IEA Greenhouse Gas R&D Programme

Eighth Annual Conference on Carbon Capture & Sequestration

IEA Greenhouse Gas R&D Programme Special Session

What have we learnt from large scale CCS projects?

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IEA GHG Contracting Parties and Sponsors

What have we learnt to date - projects?

- Review current operational large-scale CCS projects
  - Assess learning from projects
  - Identify gaps in the global CCS project portfolio
- Focus on projects relevant to full-commercial scale operation
  - Includes:
    - Large-scale pilot
    - Demonstration
    - Commercial
  - Excludes
    - Small and medium pilot
    - Lab scale
  - Define criteria – Identify projects – Collect information - Analyse

Criteria for large-scale operational projects

- Indicative criteria defined for ‘large-scale operational projects’
- Was, or had been, operational by the end of 2008, and either:-
  - Captured over 10,000 tCO_2 per year from a flue gas
  - Injected over 10,000 tCO_2 per year with the purpose of geological storage with monitoring
  - Captured over 100,000 tCO_2 per year from any source
  - Coal-bed storage of over 10,000 tCO_2 per year
- *Commercial CO2-EOR was excluded unless there was a monitoring programme to provide learning*
- *Did not need to be fully integrated*
- Added term ‘*large-scale operational*’ to IEA GHG Projects Database

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

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- 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

Project Locations

- 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

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	• Ship	• 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)

Extent of Coverage

- If integrated CCS from electricity production is a 4 link chain:
  - Electricity production
  - Capture
  - Transport
  - Storage
- 2 and 3 link chains have been demonstrated over 1Mt CO_2 per year

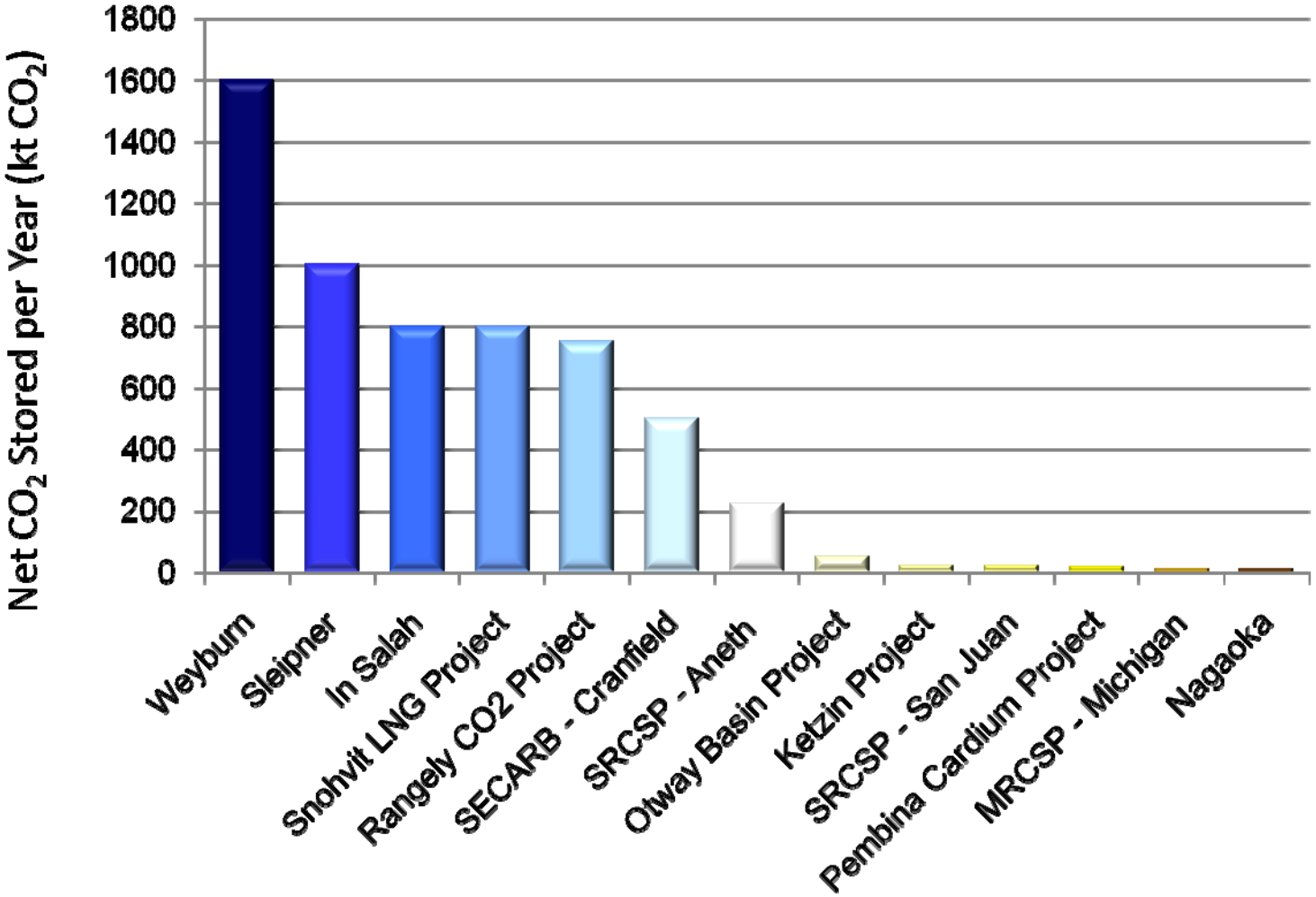
Extent of coverage - Capture

- 13 plants capturing from combustion processes
  - 11 post-combustion
  - 1 pre-combustion
  - 1 oxyfuel
- 9 projects source CO_2 from industrial processing (Natural gas separation, ammonia, LNG, hydrogen production)
- Multiple fuels represented
  - Hard coal
  - Lignite
  - Natural Gas
  - Industrial processes
- Over 10Mt of CO_2 captured per year

Extent of coverage - Transport

- Pipeline
  - Single sink source pipelines
  - Multiple source-multiple sink pipeline networks
- Truck
- Cross-border transport
- Transport over 860km

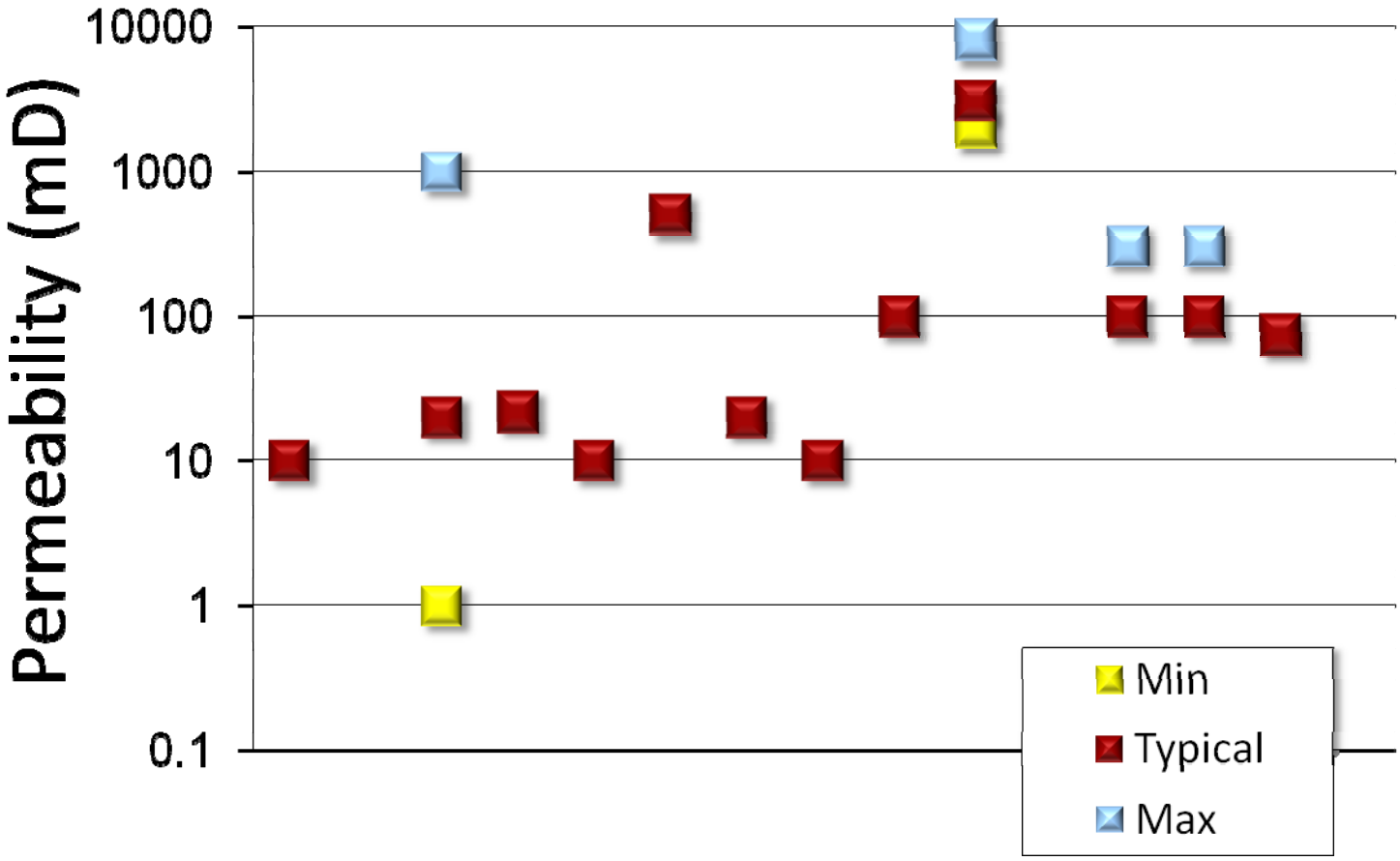
Net CO_2 Storage per Year



Extent of coverage – Monitoring

- 2D seismic
- 3D seismic
- 4D seismic
- Vertical seismic profiling
- Cross-well seismic
- Electrical conductivity
- Microseismic
- Passive seismic
- Soil gas sampling
- Detector arrays
- Eddy covariance
- Observation wells
- Time lapse microgravity
- Well temperature and pressure
- Well logs
- Tracers
- Ground water geochemistry
- Interferometry
- Satellite imaging
- Tilt meters

Permeability



Emerging Themes

- **Injectivity** – importance, problems, solutions
- **Material corrosion** – less than anticipated
- **Seismic**
  - Effective for monitoring the CO_2 plume - where it can be used
  - Not quantitative beyond a certain resolution
  - Expensive
- **Other monitoring** – e.g. electrical conductivity viewed as promising; desire for better direct sampling at reservoir conditions; can we move from R&D to commercial suite of tools?

Preliminary Conclusions

- Elements of CCS are operating at large scale
- Integrated CCS is operating at large scale, just not from power plant
- **There is a lot that has been learnt from existing projects, but more can be done to share the learning**
- CCS industry can build on existing projects' experience
- Increasing IPR issues will affect sharing learning

IEA Greenhouse Gas R&D Programme

- General - www.ieagreen.org.uk
- CCS - www.co2captureandstorage.info