt/a)
- 2 suspended (2,3 Mt/a)

Global underground gas storage facilities/capacities (2)
- 667 operational (424 bcm), mostly gas fields
- 7 new commissioned in 2021/2022 (>20 bcm)
- 68 under construction in 2021 (48 bcm)
- Re-opening of suspended facilities in EU
- Obligatory 90% filling (EU-before winter)

Hydrogen facilities/capacities (3)
- 4 in salt caverns – industry feedstock (0,17 bcm)
- >25 pre-feasibility and FEED studies for pilots/demo's
- Most based on H2 blends or pure h@ in caverns
- 1 pilot starting for pure H2 in gas fields
- Few projects foreseeing commercial operation >2025



(1) Global CCS Institute, Global Status of CCS – 2022
(2) CEDIGAZ, Underground Gas Storage in the World – 2022 Status
(3) Hydrogen-TCP Task42 – Technology Monitor Report 2023

Technical maturity and developments

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UNFC Applications (primary resources)

- Minerals
- Petroleum
- Nuclear
- Bioenergy
- Geothermal
- Hydropower
- Solar
- Wind
- Anthropogenic
- Groundwater

- Injection projects (underground)

coal

gas

+ ccs

CRM’s

Hydrogen as a energy carrier generated from primary resources

- Gray
- Low Carbon (blue, pink)
- Renewable (green)

CO_2

Hydrogen as primary resource (prospect)

- Natural Hydrogen (gold)

Hydrogen transport, storage and use

- Gas (pressurized)
- Blended (nat. gas)
- Ammonia
- Liquid H2
- Liquid Organic H2 Carrier (LOHC)

Repurposing of infrastructure

Demand for hydrogen storage volumes possibly higher than current underground natural gas storage

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Estimated Hydrogen Storage demand

EU 2030[1]:

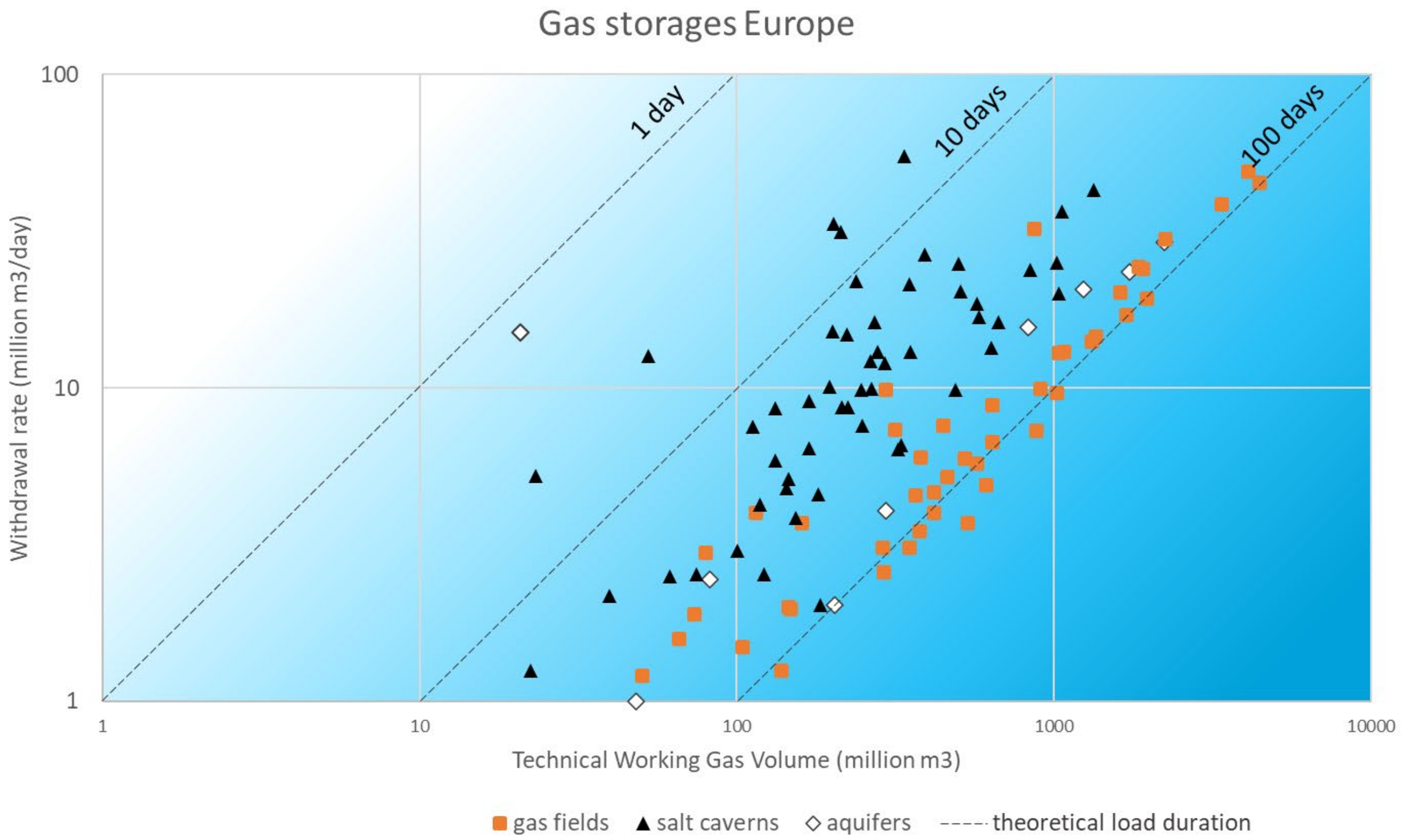
- Hydrogen demand 481 – 665 TWh
- Assumption 10 - 20% storage:
  ca. 16 bcm – 44 bcm

EU 2050[6]:

- Hydrogen demand 780 – 2.251 TWh
- Assumption 24% storage[4,5,7]:
  ca. 63 bcm – 180 bcm
- HyUsPre 2022 UHS demand[10]
  ca. 260 bcm (mid-range, 30% storage)

Global 2050[8]:

- Hydrogen demand ca. 17.000 TWh
- Assumption 10% storage[1,2,3]:
  ca. 580 bcm
- IRENA 2022 WETO[9]: 2.000 TWh storage
  ca. 670 bcm



1) IEA 2020: Natural Gas Information: Overview
2) Grand View Research 2020: Natural Gas Storage Market Size, Share & Trends Analysis Report
3) BP statistical review of global energy (via www.ourworldindata.org)
4) GIE gas storage database (April 2021)
5) EC – DG Energy 2019: Quarterly Report Energy on European Gas Markets
6) FCH-JU 2019: Hydrogen Roadmap Europe
7) GIE 2021, Picturing the value of underground gas storage to the European hydrogen system
8) IEA 2021, Net Zero by 2050 - A Roadmap for the Global Energy Sector
9) IRENA 2022, World Energy Transition Outlook
10) HyUSPRe D1.3, A. Cavanaghet al. 2022, Hydrogen storage potential of existing European gas storage sites in depleted gas fields and aquifers

Underground hydrogen storage - Technical Readiness Level

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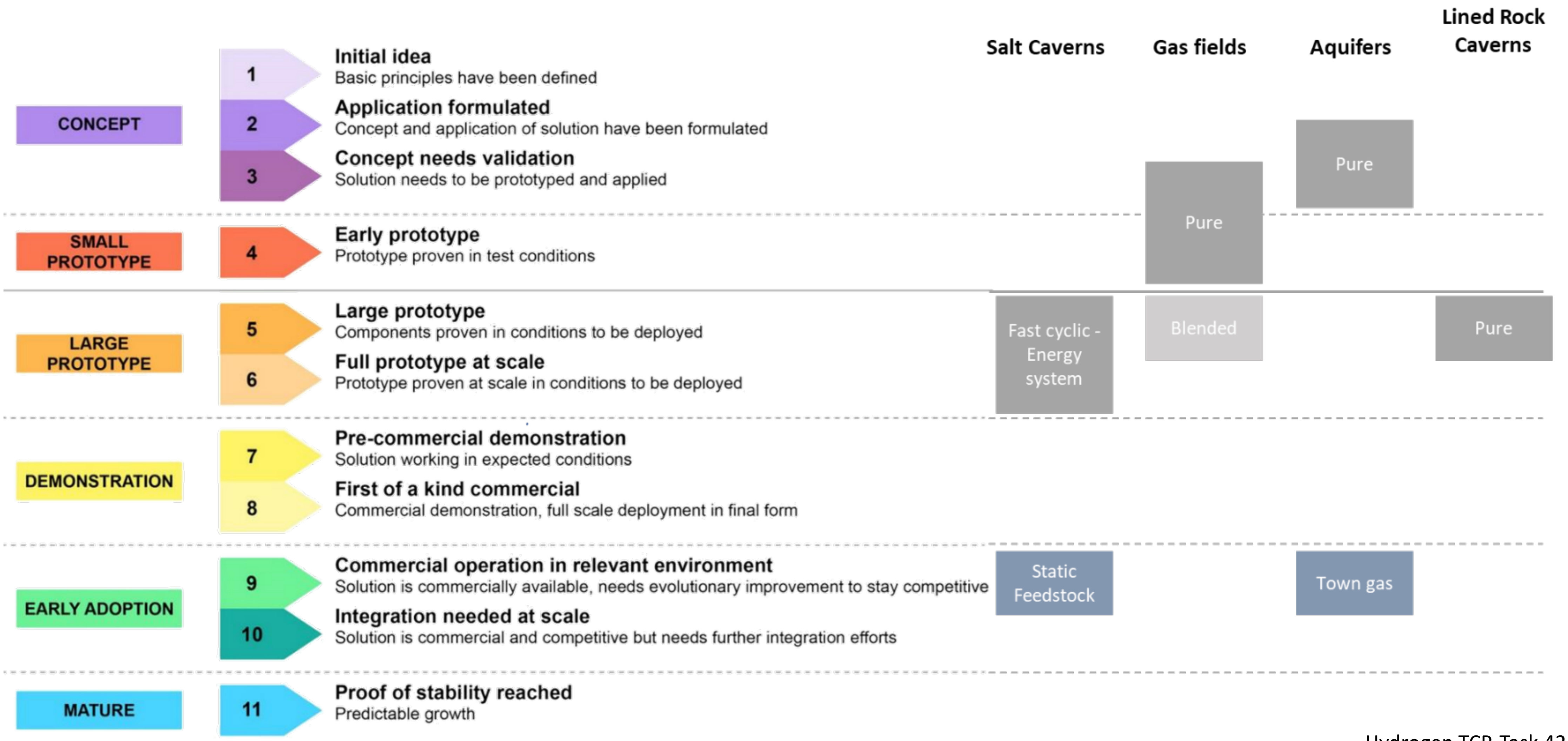
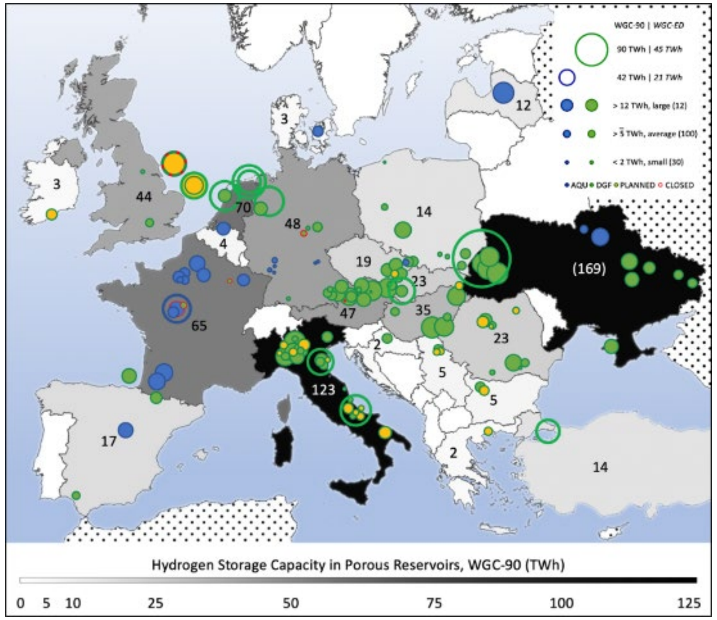


Hydrogen TCP-Task 42 (2023), “Underground Hydrogen Storage: Technology Monitor Report”

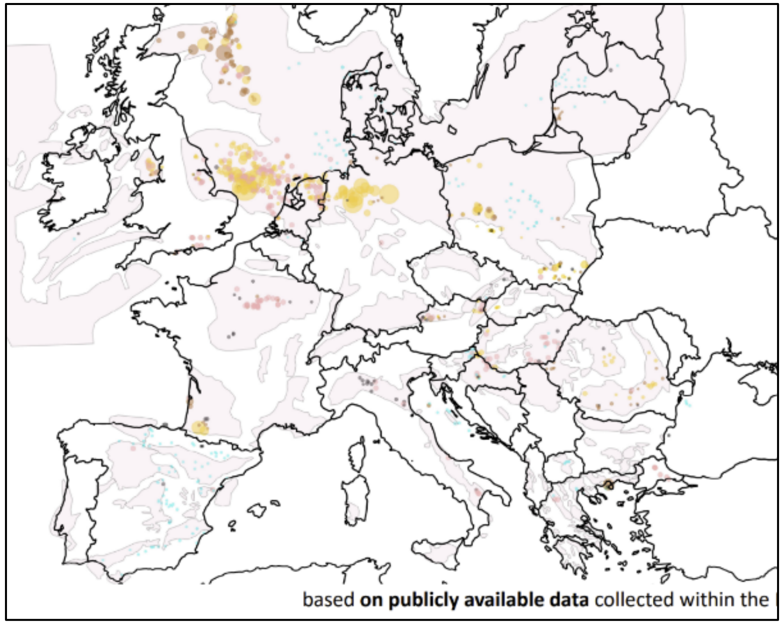
Hydrogen storage potential

Existing UGS sites



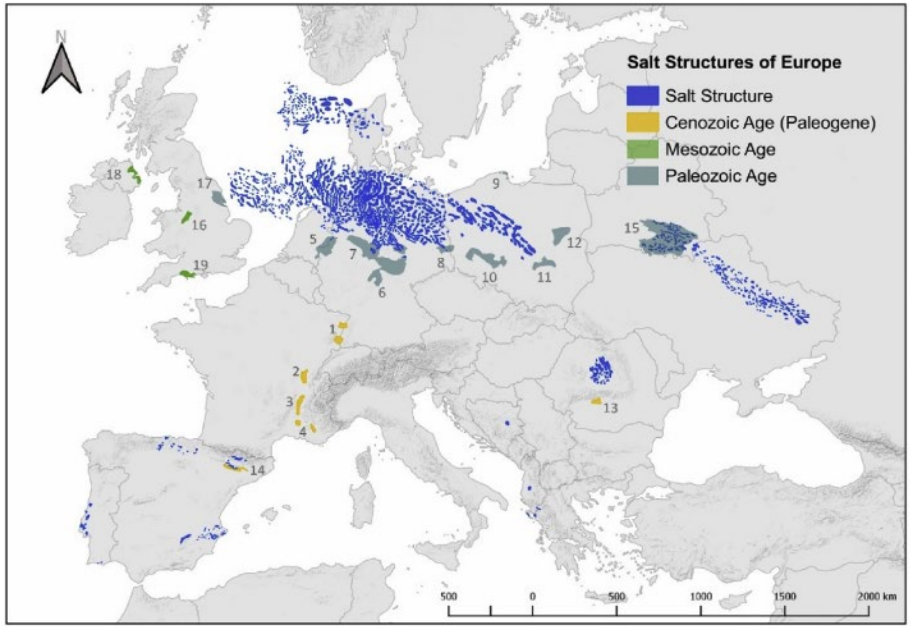
H2020 – HyUSPRe: Cavanagh, AJ, Yousefi, SH, Wilkinson, M & Groenenberg, RM. 2022: Hydrogen storage potential of existing European gas storage sites in depleted gas fields and aquifers.

Depleted gas fields and aquifers

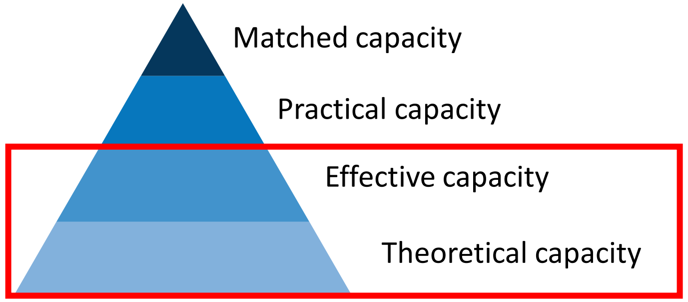


H2020 – HyStories: Ceri Vincent and Yann le Gallo, presented at 15th CO2GeoNet Open Forum, 20 September 2022

Salt caverns



Caglayan, D.G., Weber, N., Heinrichs, H.U., Linßen, J., Robinius, M., Kukla, P.A., Stolten, D., 2020. Technical potential of salt caverns for hydrogenstorage in Europe



After: S. Bachu et al. 2007.

<u>Salt caverns:</u> **<u>vs</u>**

More advanced, demonstrated
Less complex
Smaller capacity, yet scalable
Limited to specific regions

<u>Porous reservoirs:</u>

Less advanced, pre-demonstration
Many complexities (flow, recovery, quality)
Larger capacities (typically 10-20x bigger than a cavern)
Cushion gas requirements!
Widespread potential

Main challenges for Underground Hydrogen Storage

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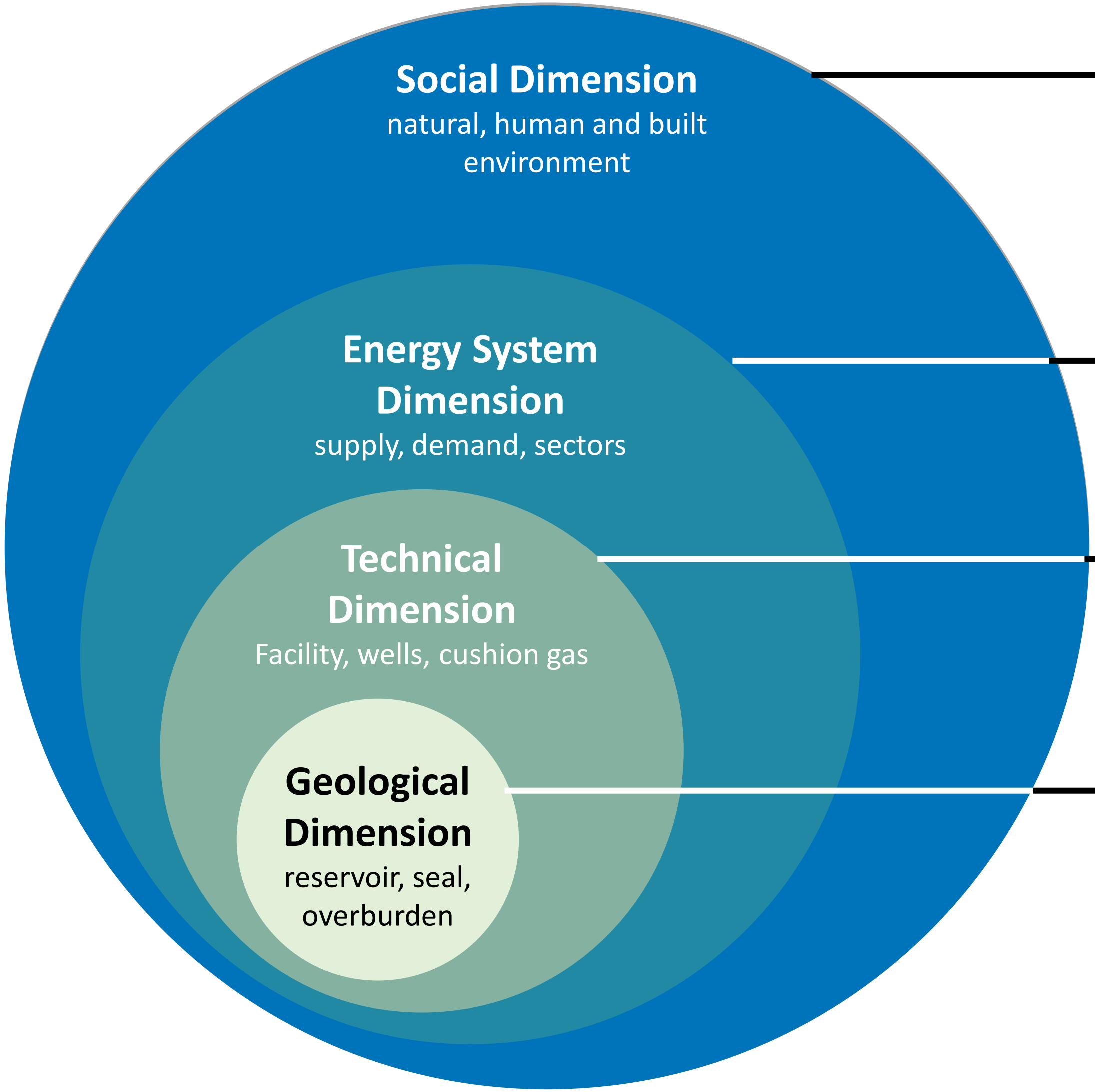
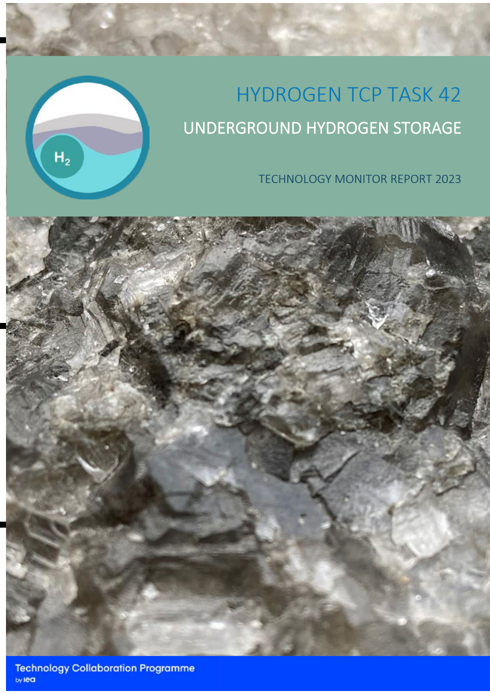


Societal Embeddedness
Societal costs and benefits
Stakeholder involvement, public engagement
Life-cycle assessment, environmental footprint
Regulations, policies

Supply demand/profiles, system integration
Costs and revenue models
Market gaps, financial instruments

Compression, dehydration, purification
Materials, design criteria
Operational parameters
Monitoring, risk management

Geochemical and Microbial Impacts (losses, contamination)
Storage Integrity (losses, stability, seismicity)
Storage Performance, recoverability
Screening and exploration



Hydrogen TCP-Task 42 (2023), "Underground Hydrogen Storage: Technology Monitor Report"

Societal Embeddedness

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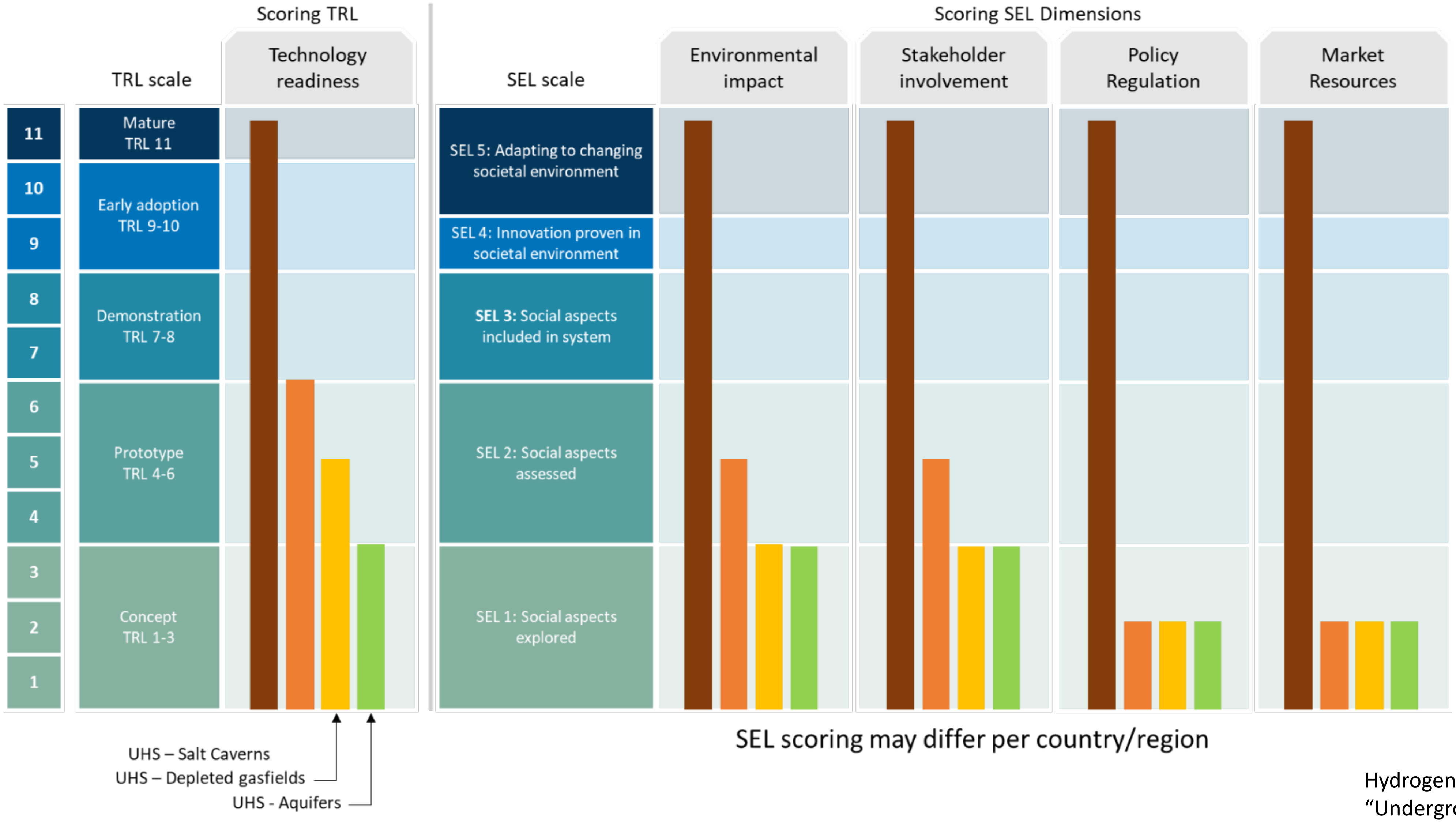
	TRL 1-3	TRL 4-6	TRL 7-8	TRL 9+
	SEL 1: Exploration	**SEL 2: Development**	**SEL 3: Demonstration**	**SEL 4: Deployment**
Dimension 1: impact on the environment	Milestones	Milestones	Milestones	Milestones
Dimension 2: stakeholder involvement	Milestones	Milestones	Milestones	Milestones
Dimension 3: policy and regulations	Milestones	Milestones	Milestones	Milestones
Dimension 4: market and financial resources	Milestones	Milestones	Milestones	Milestones

D. Mendrinos, S. Karytsas, O. Polyzou, C. Karytsas, Å. D. Nordø, K. Midttømme, D. Otto, M. Gross, M. Sprenkeling R. Peuchen T. Geerdink and H. Puts “Understanding societal requirements of CCS projects: application of the Societal Embeddedness Level assessment methodology in four national case studies ” Clean Technologies, vol. 4, no. 4, p. 893–907, 2022.

M. Sprenkeling T. Geerdink A. Slob and A. Geurts “ Bridging social and technical sciences: introduction of the Societal Embeddedness Level ” Energies, vol. 15, no. 17, p. 6252, 2022.

Societal embeddedness



SEL scoring may differ per country/region

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RESOURCE MANAGEMENT WEEK 2021

ENABLING SUSTAINABILITY PRINCIPLES IN RESOURCE MANAGEMENT

Thank you!

Serge van Gessel
Chair Working Group for Injection Projects
UNECE
Date 25-28 I 04 I 2023, Geneva

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