# What Have We Learnt about $CO_2$ Geological Storage?

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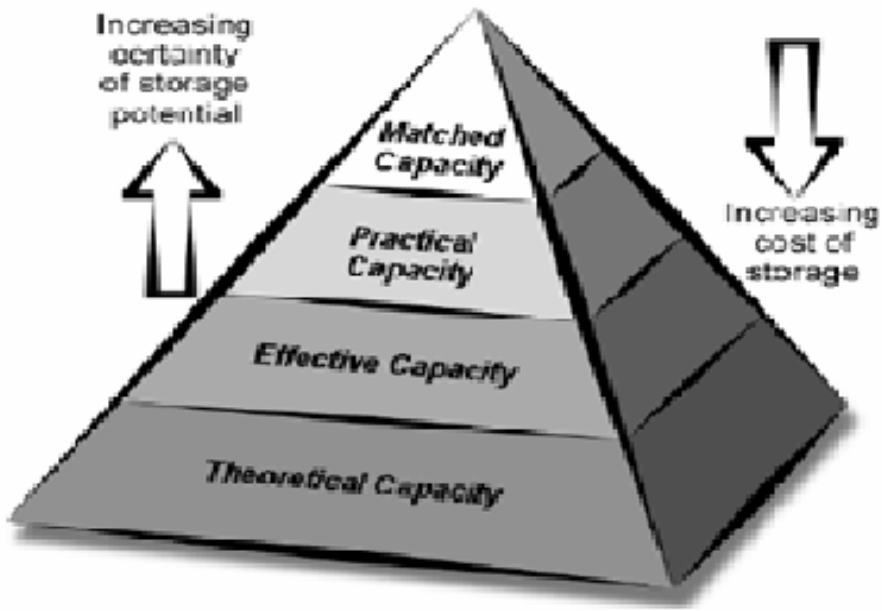
# IEA GHG Activities

1. Study programme
   - Capacity estimation
   - Site selection and characterisation
   - Environmental impact
   - Storage costs
2. International research networks
   - Risk assessment, wellbore integrity, monitoring, modelling
3. Demonstration projects

# CSLF Resource Pyramid



# Regional Storage Capacity

| Storage Type | Theoretical Regional Storage Capacity (Gt $CO_2$) | | |
|---|---|---|---|
| | North America | Europe | Indian Subcontinent* |
| Saline Aquifers | 3700 | 1500 | Not calculated |
| Depleted Gas | 40 | 33 | 5.4 – 6.2 |
| Depleted Oil/EOR | 12 | 7 | 1 |
| ECBM | 65 | | 0.35 |

# Capacity in Depleted Gas Fields

- 2009 study by Poyry Consulting, in association with Element Energy and BGS
- Provides review of worldwide storage potential
- Previous worldwide estimate of 800Gt (2000)
- Methodology: apply progressive levels of technical and economic criteria to refine storage capacity estimation
- Results aligned to CSLF resource pyramid

# Regional Storage Capacity in Depleted Gas Fields

| Region | Theoretical | Effective | Practical | Matched |
|---|---|---|---|---|
| Asia-Pacific | 100 | 75 | 45 | 28 |
| South America | 60 | 45 | 27 | 8 |
| Europe | 83 | 62 | 37 | 11 |
| Former Soviet Union | 340 | 260 | 150 | 47 |
| N America | 75 | 56 | 33 | 17 |
| Middle East & Africa | 240 | 180 | 110 | 46 |
| **TOTAL** | **900** | **680** | **390** | **160** |

# Site selection and characterisation

- Studies have highlighted paramount importance of site selection to minimise risks
- Best Practice Manuals (SACS/CO2STORE, CO2CRC) have been reviewed
- Gaps:
  - Wider variety of sites in aquifer best practice
  - Combine site characterisation and best practice
  - Best practice manuals for other scenarios e.g. depleted hydrocarbon fields

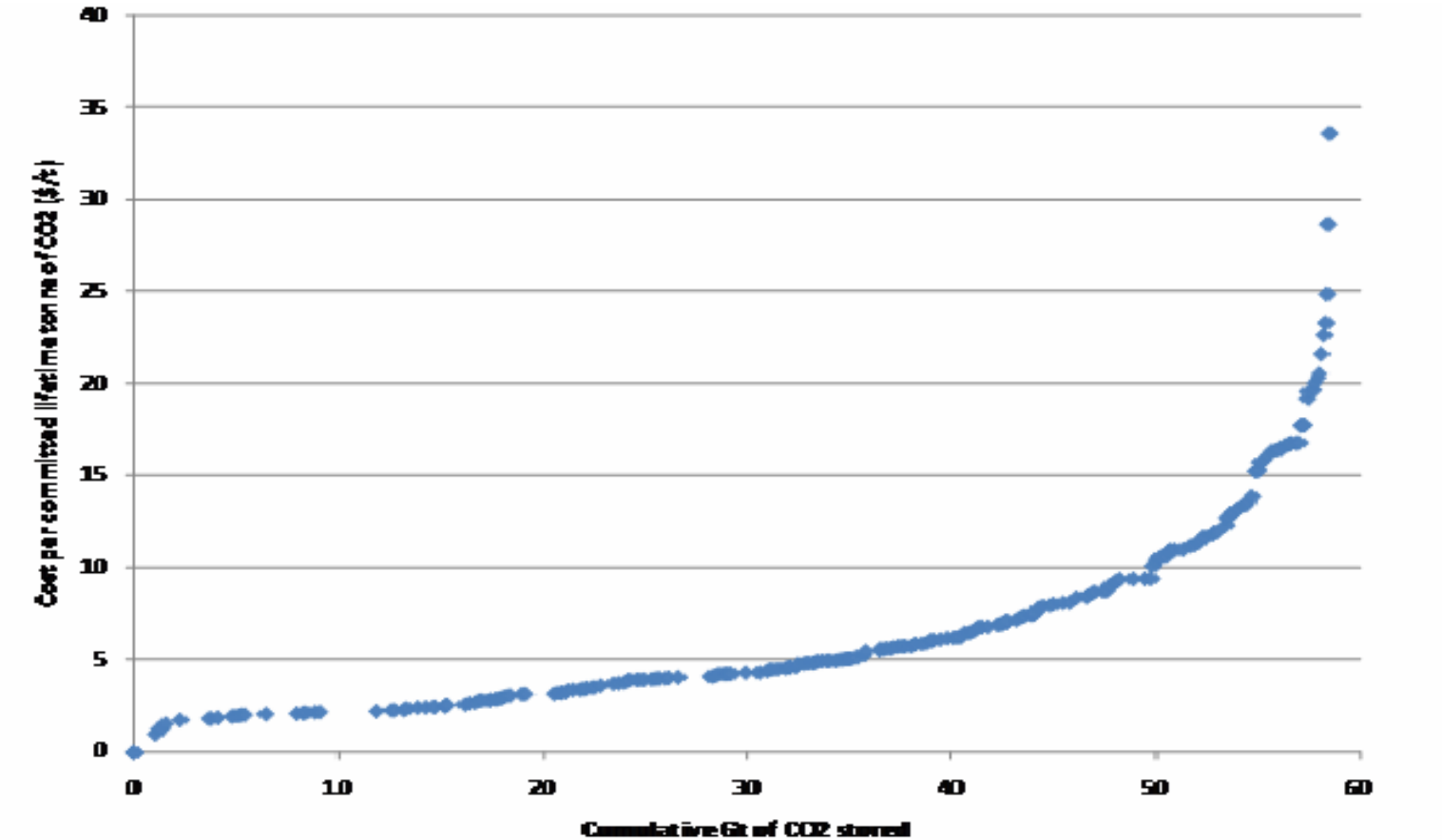
# Environmental Impact

- Two reports in 2007
- DNV report focussed on methodologies, comparing EIA and SEA for CCS relevance
- DNV recommended RA based unitary approach
- BGS reviewed onshore impacts information
- Identified knowledge gaps including impact quantification and effects of impurities

# Storage Economics (2005)

| Storage Type | Mean Reported Storage Cost | |
|---|---|---|
| | Europe (Euros/tonne) | North America ($/tonne) |
| Saline aquifer | 1 – 2.5 | 13 |
| Depleted Gas | 2 | 13 |
| Depleted Oil | 2 | 17 |
| CO2-EOR | 30 | Not calculated |
| ECBM | Not calculated | 9.5 |

# Cost Abatement Curve



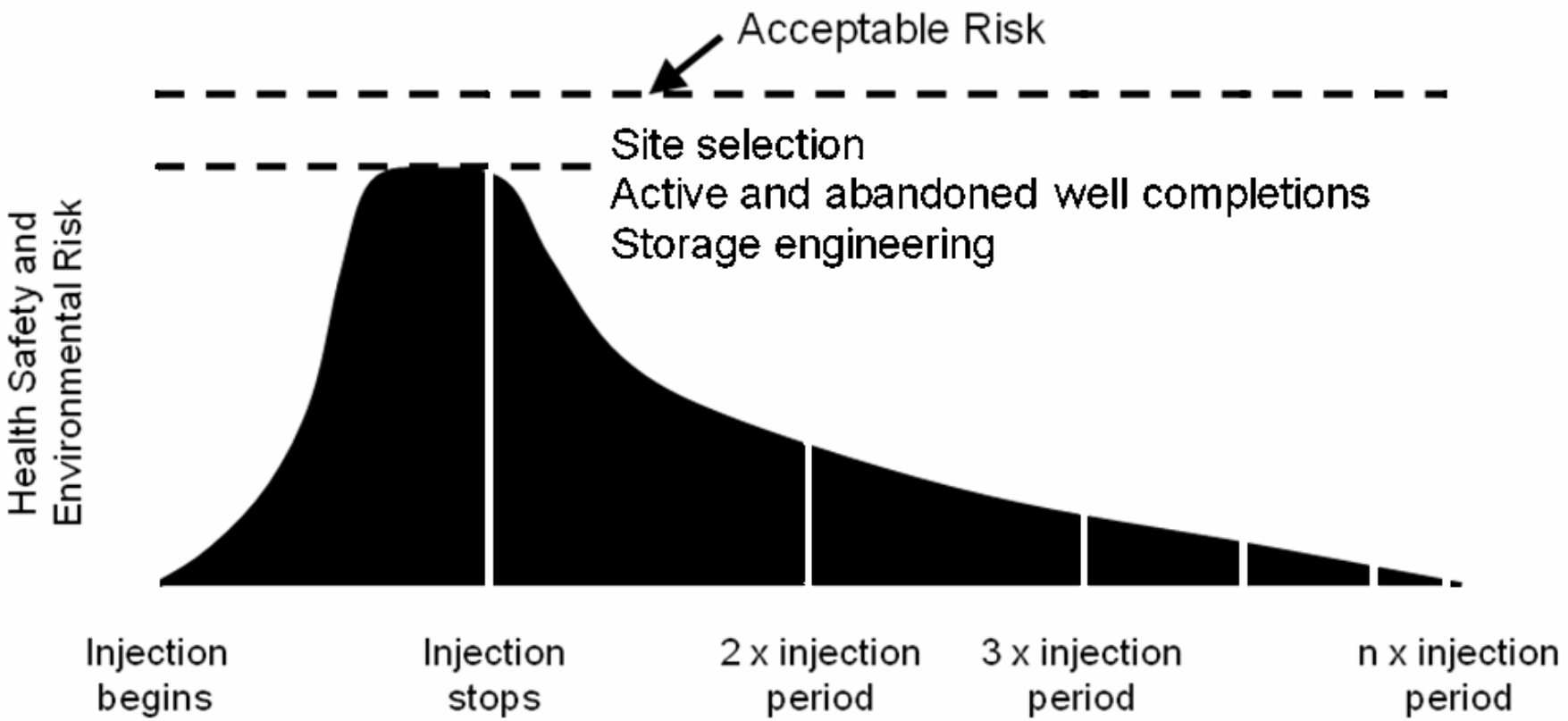
# Research Networks

- 3 networks cover risk assessment, wellbore integrity, monitoring and newly initiated network on subsurface modelling (from 2010)
- Format: 2-3 day meeting held annually, venues alternate to emphasise international aspect
- Opportunity for networking and collaboration
- Joint network meetings every 3 – 4 years (last in New York, 2008)

# Risk Assessment Network

- Risk is a function of storage performance and environmental impact assessment
- Risk assessment part of a wider risk management framework
- Network discussions have highlighted importance of natural analogues
- Current knowledge levels restrict RA to qualitative or semi-quantitative

# Schematic Profile of Storage Risk Levels



# RA Network Future Focus

- Development of standardised terminology
- Development of guidelines
- Use of worse case scenarios?
- Increase levels of confidence
- Quantification of risks through improved understanding of performance and impacts
- Wider risk management issues

# Monitoring Network

- Many techniques available from other applications e.g. Oil and gas industry
- Seismic is the most established technique, but expensive and not universally applicable
- IEA GHG online monitoring tool
- Quantification of in-situ $CO_2$ is a ‘holy grail’
- Leakage detection also important R&D area

# Monitoring Network Future Focus

- Results from demonstration projects
- Maintenance/updating of online tool
- Quantification
- Seismic surveys – maximising of information and integration with other techniques
- Duration of post-injection monitoring

# Wellbore Integrity Network

- Sound pre-existing knowledge base from other industries
- Leakage through old abandoned wells considered a key risk scenario
- Discussions have highlighted inconsistency between field, laboratory and model results
- Latest thinking suggests cement quality less important than material interfaces

# Wellbore Network Future Focus

- Discrepancies between laboratory and field
- Research projects at injection schemes
- Further development of wellbore leakage modelling
- Increased use of existing oil and gas industry experience and knowledge

# Modelling Network

- Initial workshop held in Orleans, France in February 2009
- 100 delegates from 14 countries
- Sessions covered objectives, processes and special issues
- Short presentations from invited speakers, more time on discussions
- Variety of technical outcomes, e.g. knowledge gaps

# Modelling Network Aims and Objectives

- Aim: provide an international forum for experts to share knowledge and promote collaboration
- Some specific objectives:
  - Online discussion forum and reference material
  - Guidance documents for practitioners
  - Guidance to non-technical specialists
  - Identification of knowledge gaps
  - Support to RA network

# Demonstration Projects

- Internal IEA GHG study activity started in 2009
- ‘Large scale’ CCS projects identified according to agreed criteria
- Questionnaires sent to operators
- Results analysed for key learning points for capture, transport and storage elements
- Report in progress
- Activity to be repeated every 2 years?

# Project Locations

- Capture over 100kt$CO_2$
- Injection over 10kt$CO_2$ for storage
- Monitored EOR over 10kt$CO_2$
- Capture over 10kt$CO_2$ from flue gas
- Coal bed storage over 10kt$CO_2$

# Major Knowledge Gaps

- Consistent and realistic approach to regional storage capacity estimation
- Better understanding of pressurisation and brine displacement effects for saline formations
- Design of cost-effective monitoring
- Better understanding of geochemical processes and integration into coupled predictive models
- Quantification of potential leakage and impacts

# Further Studies

- Site Selection and Characterisation (July 2009)
- Global Application of CO2-EOR (August 2009)
- Wellbore Abandonment (August 2009)
- Storage Capacity Coefficients (August 2009)
- Injection Strategies for $CO_2$ Storage (Dec 2009)
- New studies to be commissioned on Pressurisation and Brine Displacement, Groundwater Impacts, Impurities

# IEA Greenhouse Gas R&D Programme

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