Final Report from the Improved Pore Space Utilisation Task Force

Max Watson & Brian Allison (Co-Chairs)
CSLF Technical Group Delegates
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Improved Pore Space Utilisation
CSLF Technical Group Task Force

- Team:
  - Max Watson (Australia), Brian Allison (United Kingdom), IEAGHG (Tim Dixon), France (Didier Bonijoly), Norway (Britta Paasch), Japan (Ryozo Tanaka), United Arab Emirates (Fatma AlFalisi)
- Task Force Objective:
  - Investigate the current status of techniques that have the potential to improve how well the capacity of reservoirs for CO_2 storage are utilised.
- Contents:
  - General Introduction & Background
  - Non-technical Issues Relating to Improved Pore Space Utilisation
  - Improved Sweep Efficiency from the O&G Sector
  - Technologies
  - Ranked Technique Effectiveness & Technique Status

Fundamental to Improved Pore Space Utilisation (IPSU)

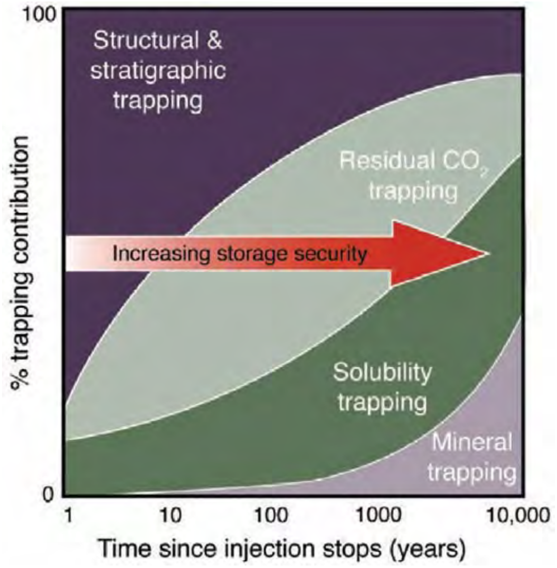
Direct costs benefits of IPSU:

- Reduced cost of monitoring

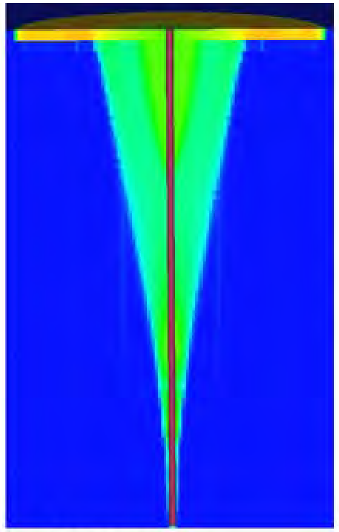
Further cost benefits of IPSU through improved economies of scale:

- Cost to explore and appraise
- Cost to transport
- Cost to operate

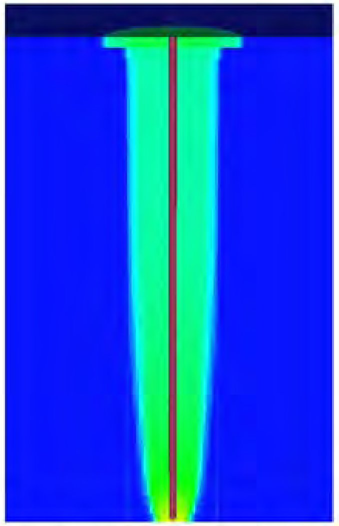
Increased storage security with IPSU



IPCC special report 2005



- Poor sweep
- Considerable CO_2 at top seal

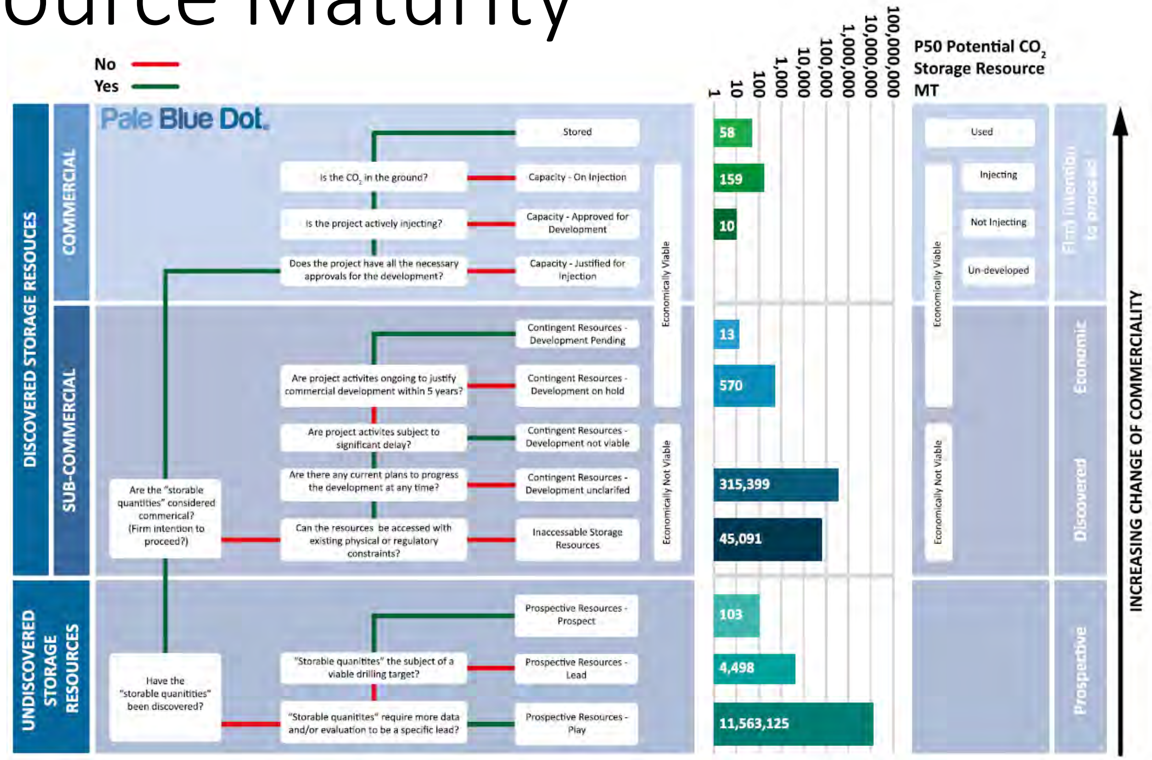


- Improved sweep
- Less CO_2 at top seal

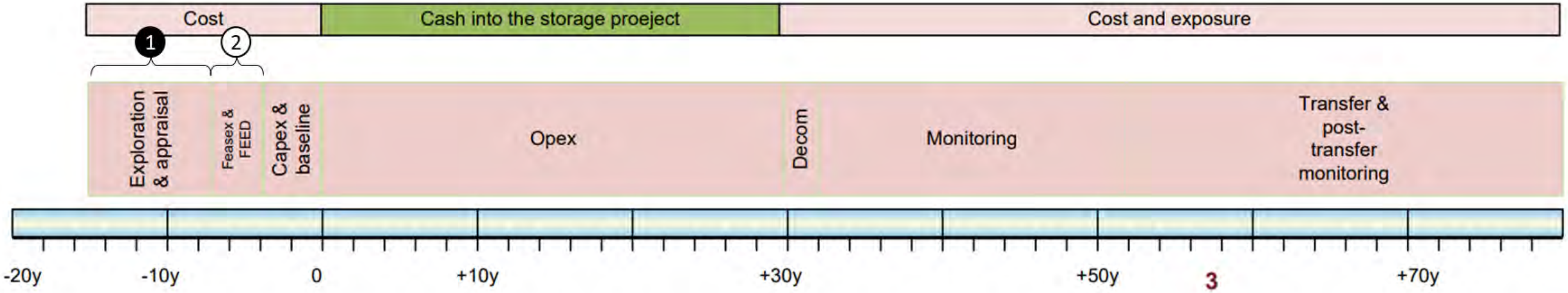
CO_2 Storage Targets and Resource Maturity

- CSLF Technology Roadmap Targets:
  - 2025: 1,800 Mt (400Mtpa), and
  - 2035: 16,000 Mt (2,400Mtpa)
- Internationally estimated storage resource: ~12,000,000 Mt
- Investment ready storage resources: ~750 Mt
- Challenge to increase resource:
  1. Geographically - Increase effort in exploration & appraisal urgently required
  2. Site specific - Improved pore space utilisation in the feasibility and design

2017
Carbon Sequestration
TECHNOLOGY
ROADMAP



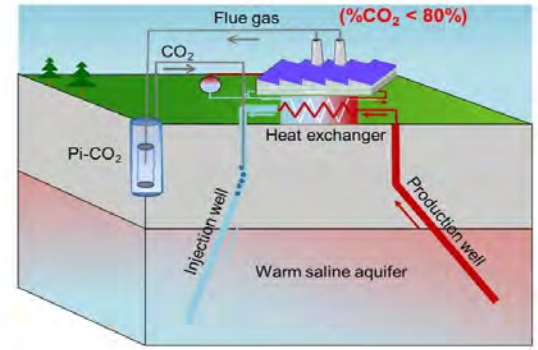
OGCI: Multinational CO_2 Storage Resource Assessment, 2017



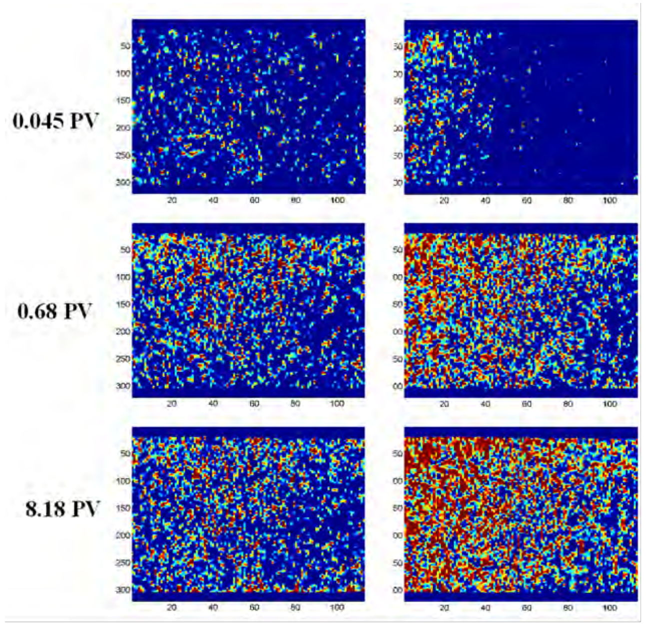
ZEP: The case of a 'market maker' and a business model for CO_2 storage, 2016

Improved Pore Space Utilisation Techniques

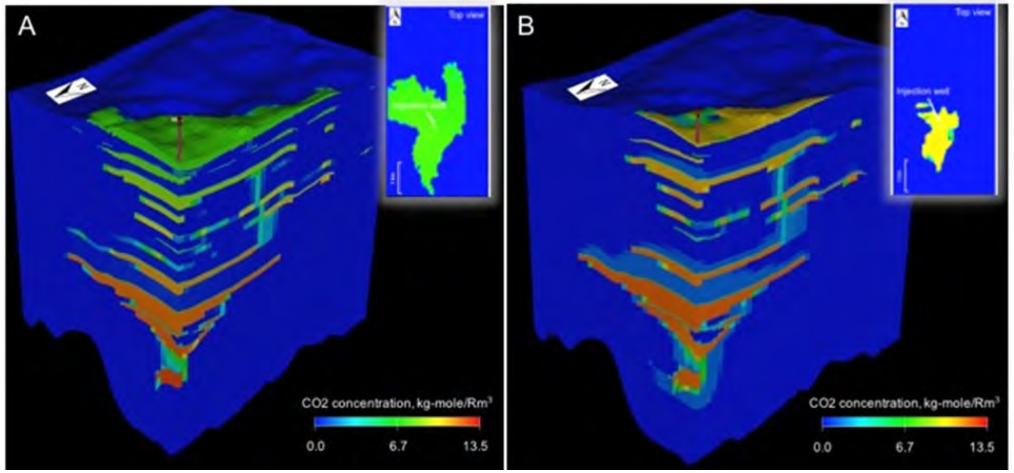
- Improved Sweep Efficiency techniques from the oil and gas sector
  - Polymers
  - Surfactants
  - Foams
- Pressure Management
  - Relief wells (active and passive)
  - Increased Injection Pressure
- Microbubble CO_2 Injection (Japan)
- CO_2 Saturated Water Injection and geothermal energy (France)
- Compositional, Temperature and Pressure Swing Injection (Norway)



CO_2 DISSOLVED facility



X-ray CT images of Brine-Saturated Cores:
Right: Microbubble CO_2 Injection
Left: Normal-size Bubble CO_2 Injection



Modelled output of compositional swing injection

Technology Maturation Prioritisation / Recommendations & Other Technologies of Merit for Site Specific Operations

P	Technology Type	Prior R&D and application	Technology Readiness Level (TRL)#	Technology Prospectively	Core Recommended Action
1	Microbubble CO_2 Injection	Laboratory and Modelled, prototype	TRL 4	High potential	Trial at in field research facility
2	Swing Injection	Laboratory and Modelled	TRL 3	High potential	Validate technology at lab scale
3	Increased Injection Pressure	Laboratory and Modelled	TRL 3	High potential	Validate technology at lab scale to assess sweep effectiveness in heterogeneous reservoirs
4	Active Pressure Relief (increase sweep & reduce lateral spread)	EOR, planned for Gorgon CO_2 injection project	TRL 6	High potential	Pressure relief - Key lessons drawn from active commercial project using pressure relief wells as a risk mitigation technique
5	Foams (block high permeability pathways)	EOR	TRL 6	Reasonably well understood	Modelling of application effectiveness prior to Demonstration at commercial scale
6	Passive Pressure Relief	Modelled	TRL 4	Limited effectiveness	Trial at field research facility. Consideration around long-term fluid management
7	Polymers (increase formation water viscosity)	EOR	TRL 7	Reasonably well understood	Cost effectiveness investigations. Demonstration at commercial scale*
8	Surfactants (reduce residual saturation of formation water)	EOR	TRL 7	Reasonably well understood	
9	CO_2 saturated water injection & geothermal energy	Laboratory and Modelled	TRL 3	Site specific & lower volume	Seek opportunity to trial PI-CO_2 technology at lab scale

Other Technologies of Merit

- Wells
  - Design: Well count, orientation
  - Downhole design:
  - Injection operation: Flow control, well switching, pulsing

Recommendations for a 'Related', 'Future' CSLF Task Force Activities

IPSU focused on leveraging the pore space to maximise development investment and minimise area for monitoring

It did not include reservoir management from a risk basis

Recommendation: A future new task force on CO_2 storage reservoir management is recommended incorporating:

- The IPSU TF's learnings and associated technology maturation
- Existing and emerging reservoir management practices*
- Existing and emerging well engineering practices*

*Including CSLF recognised project's practices

Thank you