Geological Storage of CO_2: Status and Issues

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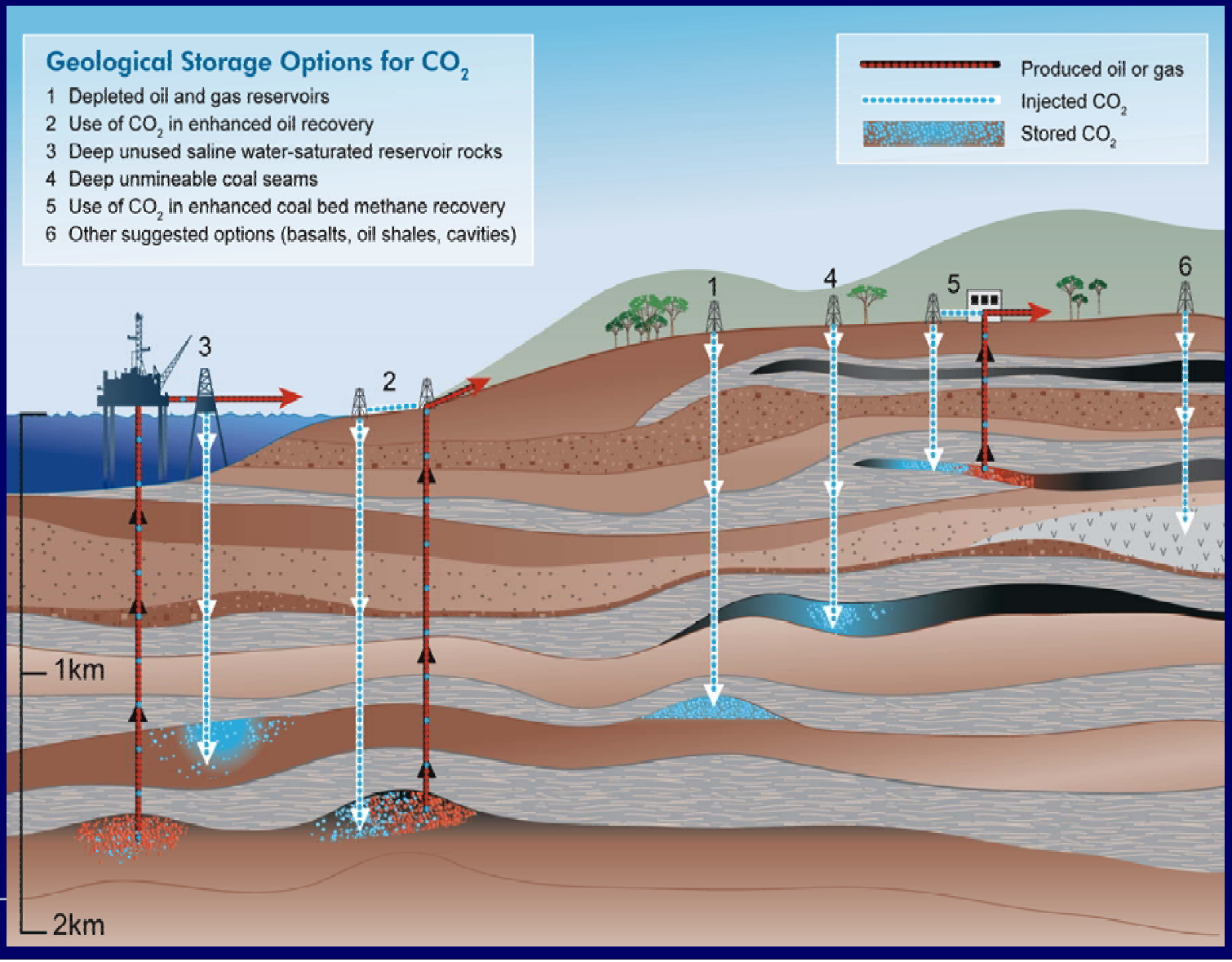
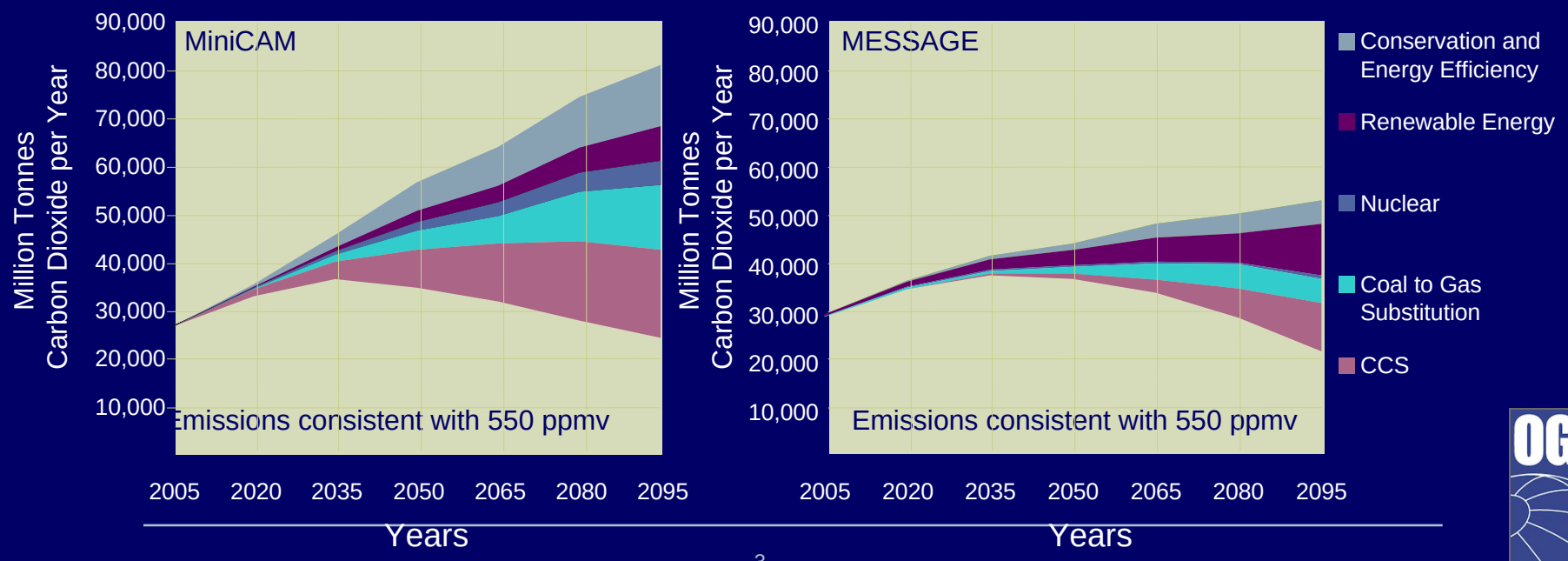
Options for storing CO_2



Facts - 1

There is significant storage capacity

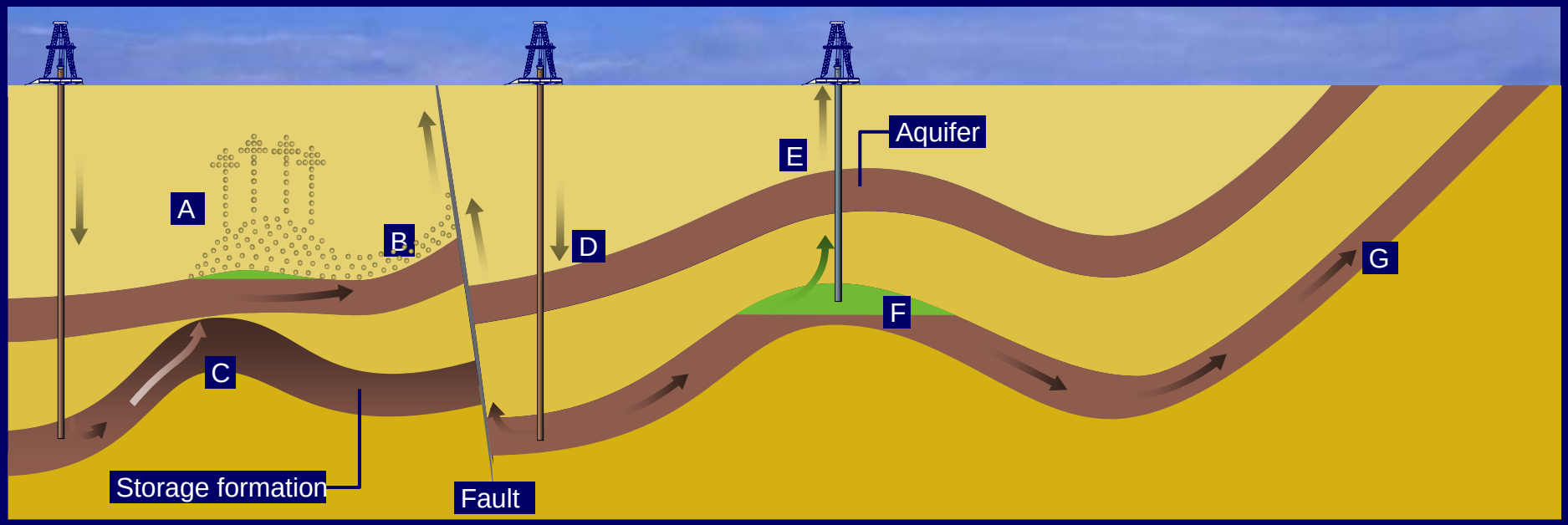
- Technical potential likely to exceed 2000 $GtCO_2$
- In most scenarios CCS contributes between 220 and 2200 $GtCO_2$ to achieve stabilisation between 450 and 750 ppm CO_2



Facts - 2

CO_2 can be stored safely if...

- storage mechanisms are known
- sites are selected properly
- monitoring and verification is implemented



Potential escape mechanisms

A. CO_2 gas pressure exceeds capillary pressure & passes through siltstone	B. Free CO_2 leaks from A into upper aquifer up fault	C. CO_2 escapes through 'gap' in cap rock into higher aquifer	D. Injected CO_2 migrates up dip , increases reservoir pressure & permeability of fault	E. CO_2 escapes via poorly plugged old abandoned well	F. Natural flow dissolves CO_2 at CO_2 /water interface & transports it out of closure	G. Dissolved CO_2 escapes to atmosphere or ocean

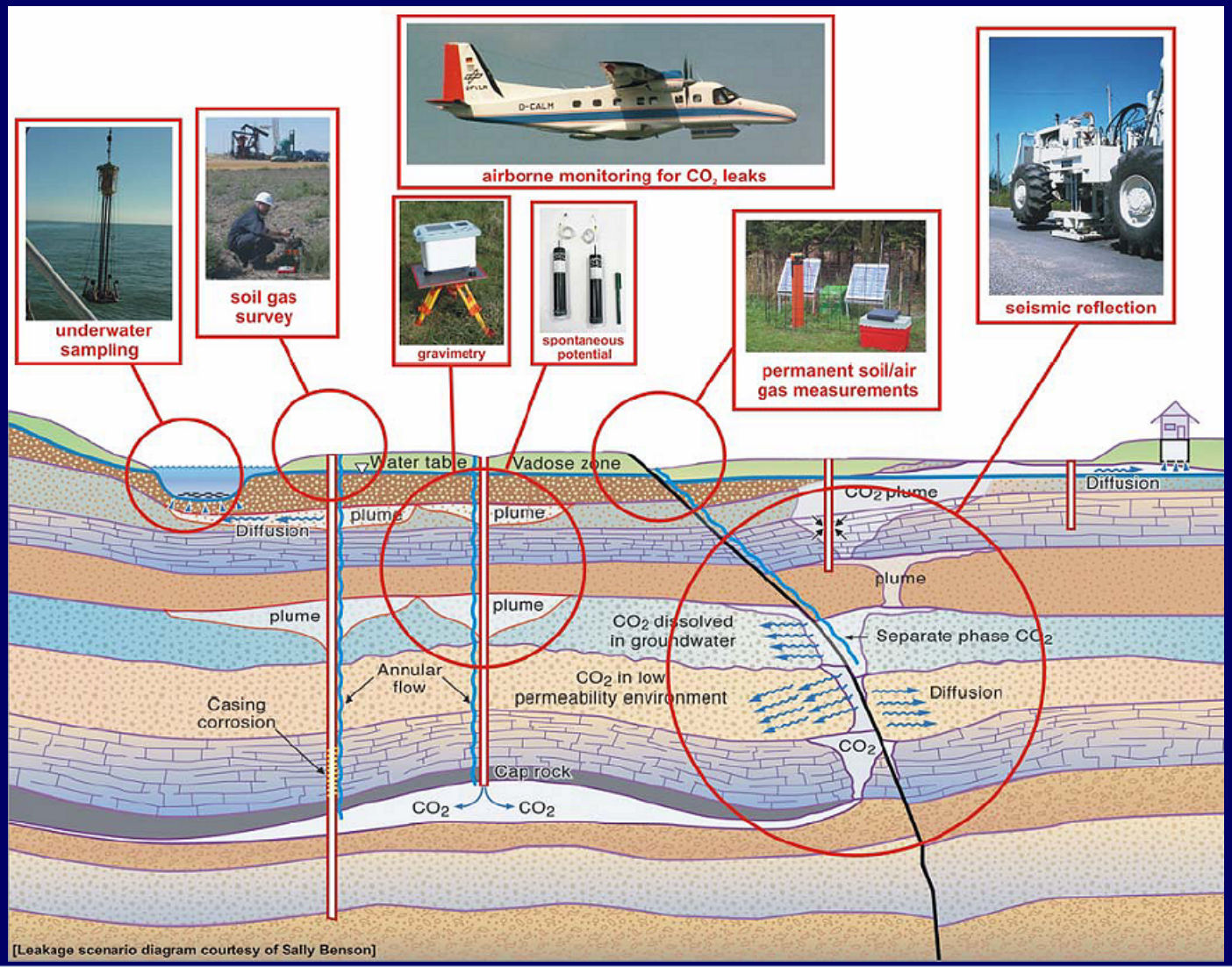
Remedial measures

A. Extract & purify ground water	**B**. Extract & purify ground water	**C**. Remove CO2 & re-inject elsewhere	**D**. Lower injection rates or pressures	E. Re-plug well with cement	**F**. Intercept & re-inject CO2	**G**. Intercept re-inject CO2

What makes a good storage site?

Stratigraphy	**Caprock**	**Storage formation**
	Low permeability	High permeability
	Large thickness	Large thickness
	Lateral continuity	Areally extensive
	Absence of faults	
Geomechanics	Tectonically stable	
	Favorable stress conditions	
	on faults and fractures	
Geochemistry	Mineralogies that:	
	- Buffer acidity increase	
	- Promote trapping as an immobile solid phase	
Anthropogenic Factors	Location and conditions of abandoned wells	

Monitoring: tailored to the storage site



[Leakage scenario diagram courtesy of Sally Benson]

Facts - 3

- CO_2 can be stored for 1,000s of years or longer
  - Based on fundamental chemistry and physics
  - Based on engineered and natural analogues

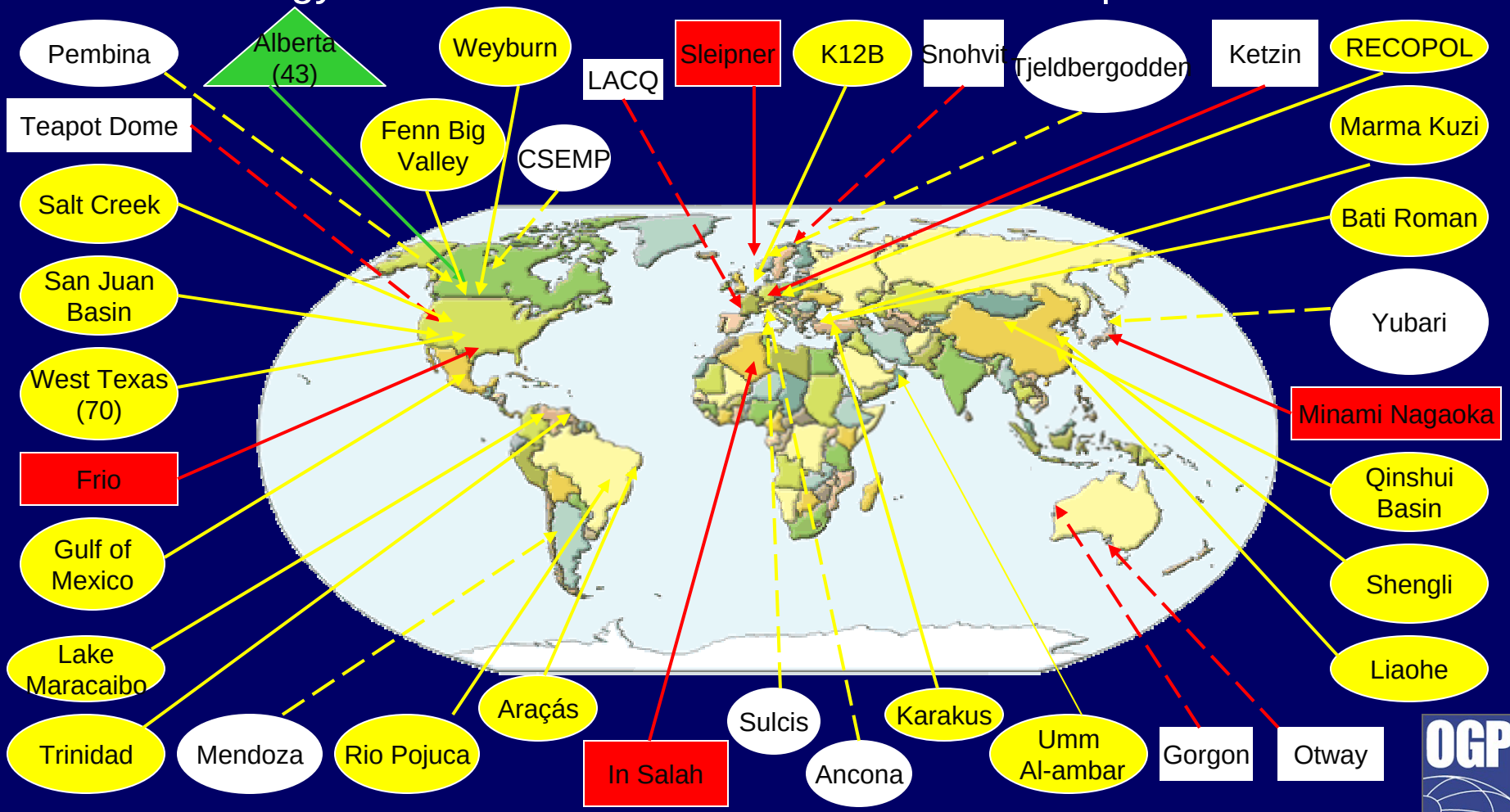
- According to IPCC the fraction retained in appropriately selected and managed geological reservoirs is:
  - very likely to exceed 99% over 100 years, and
  - likely to exceed 99% over 1,000 years.

"very likely“ is a probability between 90 to 99%

“likely" is a probability between 66 and 90%

Technology Deployment

- Clear momentum exists as projects are being deployed and technology continues to be researched and developed.



Regulatory Gaps - 1

- Existing regulations/legislation were not drafted with CO_2 storage in mind. There are no regulatory precedents for injection of large amounts of fluids into the underground for the purpose that they remain there for long periods of time.
- What is the legal status of CO_2 storage under national legislation and international environmental treaties?
  - There is a need to address the legal uncertainty about the implications of the OSPAR convention (for the permissibility of CO_2 storage under the North Sea) and the London Convention and Protocol.
- What post-abandonment does liabilities the operator have?
  - If liability is transformed into a state liability, when will this occur (at abandonment, or 10, 20 or 100 years thereafter) and what is the procedure/protocol that governs the transfer?

Regulatory Gaps - 2

Long term monitoring, verification and maintenance:

Who is responsible?

When CO_2 injection ceases, the operator should remain responsible for ongoing monitoring …

… until regulator and operator agree that trapping has been proven.

Who bears the costs?

The operator pays for long-term maintenance that could be required to ensure that CO_2 remains contained in the storage formation …

… until regulator and operator agree that trapping has been proven.

Public perception

- Public awareness of CCS is generally low to non-existent. Even when there is awareness, the people who are surveyed about their opinion towards CCS are often confused about the ability of CCS to address greenhouse gas emissions.
- The public in the EU and some environmental NGOs are becoming slightly less skeptical of the technology.
- Public perception is likely to change in the future. There are indications that geological storage could be viewed more favorably if it is adopted in conjunction with alternatives, and provided that CCS is seen as environmentally safe and climate change as an urgent problem.

Policy incentives

- Environmental technologies like CCS have no ‘natural’ markets in the absence of environmental policy.
- Emissions trading (EU ETS) and CDM could provide vehicles for incentivising potential investments in CCS.
- Eligibility for CCS credits under EU ETS and CDM untested.
- Commercially workable rules for long-term liability needed
- Extensive existing support for R&D activities; technology deployment and infrastructure development needs further consideration.

The Challenge

- CCS may become critical to society as a cost-effective way to reduce CO_2 emissions
- But:
  - Policies need to provide legal and regulatory clarity, thus ensuring a clear and stable business environment
  - Widespread deployment is dependent on environmental policies that create markets for CCS technologies
- Policy-makers need to create the framework
- Oil & Gas industry can offer expertise and opportunities