IEA Greenhouse Gas R&D Programme

What have we learnt from regulatory developments and large scale projects?

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Introduction

- Discuss regulatory developments and summarise learning
- Discuss recent work IEA GHG has undertaken on summarising learning from existing large scale projects

Regulatory Developments

- EC CCS Directive
  - Enabling regulatory framework to ensure environmentally sound CCS
- Issued 6 April 2009
- Principles:
  - Follows IPCC GHG Guidelines and OSPAR
  - Objective is permanent storage
  - Ocean storage prohibited
  - Permits will be required for CCS – exploration and storage
  - Storage permit only if “no significant risk of leakage”
  - Emphasis on site selection, characterisation, risk assessment, monitoring plan
  - Corrective measures plan, and provisional post-closure plan

ETS Directive

Proposed 23 Jan 2008 - to strengthen, expand and improve the ETS from 2013. Now agreed.

CCS

- CCS fully included from 2013
  - Site and operation will need to comply with CCS Directive
  - Needs monitoring and reporting guidelines - underway
- No free allocation to CCS (same as electricity)
- Separate permitting of capture, transport and storage
- If any leakage – surrendering of allowances
- If leakage from storage suspected from monitoring under CCS Directive, then trigger ETS monitoring to quantify
- Biomass and CCS can be opted in

National European Regulations

- UK
  - Energy Act - Enabling powers to control CCS
  - Assert UK right to store beneath seabed to 200nm
  - Assigns ownership to State
  - Requirement for lease
  - Requirement for licence
  - Provision for regulation of site after closure
  - Extend Petroleum Act to cover decommissioning
  - Passed on 26 Nov 2008 – now Act of Parliament – law from 6 April
  - Industry consultation underway
- Germany – modifying existing oil and gas exploration regulations
  - Expected July 2009

Australian Legislation

- **Offshore Petroleum and Greenhouse Gas Storage Act 2006 (Nov 2008)**
- Access and property rights for waters under Commonwealth juristiction
- Site Plan – site characterisation, predictions, operations, monitoring, risk assessment and management, remediation
- Requires operators to bear the Commonwealth's costs of post-closing monitoring and verification
- 20-year limit following project closure on common law liability (5 +15). After this time, the Federal Government assumes long-term liability
- “No significant risk of significant adverse impact” (petroleum and ghg)
- Regulations and Guidelines under development.
- Release of 10 areas for exploration applications 27 Mar 2009 – incl access to CO2 supply

Australian Legislation

- **Carbon Pollution Reduction Scheme (CPRS) – ETS proposed in White Paper Dec 2008**
  - Cap and trade scheme
  - Operational 2010
  - CO_2 transferred to CCS counts as not emitted
  - Obligations for emissions from capture, transport and storage
- **Federal Legislation**
  - Victoria Greenhouse Gas Geological Sequestration Act 2008
  - Queensland Greenhouse Gas Storage Act 2009

Regulatory developments in other regions

USA –

- Existing Underground Injection Control programme for ground water protection adapted for Pilot projects
- US EPA have developed Federal level regulations “Draft Rule” for CO_2 storage (Jul08)
- Interstate Oil and Gas Compact Commission developed recommendations for regulations for CO_2 storage at a State Level

Canada

- Canada – acid gas injection and CO2-EOR already permitted in states like Alberta
- Federal /AlbertaTask Force recommendations for CCS regulations (Apr08)

Japan

- Adapted marine laws

Regulatory lessons learnt

Regulatory principles for CCS to ensure environmental integrity:

- Site-by-site assessment
- Risk assessment
- Site characterisation and simulation, supported by monitoring
- CO_2 stream impurities determined by impacts on integrity

Development of regulation:

- Use the technical and scientific evidence base
- Learn from existing regulatory developments
- Benefit of having real projects to drive and test regulations

What have learnt from these projects?

- Feedback from a study undertaken by IEA GHG
  - Canvassed large scale injection projects
- Feedback from our international research activities :
  - Monitoring
  - Well bore integrity
  - Risk assessment
  - Modelling

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 100ktCO_2
- Injection over 10ktCO_2 for storage
- Monitored EOR over 10ktCO_2
- Capture over 10ktCO_2 from flue gas
- Coal bed storage over 10ktCO_2

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Largest CO_2 Storage Projects

Snohvit capturing and injecting 0.7Mt/y CO_2 since 2008

Rangeley injecting 0.8 Mt/y CO_2 since 1980's

Sleipner capturing and injecting 1Mt/y CO_2 since 1996

Weyburn capturing and injecting 1.6 Mt/y CO_2 since 2000

Total Anthropogenic CO2 captured and injected currently 5 Mt/y

In-Salah capturing and injecting 0.8 Mt/y CO_2 since 2004

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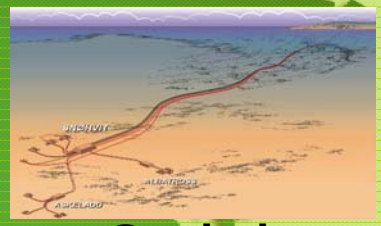
Capture and Transport Technical Status

ICON

Pipeline network to capture and supply 1.2Mt/y CO2 by 2010

CO flooding in the Permian Basin demonstrating COsources (yellow), flooded oil fields (green) and associated transmission lines.

Permian Basin, 3000km pipeline network operating since mid 80's



Snohvit 160km Sub sea pipeline

Weyburn 300km transboundary pipeline

Long distance transport of CO2 by pipeline is established technology

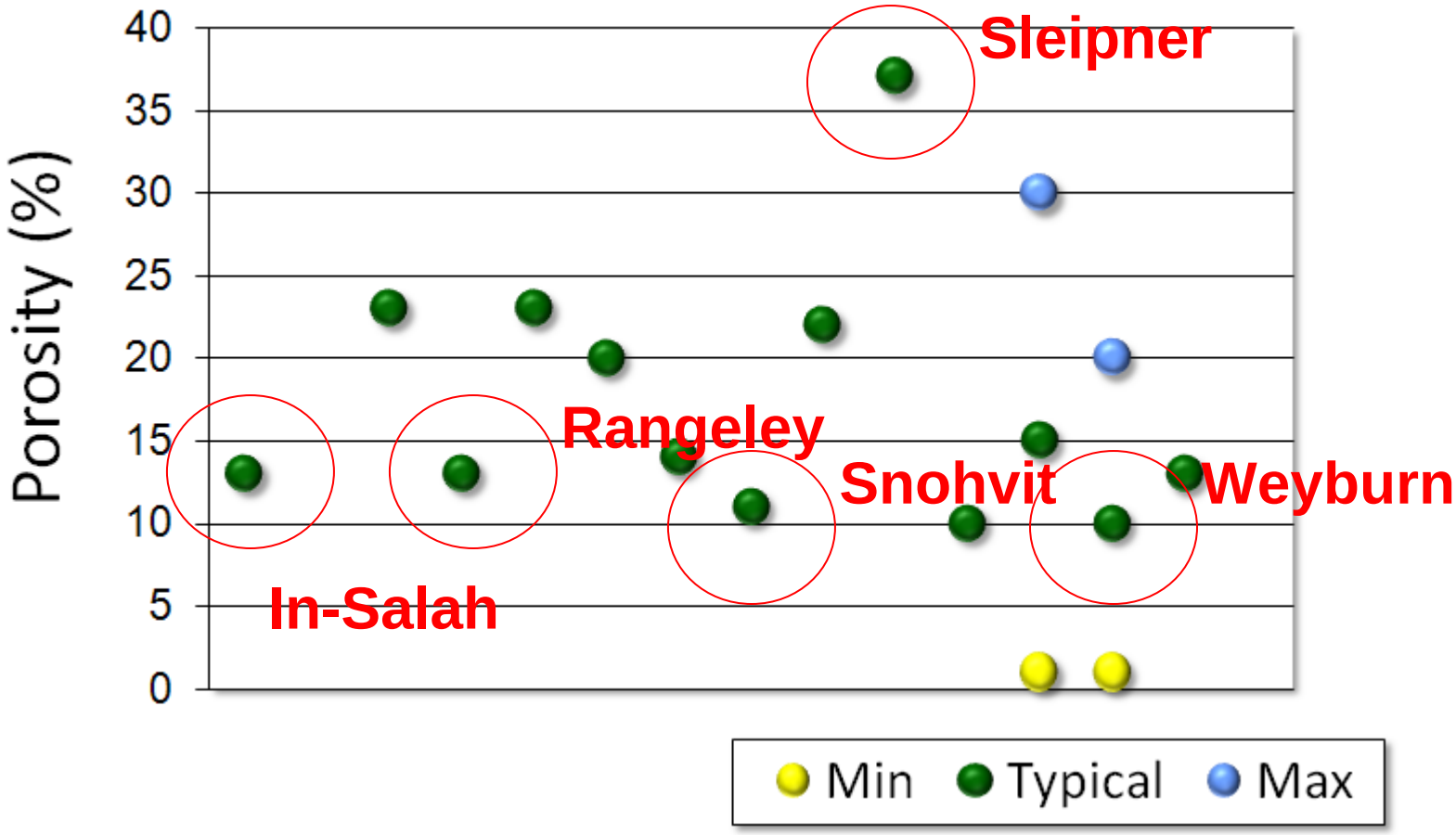
Capture

- Amine scrubbing demonstrated at 1Mt/year scale on natural gas plants
  - No significant operational problems reported
- No demonstrations on power plants yet
- Not in a position to decide which is best capture options
  - All three options still on the table
  - Allowed impurity levels will define costs

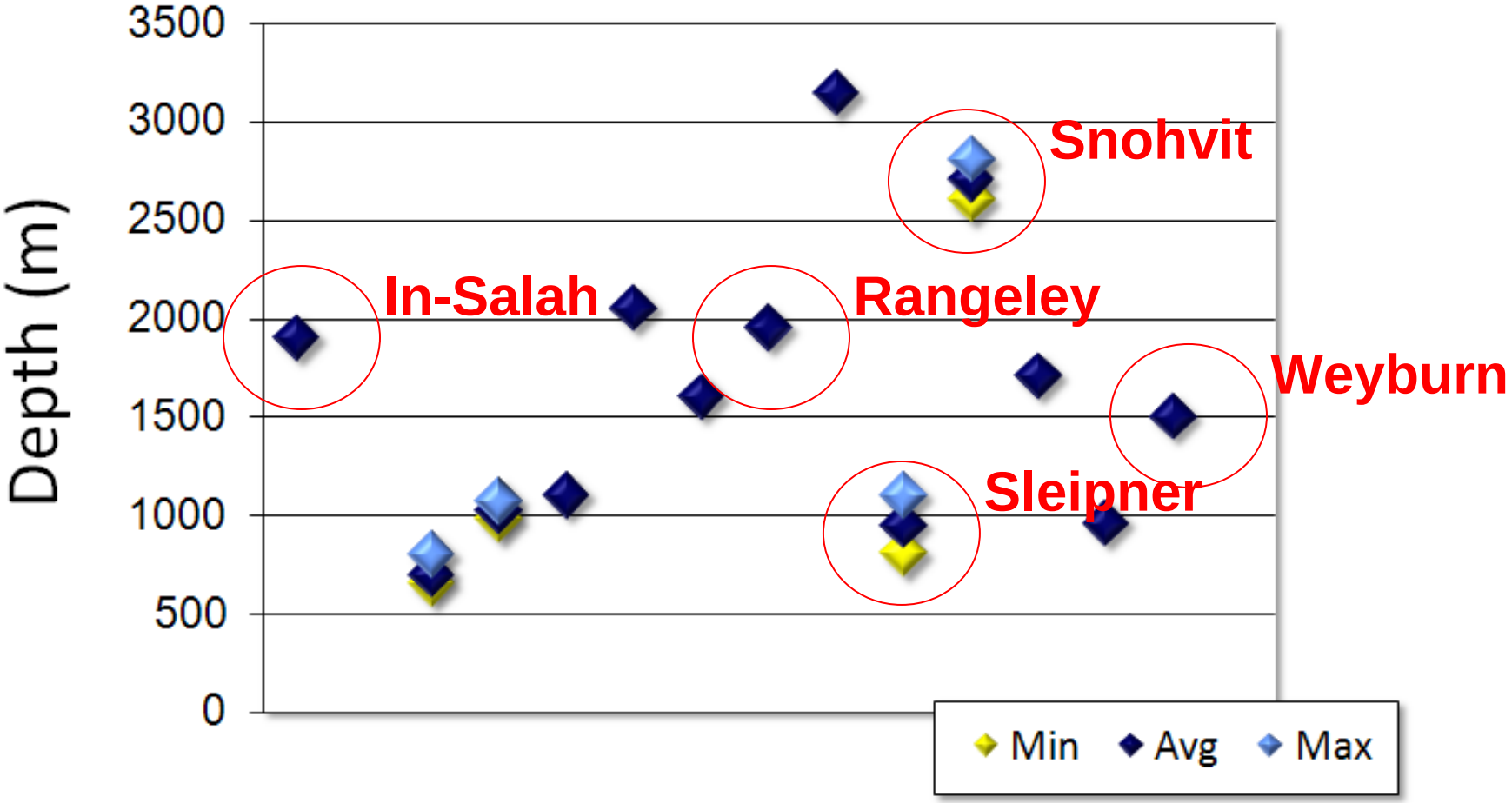
Technical Challenges

- Post combustion capture on flue gas
  - Large number of pilot plants in operation
  - A lot of commercial activity
  - Technology not yet demonstrated at scale
- Pre combustion capture
  - Technology components available but whole process integration could be a challenge
  - Hydrogen turbine not commercially available?
- Oxy fuel combustion
  - Pilot scale tests needed to build confidence in this option.

Porosity Range of Large Injection Projects



Reservoir Depths



Summary

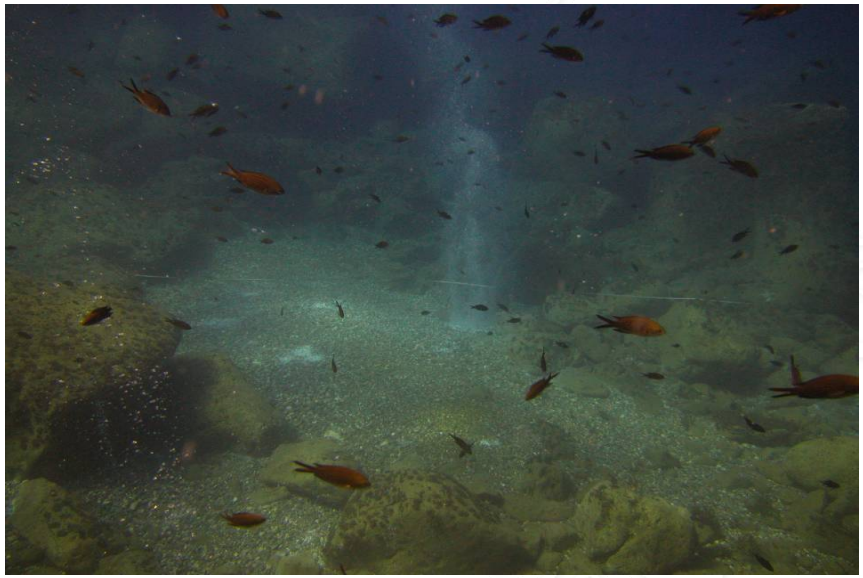
- CO_2 has been injected into:
  - Unconsolidated sand bodies offshore (Sleipner)
  - Both tight sandstone and carbonate reservoirs on shore (In-Salah & Weyburn)
  - Depths ranging from 800 to >3000m
- Some injection problems identified
  - No insurmountable problems
- Injection wells
  - Single well - Sleipner
  - Multiple distributed wells - Weyburn

Monitoring Experience

- No firm evidence from any of the large scale projects that leakage is occurring
  - Weyburn (~7years), Sleipner (~13 years), Rangeley (~25 years)
- Only one project has identified any surface seepage – Rangeley
  - Most recent results indicate CO_2 at surface is biologically converted from CH_4 microseepage
- Monitoring lifetimes are short <25 years
- Cannot quantify injection volumes or seepage rates at present

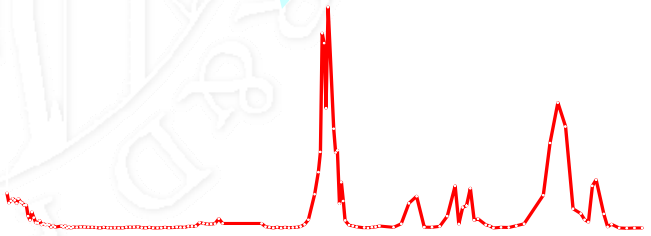
Leakage

- Natural analogues have been used to study environmental impacts of leakage along faults



The impact of the gas is limited. Schools of fish swim around the gas plume **Panarea, Italy.** Prof Lombardi. URS

Latera caldera



CO_2 flux - *leakage only at permeable points along faults*
Prof Lombardi. URS

Summary

- Have an extensive database of information from existing projects
- PC Capture demonstrated at 1 Mt/y scale on natural gas refining plants
- Long distance pipeline transport demonstrated
- Portfolio of storage projects
- Storage demonstrated at 1 Mt/y scale in wide rage of geological reservoirs

Thank You!

Happy to take any questions!