Carbon Sequestration Leadership Forum
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CCS Technology Developments Gaps, Opportunities and Research Fronts

Washington D.C. United States
CSLF Technical Group Meeting
November 5, 2013

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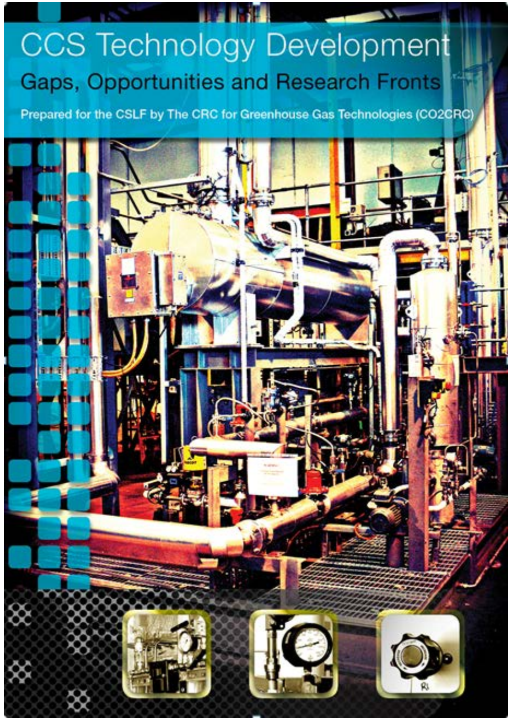
CEO CO2CRC

Technology Opportunities & Gaps Task Force



carbon sequestration leadership forum

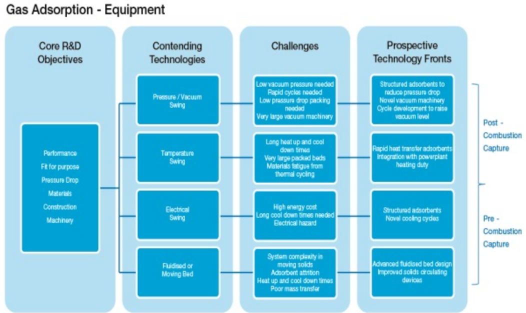
– Members:

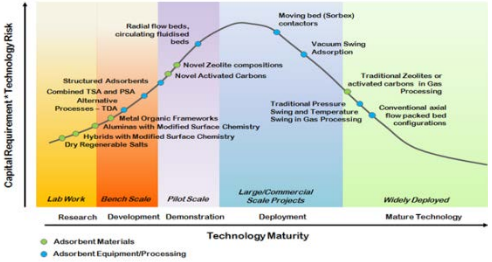
- Australia: Richard Aldous
- Korea: Chang-Keun Yi
- Norway: Lars Ingolf Eide
- USA: Mark Ackiewicz

- Also valuable input from CO2CRC researchers and Valery Linton & Stanley Santos

Overview

- Identified key research fronts in CCS
- Opportunities, gaps & recommendations
- Considers the dynamics around CCS technology development
- Supports 2013 CSLF - TRM
- A CSLF listing of R&D pilot plants

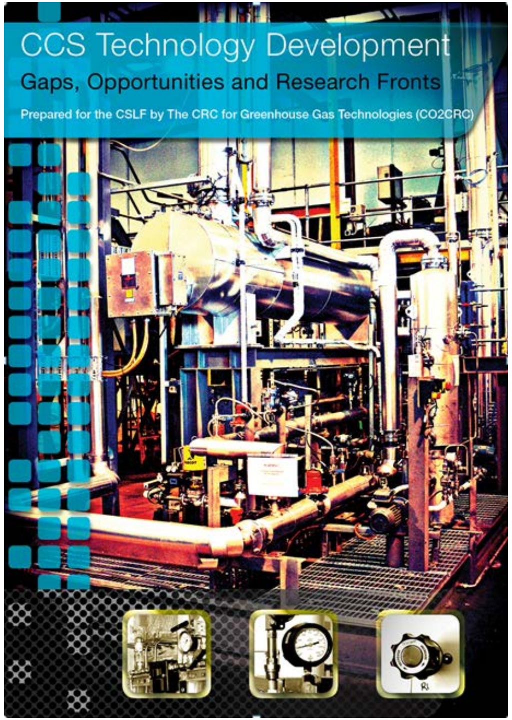




Sections of Report:

carbon sequestration leadership forum

- **Capture and Integrated Combustion**
- **CO_2 Transport**
- **Storage**
- **MMV**
- **Knowledge & capability building**
- **Industry dynamics and technology development**
- **Listing of pilot projects**



Example

Solvent Absorption - Materials

Core R&D Objectives	Contending Technologies	Challenges	Prospective Technology Fronts
		Regeneration Energy	

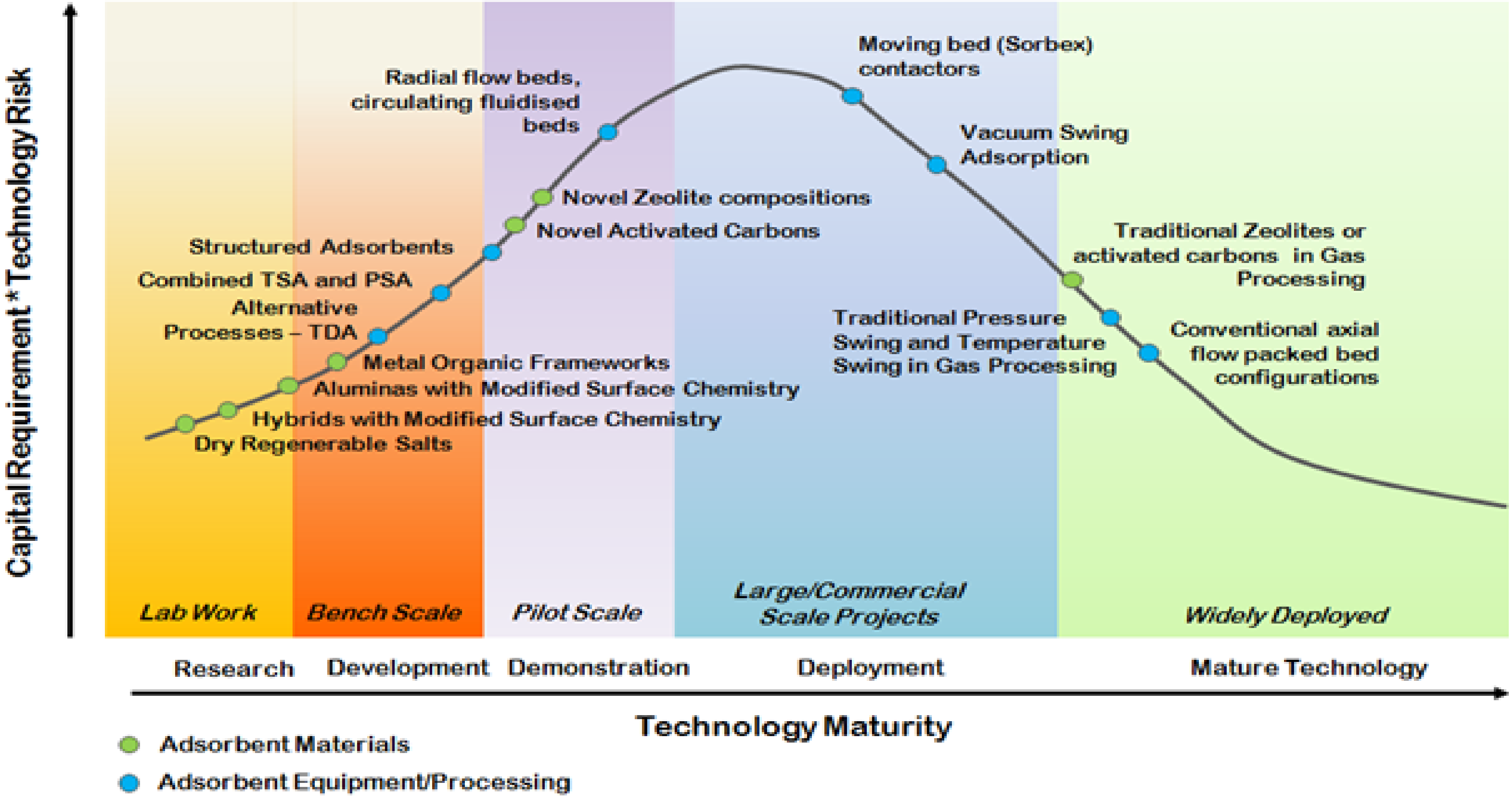
Prospective Technology Fronts : Solvents

- Amines	Precipitating amino acids Oxidation inhibitors Reducing vapour pressure
- Carbonates	Promoting reaction rates Solids handling
- Blends	Combining best features of solvents
- Ionic liquids & Immiscible liqs.	Separation techniques material manufacturing
-Physical Solvents	Blends to improve absorption rates High temperature thermal stability

Post - Combustion Capture

Pre - Combustion Capture

Current Status of Adsorbent Technology



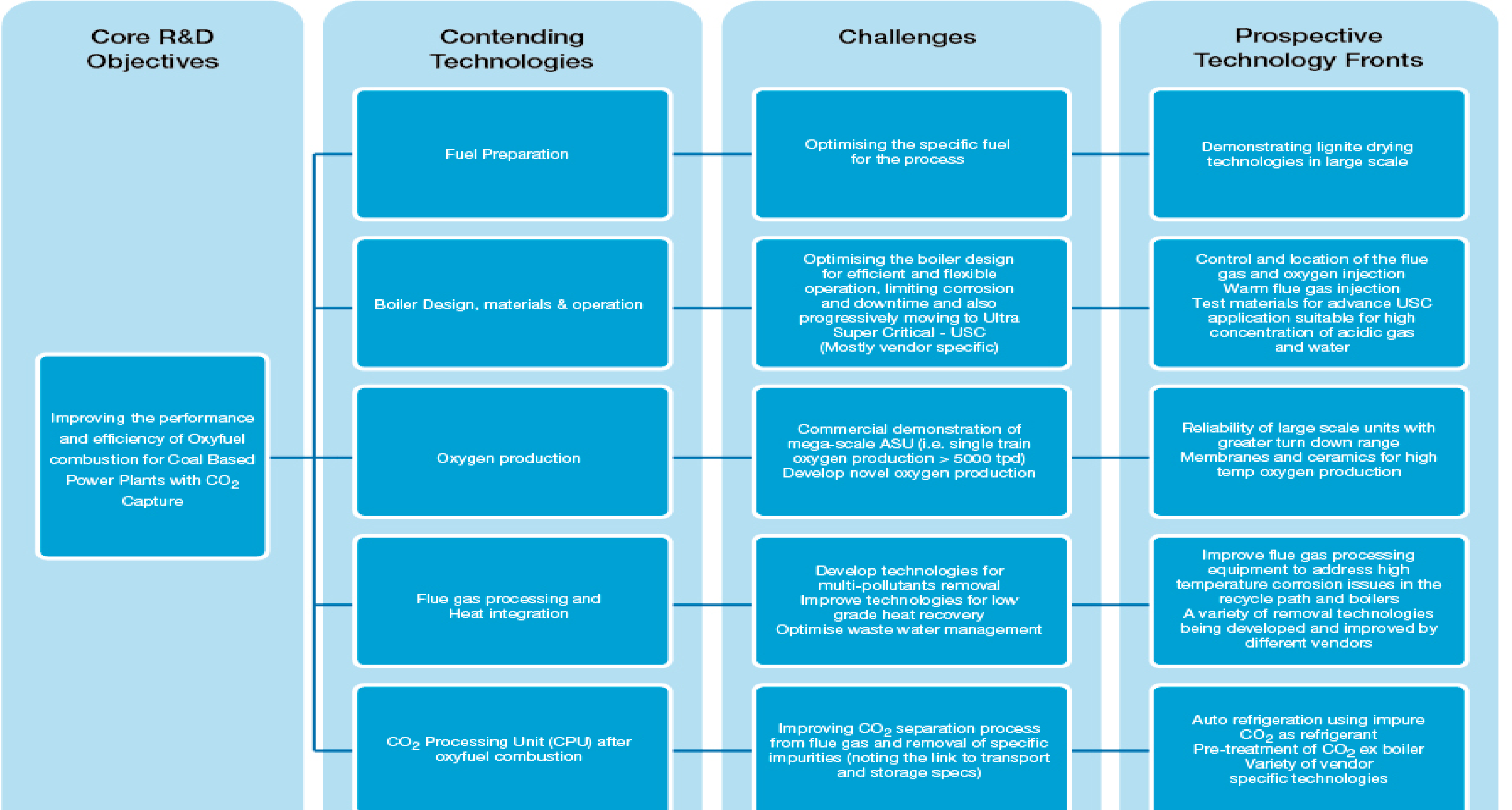
Overall High Level Observations

- At a high level there are no major technology gaps
  - CCS technologies are ready and available and being deployed today.
- There are many contending capture technologies – in both current technologies & 2nd and 3rd generation technologies
- Next generation technologies vital for substantial cost reduction
- No strong market pull for technologies at the moment
- The lack of exploration is a significant barrier to rapid deployment and thus learning by doing

Observations on Capture & Integrated Combustion

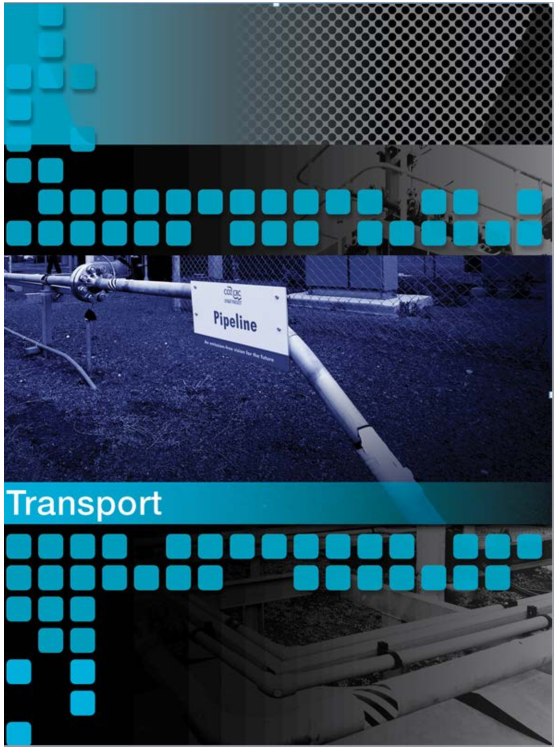
- Capture technologies are available (mostly solvent-based) and deployed
  - cost of these technologies will continue to fall substantially by 2025-2030.
- Need to support 2nd and 3rd generation technologies,
  - Lead times can run to decades.
  - Adsorbents and membranes may well play a big role.
- Pre-combustion capture also progressing
- Chemical looping – cement industry developments
- Oxy fuel technologies progressing well – low cost ASU the key
- Capture of CO_2 from gas combustion needs to be progressed

Technology and Engineering Fronts for Oxyfuel Combustion



Transport

- Transport pipeline technology is mature and available; however, some technology improvements are needed to get costs down and further increase safety.
- Large scale transport of CO_2 by ship offers promise and needs to be demonstrated at scale.
- Experience is needed in planning, designing and implementation of large-scale CO_2 transport networks.



Fundamental Storage R&D

Storage Geology

Eg Seals, faults saline aquifers

Sub surface CO2 behaviour

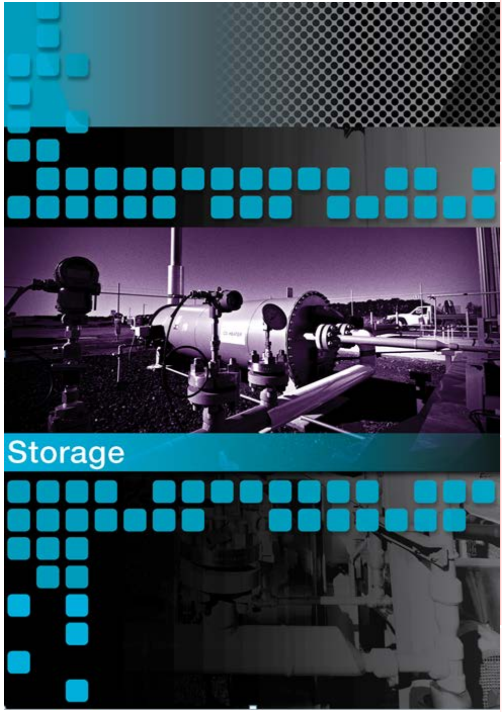
Eg fluid flow, trapping mechanisms.

MMV technologies

Eg seismic EM etc

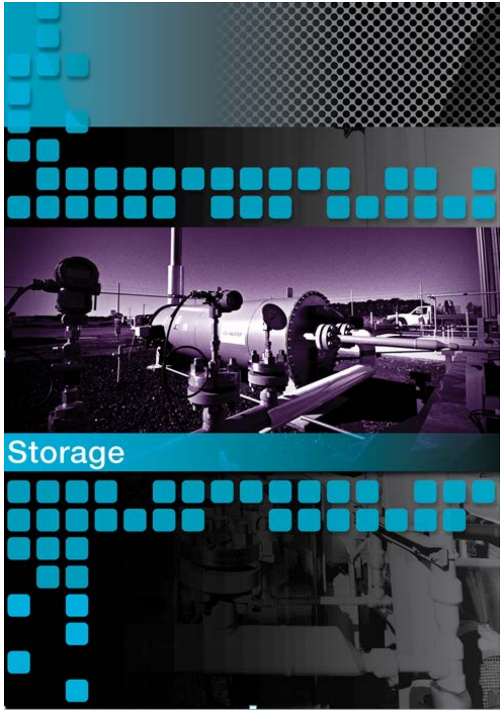
Storage

- CO_2 storage technology builds on years of research & experience in oil & gas
- There are fundamental and applied aspects of CCS that are unique



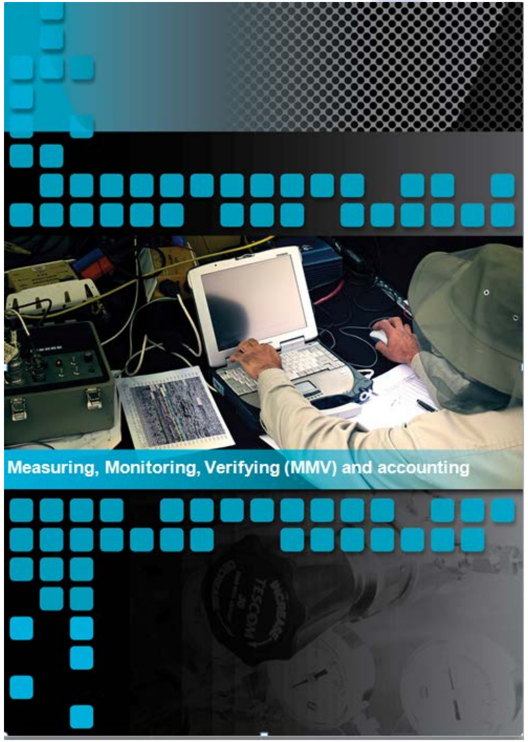
Recommendations on Storage

- Need to continue both fundamental and applied R&D
  - Modelling and understanding CO_2 behavior in the subsurface must be continued to improve operational efficiency and effectiveness of storage
- Internationally consistent standards required (based on oil and gas industry practice) for:
  - Storage site characterisation methodologies;
  - Storage efficiency factors; and
  - Capacity estimation and reporting standards.
- Technology and risk management strategies to mitigate or manage unintended CO_2 migration.



Recommendations on MMV

- Continue towards continuous, high resolution, low cost, low impact subsurface monitoring;
- Develop new seismic interpretation and inversion techniques for enhanced CO_2 detection.
- Establish technologies and methodologies for offshore (sub marine) MMV
- Continue work on controlled release calibration and natural analogues; important for CO_2 detection and accounting;
- Develop an agreed methodology and language for dealing with most monitoring – a null result;



Recommendations on other aspects

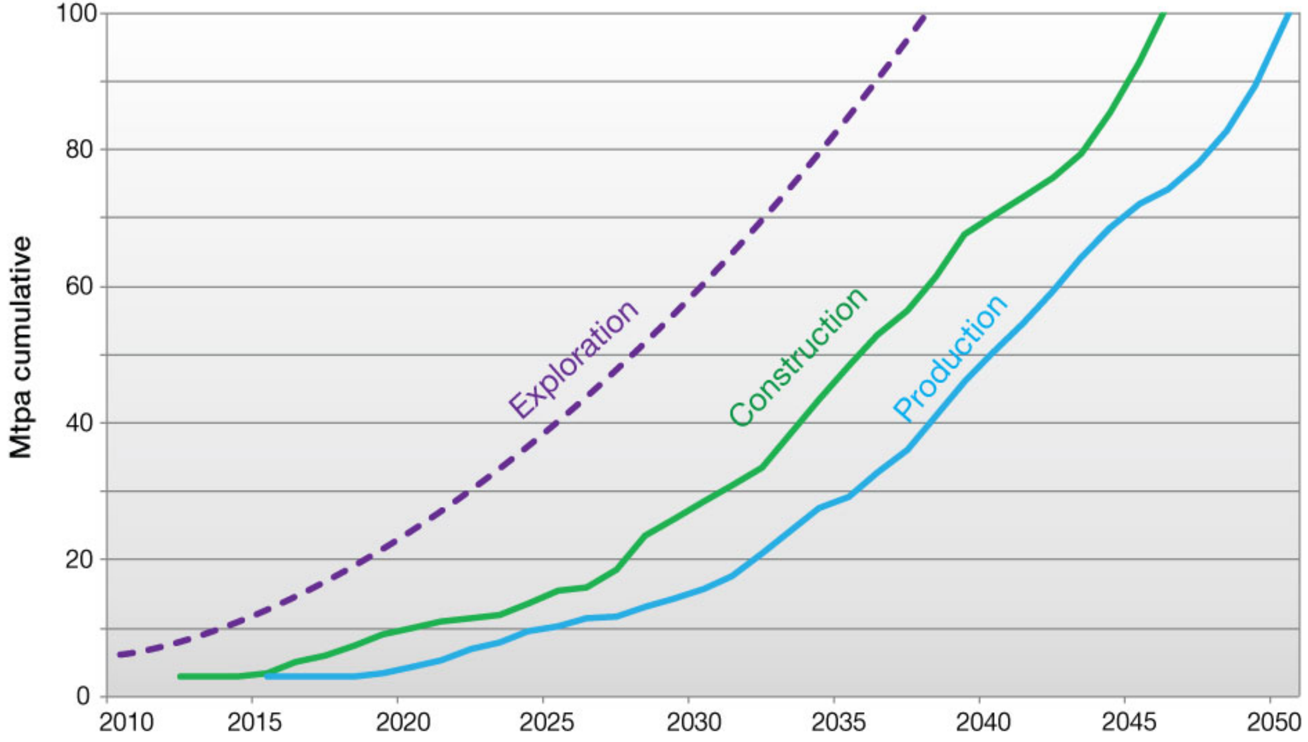
Building technical knowledge capability and people

- Continue R&D and technology development to both develop the knowledge base and to train engineers and scientists in CCS technologies.
- Stimulate international collaboration.

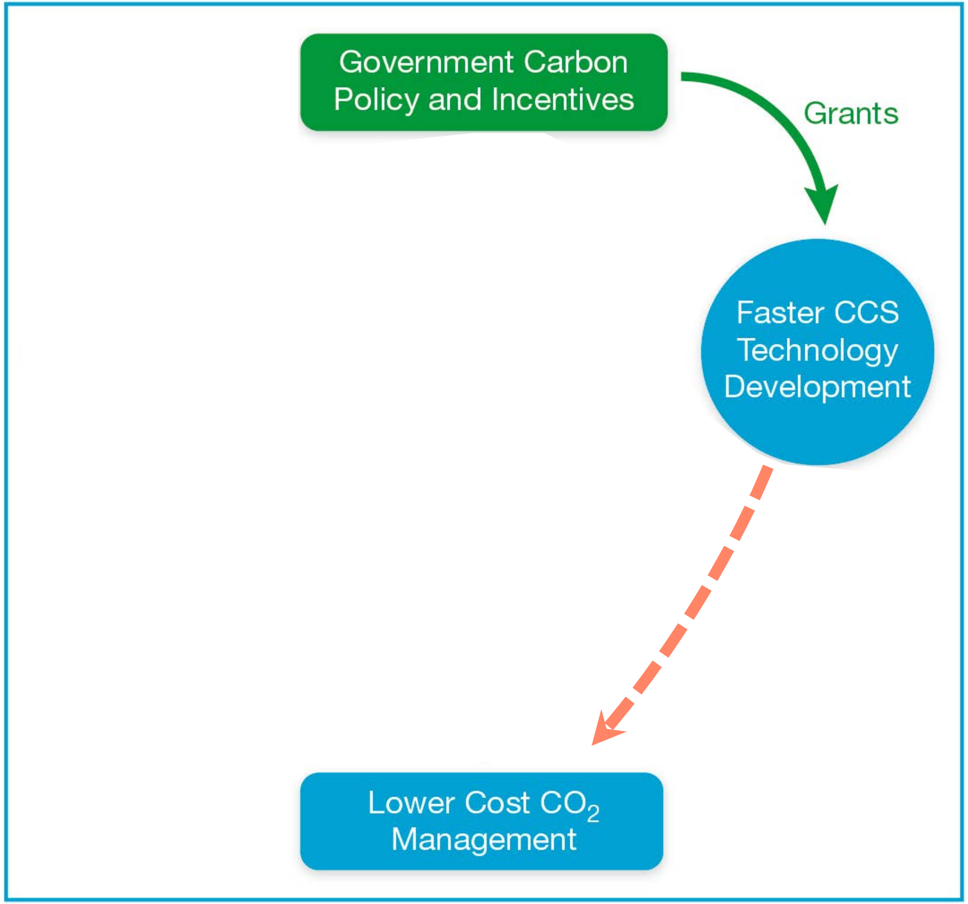
Industry dynamics associated with exploration and technology development

- Start the identification and pre-competitive data generation of prospective storage basins, making assessments of the likely realistic storage capacity.
- Either start exploration or incentivise the private sector to start exploration.

Exploration Lead Times



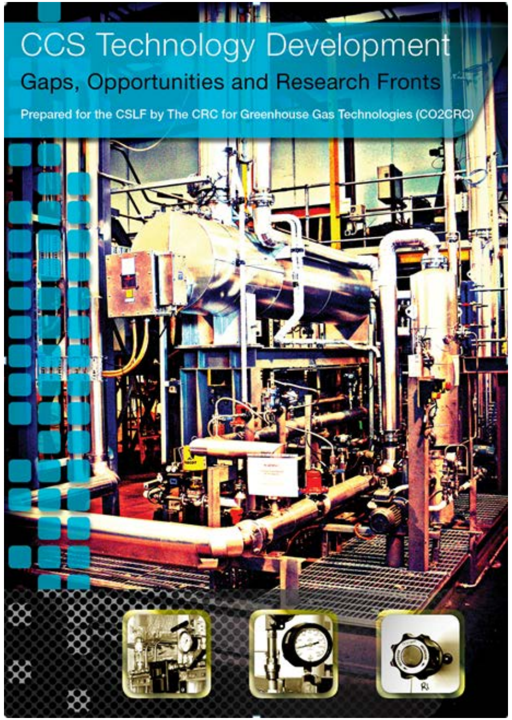
Incentives Dynamics Exploration & Technology



- Governments provide grants or incentives
- Market dynamics will drive exploration and technology progress

Concluding Thoughts

- Governments now have a technology that can be deployed to manage carbon emissions.
- Consider the role of government in USA SO_2 scrubbing and the nuclear industry , and gas pipelines in many countries
- The rate of take-up and associated improvements in technology needs to be incentivized.
  - important for getting new projects up
  - vital to pull next generation technologies through development



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