

Geological Storage

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IEAGHG



A world map with a green landmass and white oceans, surrounded by various logos and national flags of member organizations. The logos include: Statoil, TOTAL, VATTENFALL, ALSTOM, B&W power generation group, BG GROUP, bp, CEZ GROUP, Chevron, CIAB, ConocoPhillips, eni, e-on, EPRI, ExxonMobil, GLOBAL CCS INSTITUTE, JGC, REPJOL YPF, RWE (The energy to lead), Schlumberger, Shell, and the European Union flag. National flags shown include Switzerland, United Kingdom, USA, Australia, Austria, Canada, Denmark, Norway, Sweden, Spain, South Africa, South Korea, Japan, India, Germany, and France.

Geological Storage of CO₂

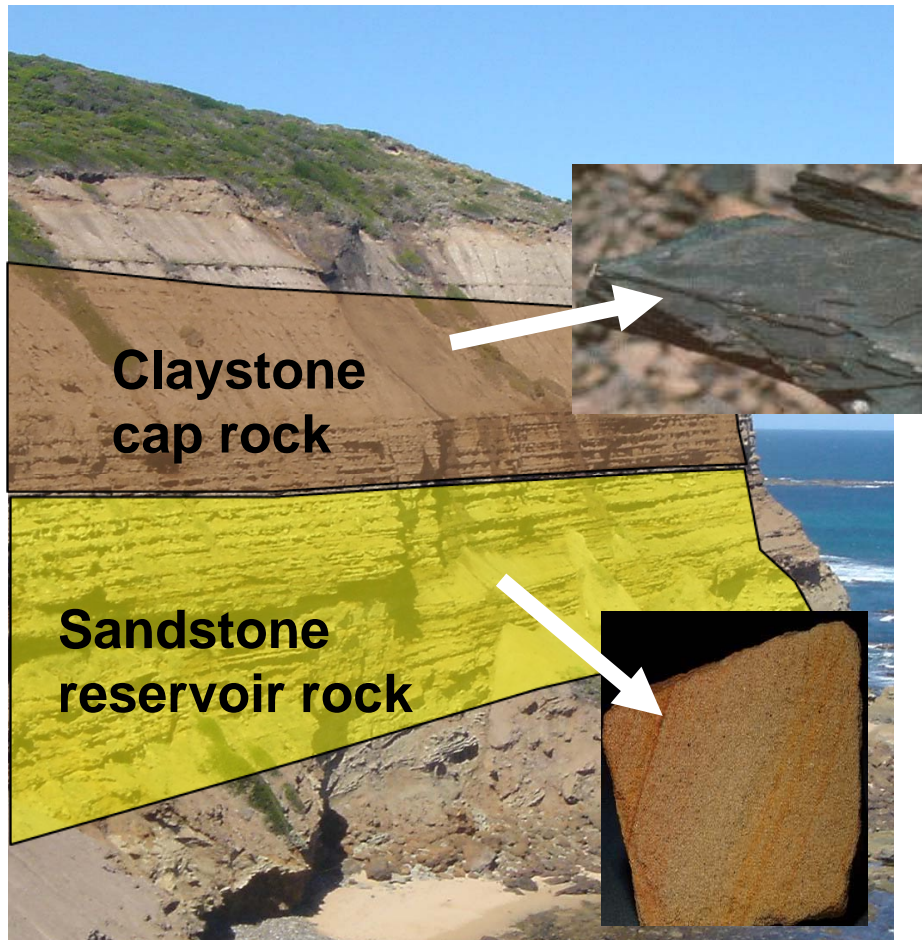


Requires three ingredients for success:

- ***Capacity***
- ***Injectivity***
- ***Containment***



Geological Storage of CO₂



What do we need?

RESERVOIR ROCK – porous, e.g. sandstone

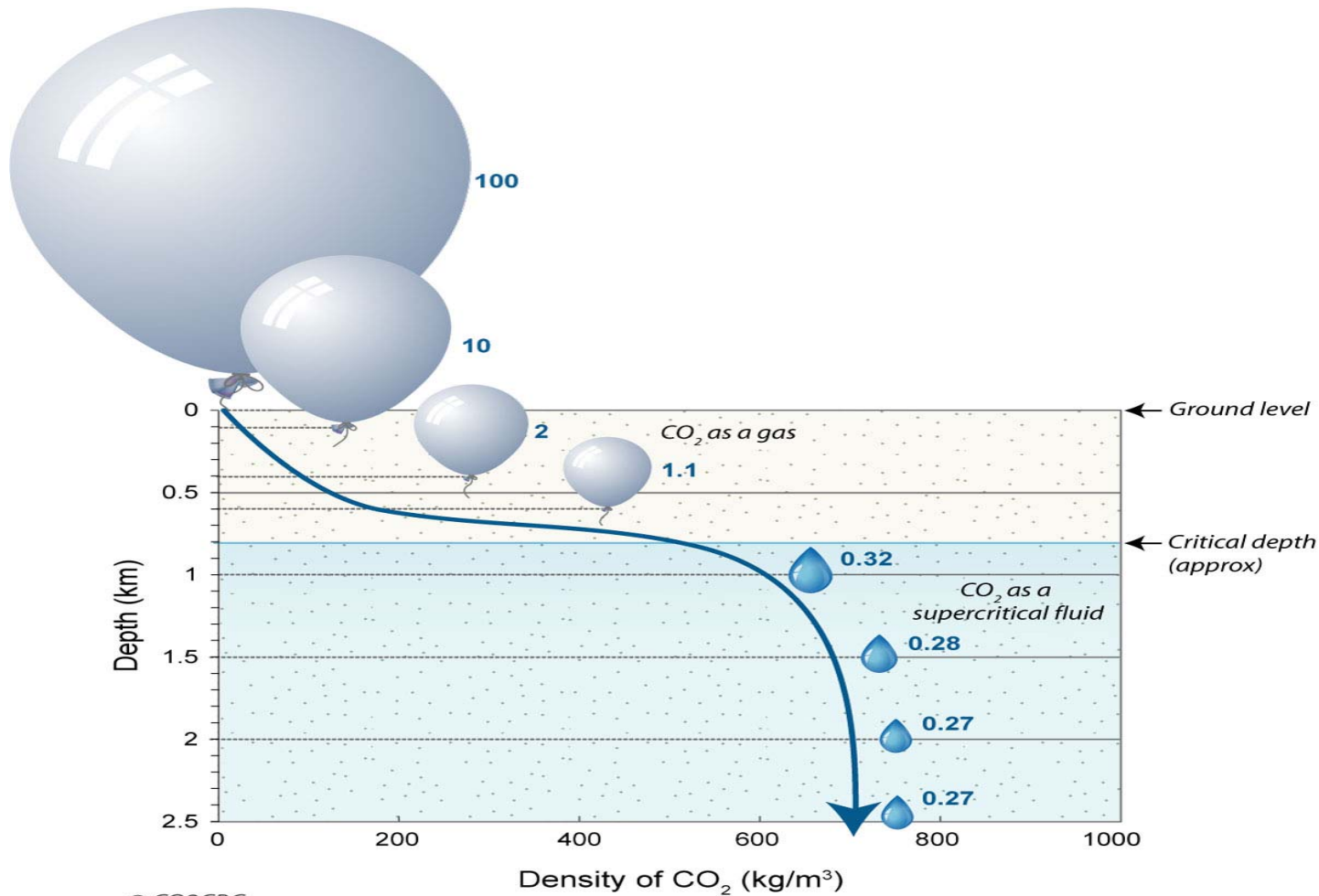
SEAL ROCK – non-porous, e.g. claystone

How does it work?

- CO₂ injected into porous reservoir rock
- CO₂ held in place by overlying non-porous seal rock

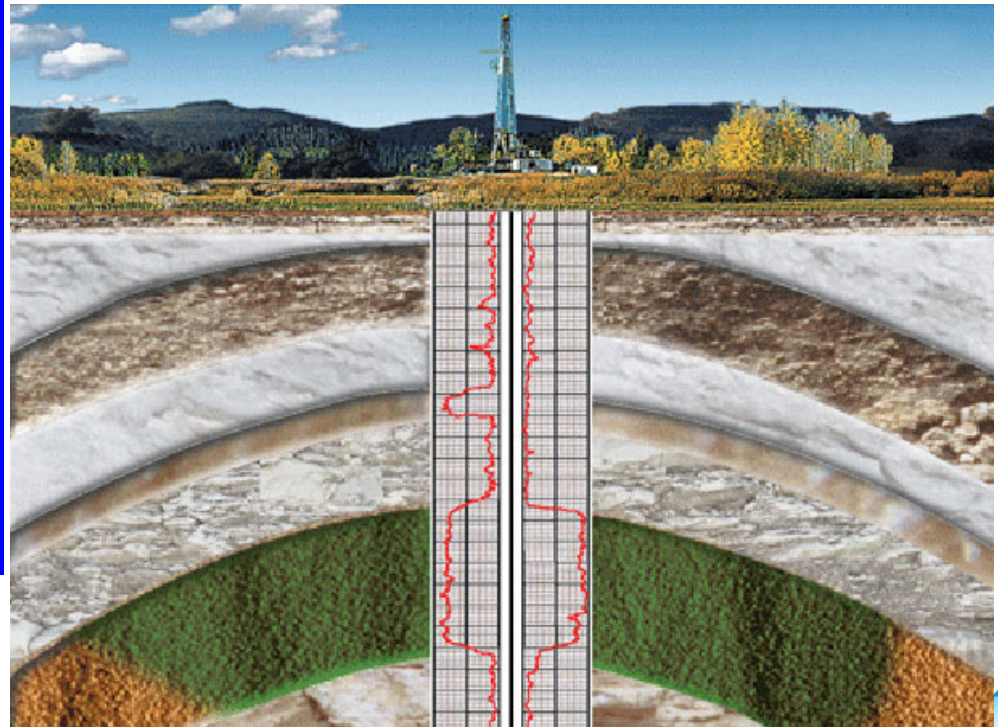
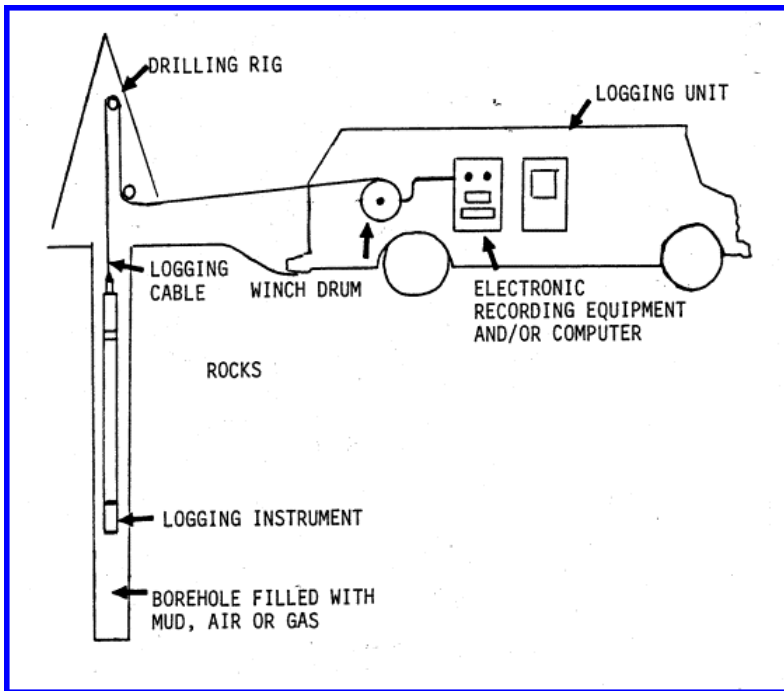


CO₂ Properties change with Depth

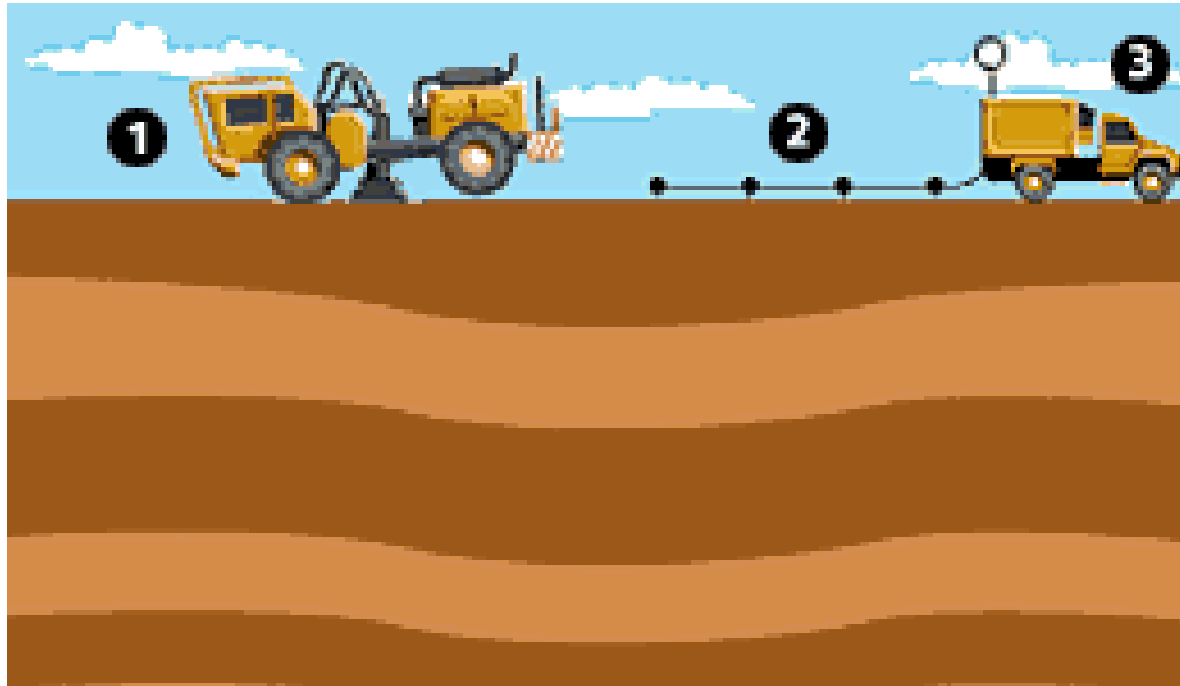




Wells and Logging



Seismic Surveys

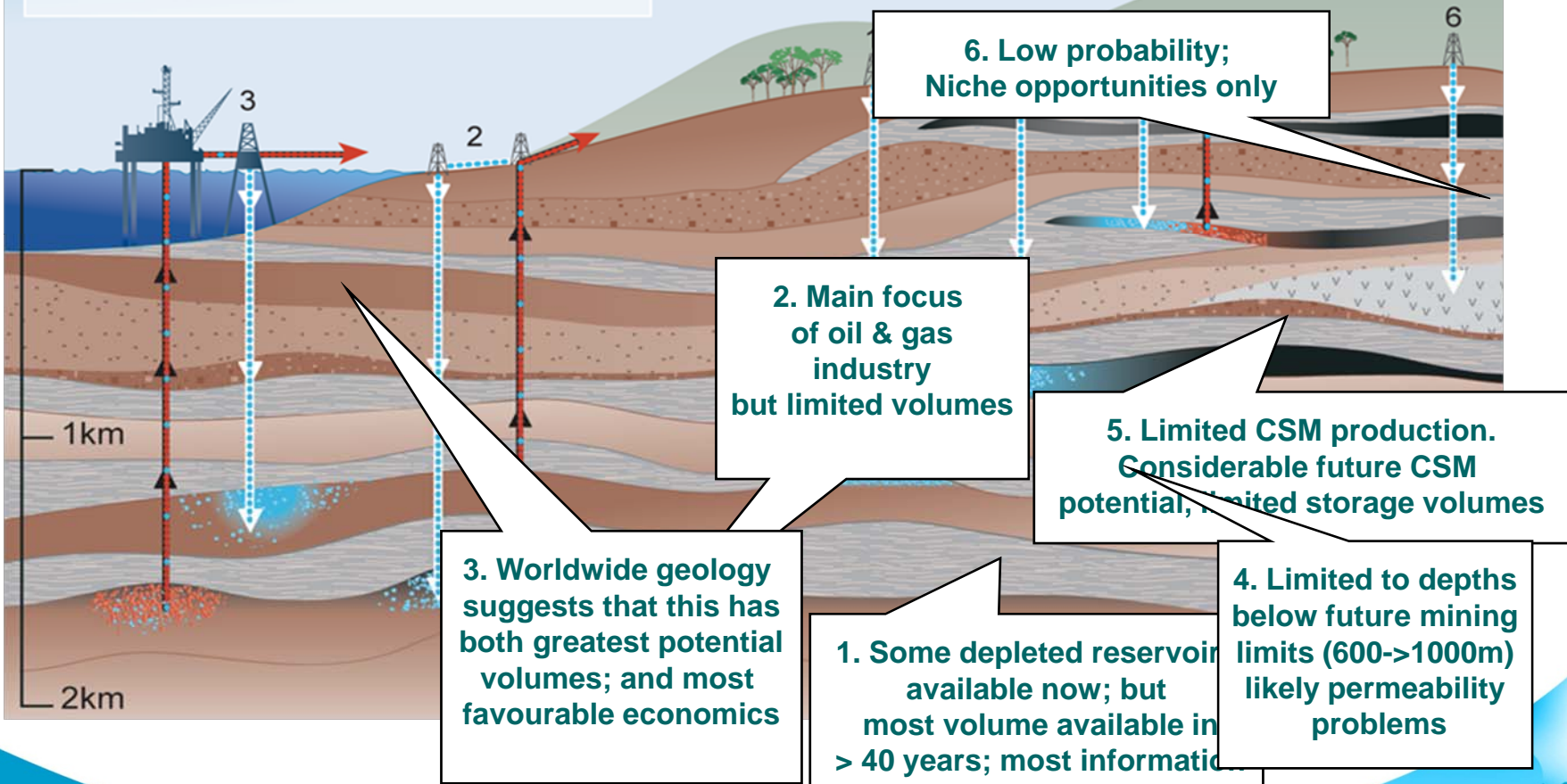
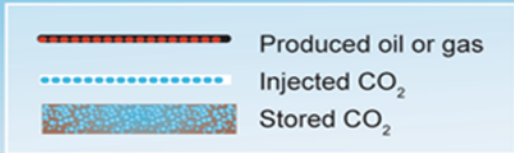


Seismic imaging uses reflected sound waves to create a picture of underground rock formations. It can show potential CO₂ reservoirs and seal rocks and other geologic features such as faults. After injection begins, it can show the location of the CO₂.



Geological Storage Systems for CO2

- 1 Depleted oil and gas reservoirs
- 2 Use of CO₂ in enhanced oil recovery
- 3 Deep unused saline water-saturated reservoir rocks
- 4 Deep unmineable coal seams
- 5 Use of CO₂ in enhanced coal bed methane recovery
- 6 Other suggested options (basalts, oil shales, cavities)

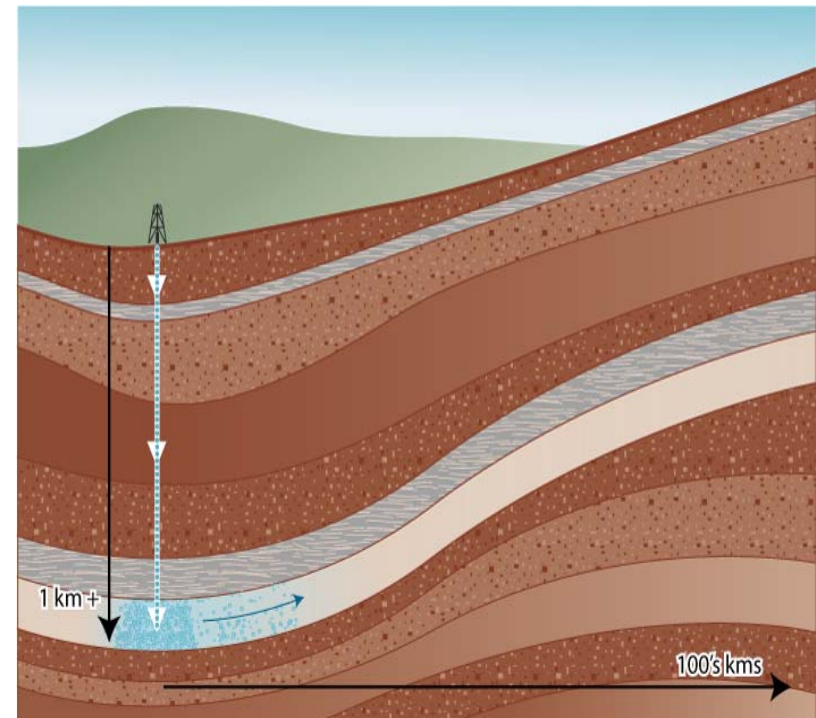




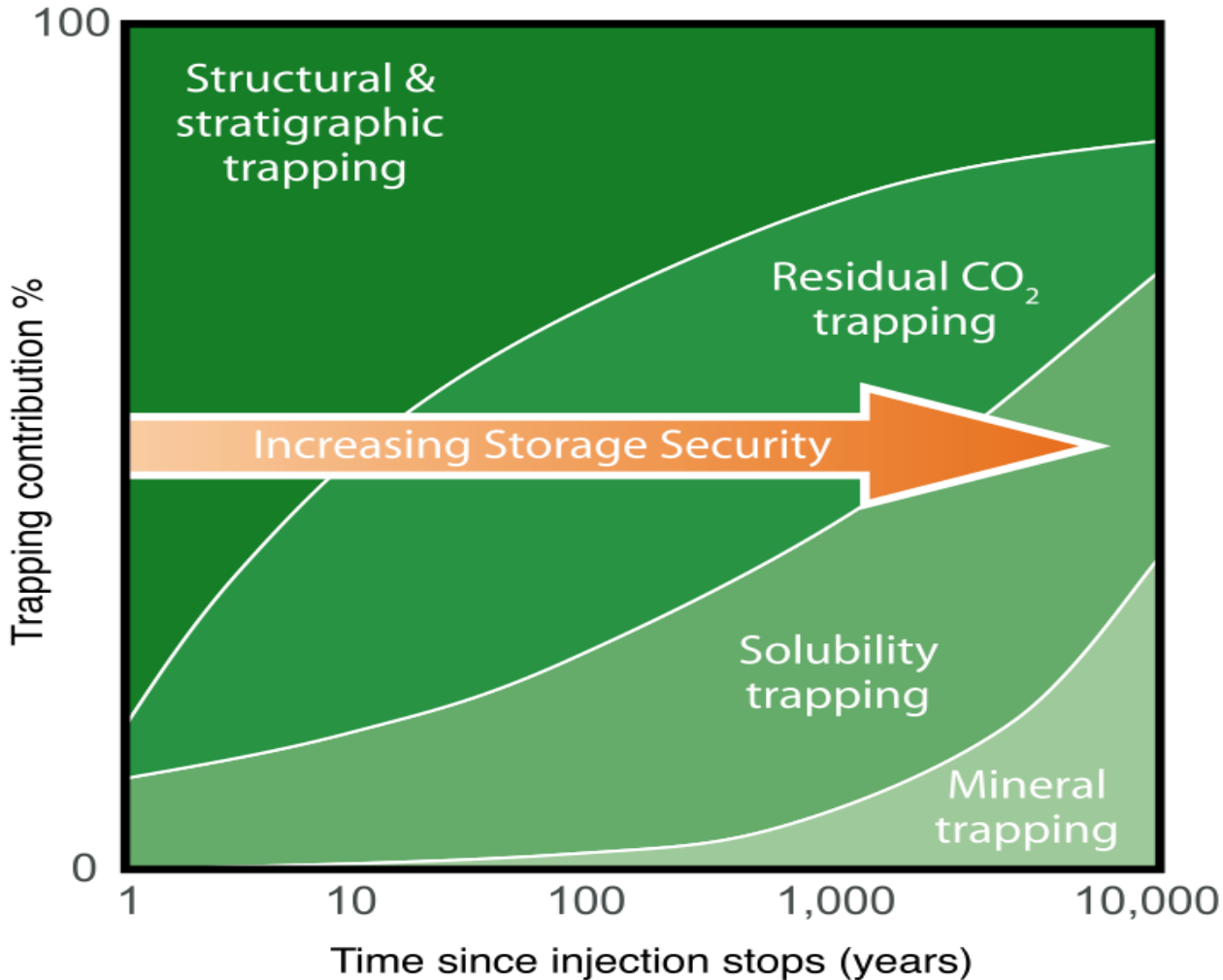
Deep Saline Formations

Trapping mechanisms

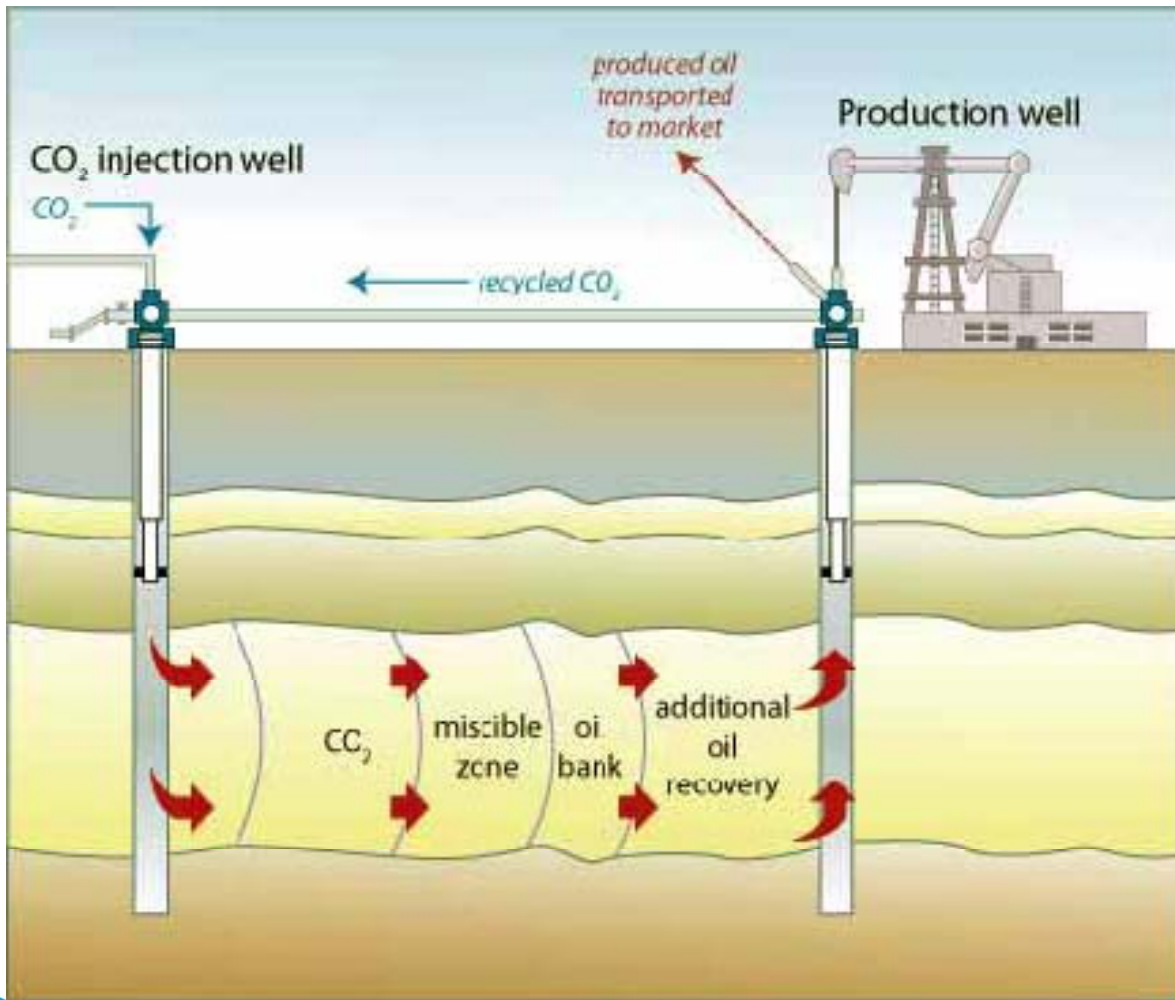
- Structural***
- Residual***
- Solution***
- Mineral***



CO₂ Containment Mechanisms



Oil & Gas Reservoirs: EOR with CO₂ Storage



- Proven containment (seal held oil & gas)
- Data rich (lots of wells, seismic)
- Objective: produce more oil (CO₂ storage secondary!)

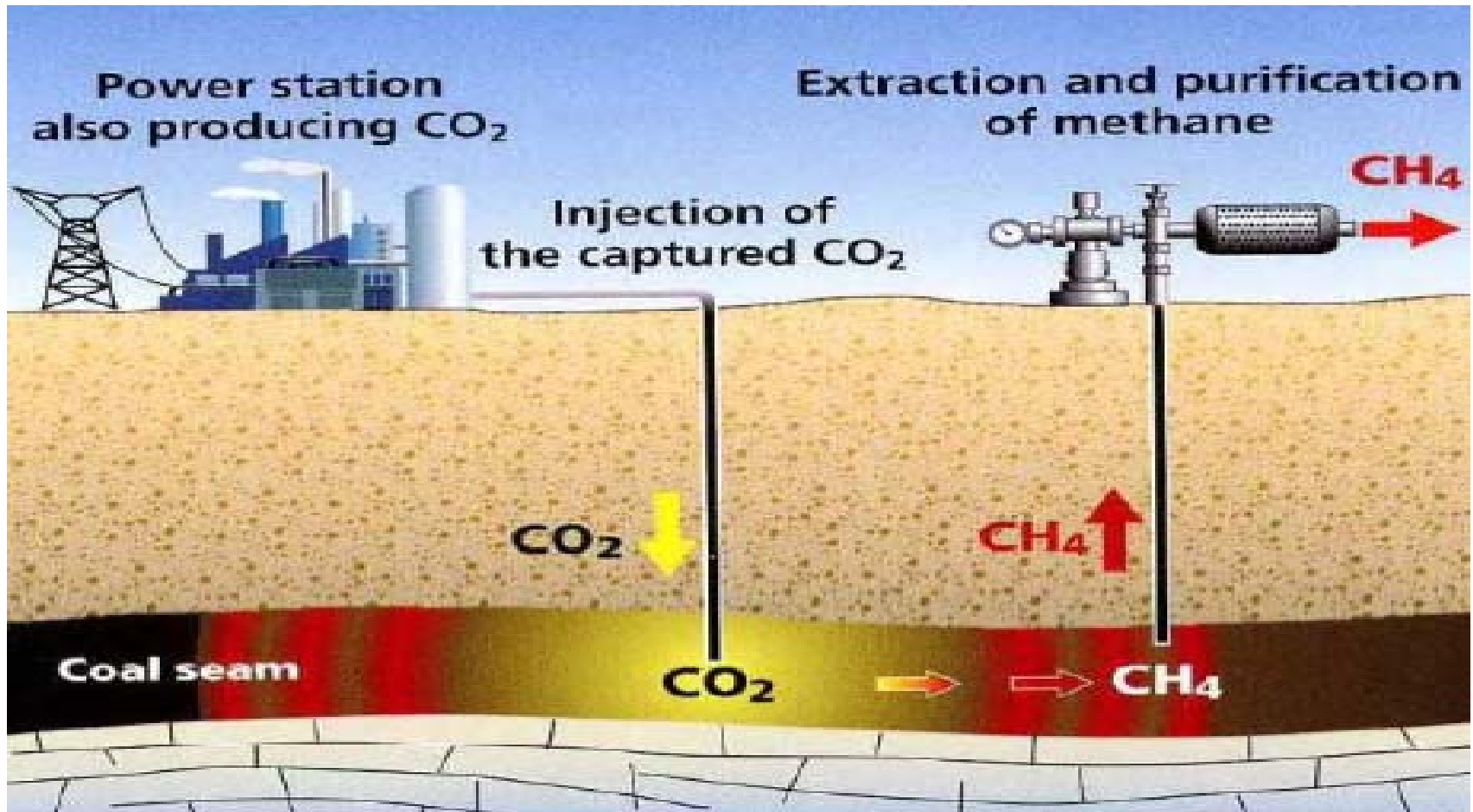
CO₂ Storage in Coal Sequences



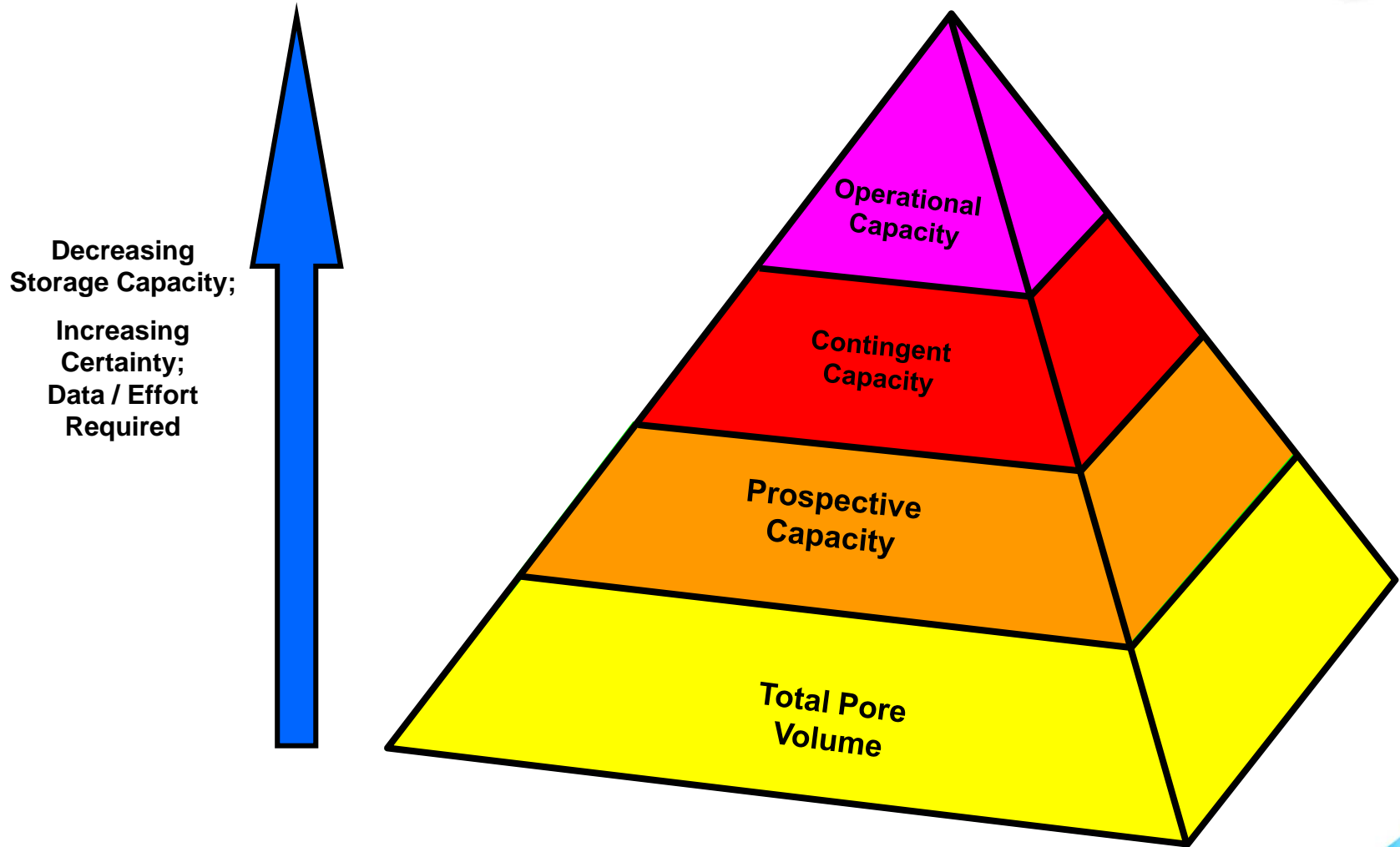
CO₂ storage potential may include coal systems (coal seams and associated sediments) as well as the storage potential arising from using CO₂ for Enhanced Coal Bed Methane Recovery



Coal bed storage



Storage Capacity Estimation



CO₂ Storage Capacities

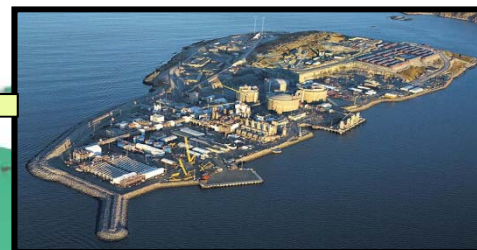


Storage Type	IPCC Estimated Global Capacity (Gt)	IEA GHG Estimated Global Capacity (Gt)
Saline Formations	1,000 to 10,000	
Depleted Gas Fields		160 to 390
CO ₂ -EOR	675 to 900	11 to 130
Coal Beds	3 to 200	

Commercial-scale CCS Projects



Sleipner



Snøhvit



In-Salah








Weyburn/Midale

Images Courtesy of BP, Statoil, and PTRC

CCS Projects identified



Bellingham Cogeneration Facility	IFFCO CO2 Recovery Plant – Aonla
CASTOR Project	Prosint Methanol Plant
Great Plains Synfuel Plant	Rangely CO2 Project
IMC Global Soda Plant	Schwarze Pumpe
In Salah	SECARB - Cranfield II
K12-B	Shady Point Power Plant
Ketzin Project	Sleipner
MRCSP - Michigan Basin	Snohvit LNG Project
Nagaoka	SRCSP - Aneth EOR-Paradox Basin
Otway Basin Project	SRCSP - San Juan Basin
Pembina Cardium Project	Sumitomo Chemicals Plant
Petronas Fertilizer Plant	Warrior Run Power Plant
IFFCO CO2 Recovery Plant - Phulpur	Weyburn
Chemical Co. "A" CO2 Recovery Plant	Zama EOR Project

-  Capture over 100ktCO₂
-  Injection over 10ktCO₂ for storage
-  Monitored EOR over 10ktCO₂
-  Capture over 10ktCO₂ from flue gas
-  Coal bed storage over 10ktCO₂

Extent of coverage vs ZEP project matrix



Archetype 1	• Lignite/co-firing with Biomass	• Pre-combustion, variant A	• Cross-border pipeline	• Offshore depleted oil & gas field
Archetype 2	• Gas	• Post-combustion, variant A	• Pipeline	• Onshore structural deep saline aquifer
Archetype 3	• Hard Coal	• Oxy-fuel, variant A	• Shlp	• Offshore open deep saline aquifer
Archetype 4	• Hard Coal	• Post-combustion, variant A	• Pipeline	• Onshore depleted oil & gas field
Archetype 5	• Lignite	• Oxy-fuel, variant B	• Pipeline	• Onshore structural deep saline aquifer
Archetype 6	• Hard Coal	• Pre-combustion, variant B	• Pipeline	• Offshore depleted oil & gas field
Archetype 7	• Hard Coal	• Post-combustion, variant B	• Pipeline	• Onshore open deep saline aquifer

Demonstrated in operational large projects

Not demonstrated in operational large projects

Project matrix courtesy of EU Technology Platform for Zero Emission Fossil Fuel Power Plants - ZEP (2008)

Summary – current status



Injection of CO₂ into depleted oil fields (CO₂-EOR) and deep saline formations (CCS demo's) is technologically proven

IEAGHG survey – nearly 10Mt CO₂ per annum collectively stored around world by end of 2008, excluding commercial CO₂-EOR

Deep saline formations widely considered to have greatest volumetric potential

Storage in other geological media is less certain or unproven, e.g. basalts, shales, coal beds

Storage Challenges



- Implementation of commercial scale CCS***
- Pressure build up and brine displacement in deep saline formation storage***
- Public outreach and communication***
- Long term liability issues***
- Other technical challenges are not considered to be 'show-stoppers'***



Thank you for your attention