



# **What Have We Learnt about CO<sub>2</sub> Geological Storage?**

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## IEA GHG Activities

### 1. Study programme

- Capacity estimation
- Site selection and characterisation
- Environmental impact
- Storage costs

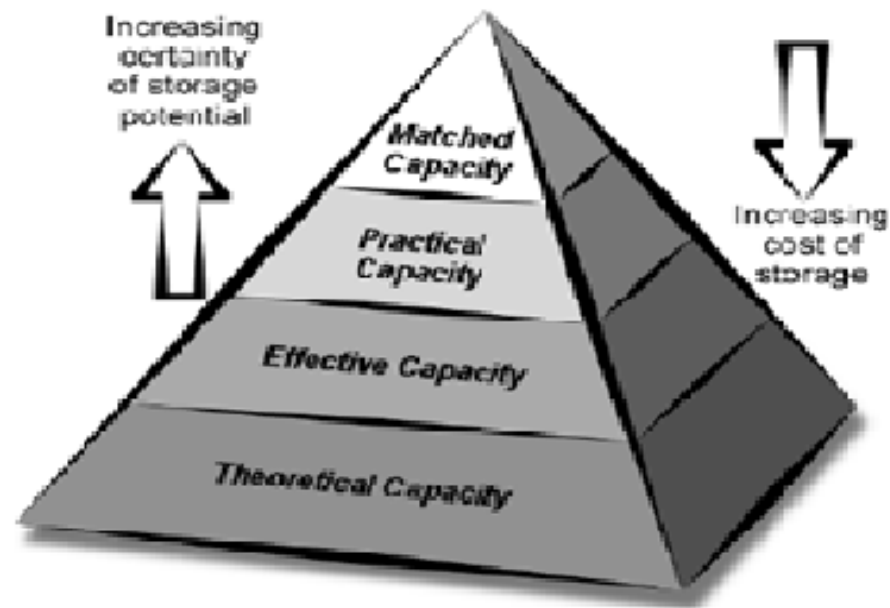
### 2. International research networks

- Risk assessment, wellbore integrity, monitoring, modelling

### 3. Demonstration projects



## CSLF Resource Pyramid





## Regional Storage Capacity

Storage Type	Theoretical Regional Storage Capacity (Gt CO <sub>2</sub> )		
	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
<b>TOTAL</b>	<b>900</b>	<b>680</b>	<b>390</b>	<b>160</b>



## 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



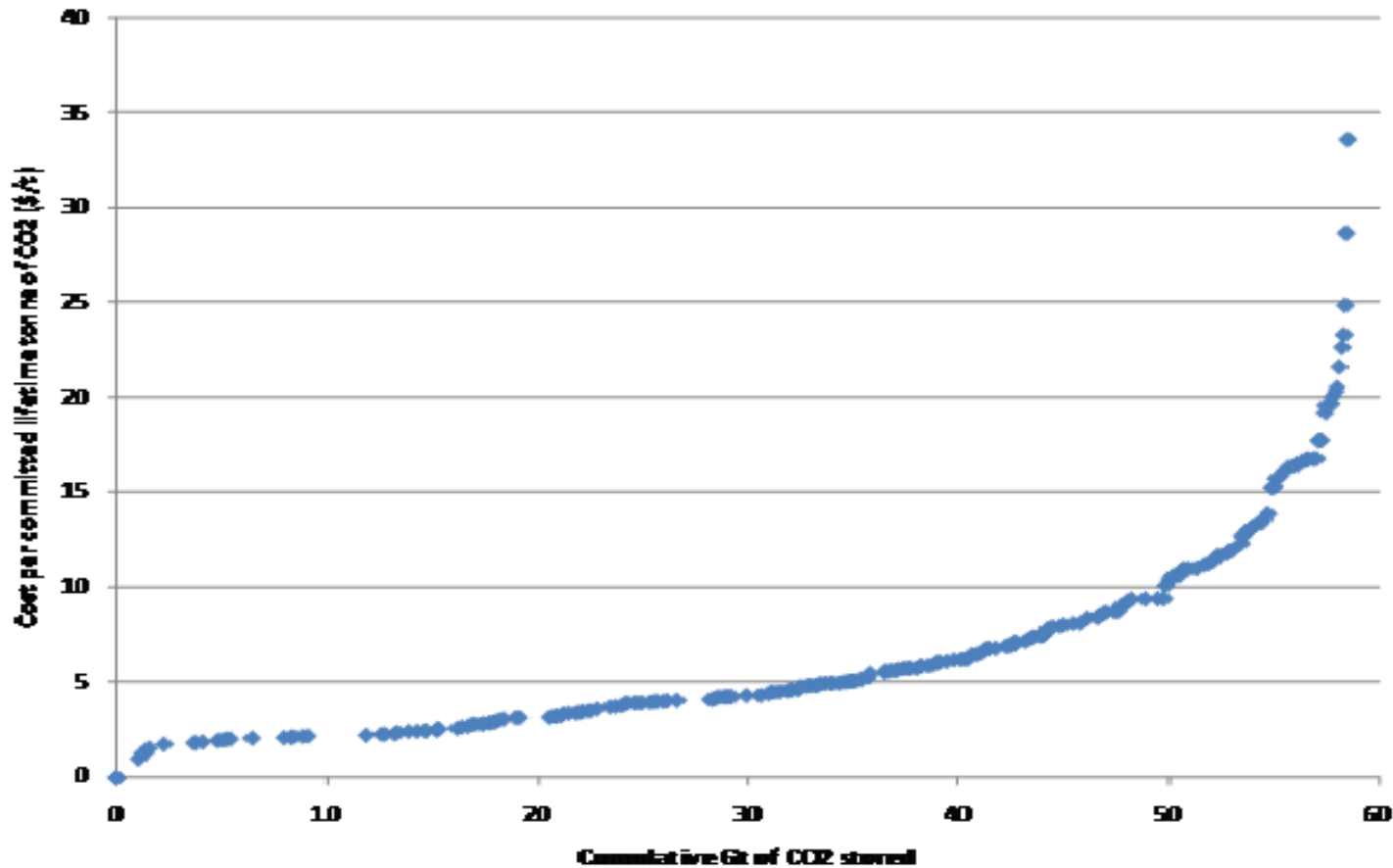


## Storage Economics (2005)

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
CO <sub>2</sub> -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)

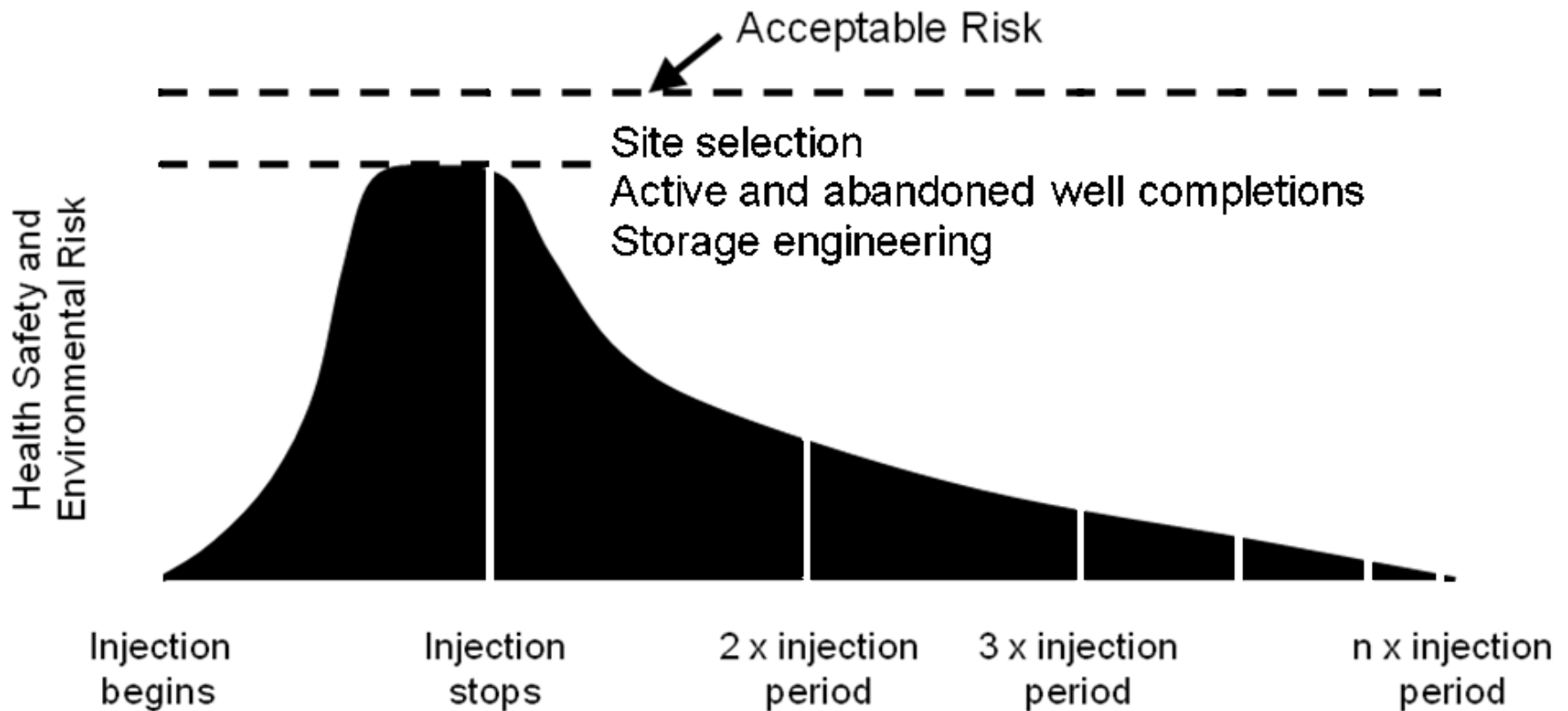


## Risk Assessment Network

- 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<sub>2</sub> 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







## 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 CO<sub>2</sub>-EOR (August 2009)
- Wellbore Abandonment (August 2009)
- Storage Capacity Coefficients (August 2009)
- Injection Strategies for CO<sub>2</sub> Storage (Dec 2009)
- New studies to be commissioned on  
Pressurisation and Brine Displacement,  
Groundwater Impacts, Impurities



# IEA Greenhouse Gas R&D Programme



## IEA Greenhouse Gas R&D Programme

- General - [www.ieagreen.org.uk](http://www.ieagreen.org.uk)
- CCS - [www.co2captureandstorage.info](http://www.co2captureandstorage.info)

