IEA Greenhouse Gas R&D Programme

Defining R&D Needs to Assess Environmental Impacts of CO2 Leaks

Workshop

15-17 Sep 2008

BGS, UK

Why are we here?

- BGS/IEAGHG Report (2007)
- Need to know consequences if things go wrong

- Objectives – identify R&D gaps and needs for environmental impacts of onshore CO2 leakage

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Regulator Views
Environmental Impacts of Leaks

Tim Dixon

IEA Greenhouse Gas R&D Programme

R&D Needs for Environmental Impacts of Leaks
BGS. September 2008

Contexts – the need

- Environmental Impact Assessment
- Risk Assessment processes – permitting
- Monitoring for leakage
  - Detection
    - Impact assessment (and recovery assessment)
  - Quantification

Environmental Impacts - Scope

- Short term (during operation)
- Long term

- Local
- Global – climate change

Leakage Impacts - Terrestrial

- Affect human and animal health
- Inhibit plant growth / plant death
- Change biological diversity
- Change subsurface biogeochemical conditions and processes – pH, microbial populations, nutrients
- Change groundwater – pH, mobilised substances

Leakage Impacts - Marine

- Local effects on biological communities
- Change seawater chemistry – pH, nutrient systems
- Change subsurface biogeochemical conditions and processes – pH, microbial populations, nutrients, mobilised substances

London Convention and Protocol

- Marine Treaty - Global agreement regulating disposal of wastes and other matter at sea
- Convention 1972 (83 countries), Protocol 1996 – ratified March 2006 (35 countries)
- Prohibited some CCS project configurations

CCS work

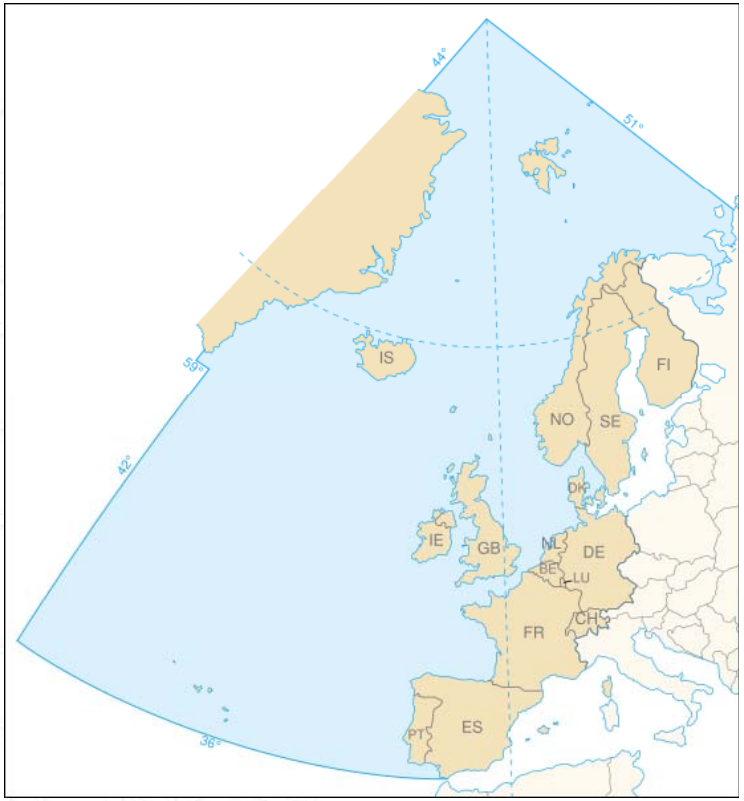
- Assessed by LC Scientific Group
- 2006 - **Risk Assessment Framework for CO2**

- To allow prohibited CCS Configurations - **amendment adopted** at 28th Consultative Meeting, 2 Nov 2006 - came into force 10 Feb 2007 **to allow disposal in geological formations**

- 2007 - **CO2 Specific Guidelines**

OSPAR

- Marine Treaty for NE Atlantic
- 15 nations and EC
- Prohibited some CCS configurations
- Considered CCS and CO2 impacts on seas



- To allow prohibited CCS configurations - **OSPAR amendments** (to Annexes II and III) for CO2 storage **adopted June 2007** - but need ratification by 7 Parties
- **OSPAR Decision** – requirement to use Guidelines when permitting.
- **OSPAR Guidelines** for Risk Assessment and Management of Storage of CO2 in Geological Formations – includes the **Framework for Risk Assessment and Management (FRAM)**
- Storage in water column prohibited

London and OSPAR Guidelines for Risk Assessment and Management

- Scope – scenarios, boundaries
- Site selection and characterisation – physical, geological, chemical, biological
- Exposure assessment – characterisation CO2 stream, leakage pathways
- **Effects assessment – sensitivity of species, communities, habitats, other users**
- Risk characterisation – integrates exposure and effects - environmental impact, likelihood
- Risk management and permitting requirements – incl. monitoring, mitigation plans

OPSAR Permit Conditions

- Permit in accordance with OSPAR Guidelines on Risk Assessment and Management
- Only issue permit if full risk assessment and management process completed to satisfaction of Reg Auth.
- And if “will not lead to significant adverse consequences for marine environment...”

EU Directives: Strategic Environmental Assessment (SEA); Environmental Impacts Assessment (EIA)

- SEA - a structured and systematic methodology for evaluating environmental impacts of proposed policies, plans and programmes (ie public sector) for a specific location
- EIA – for potential environmental impacts of project activities (private sector) for a specific location
- Limited to lifetime of project

EC Draft CCS Directive

Enabling regulatory framework to ensure environmentally sound CCS (23 Jan 2008)

- 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, and if no significant negative environmental or health impacts are likely to occur"**
- Emphasis on site selection, characterisation, risk assessment,
- **Monitoring plan – includes to detect leakage; to detect significant adverse effects for the surrounding environment**

EC Draft CCS Directive

- **Corrective measures plan**
- EC has right to review
- CO2 stream acceptance criteria - “overwhelmingly CO2” – impurity levels based on integrity
- Reporting and inspections at least once a year
- Financial security required from operator
- After closure, liability transfer to regulatory authority “when evidence indicates contained for indefinite future”. EC may review. Monitoring may cease.
- Access to transport networks and storage, unless technical issue or lack capacity
- Removes barriers in other Directives – IPPC, Waste, LCPD, Water, **EIA (adds CCS)**, ELD
- Capture-ready in LCPD >300MW – based on IEA GHG report

EC Draft CCS Directive - Annexes

- Annex 1 - Site characterisation
  1. Data collection
  2. Static Simulation
  3. Dynamic simulation - security characterisation (ie performance assessment)
  4. Risk assessment
     - Exposure Assessment
     - **Effects Assessment**
     - Risk Characterisation

- Annex 2 – Monitoring plan
  - For **baseline,** operations, post-closure
  - Criteria, coverage, updating
  - Non-prescriptive on techniques or timescales

EU CCS Directive

- **Effects Assessment**
  - Based on sensitivity of species, communities, habitats to potential leakage events identified
  - Effects of exposure to elevated CO2 levels in biosphere (inc soils, marine sediments, benthic waters)
  - Also effects of other substances in CO2 stream (incidental associated substances and mobilised substances)
  - Range of temporal and spatial scales

What level of detail will be required?

- Not specified – London and OSPAR may have assumed data available from literature
- Examples considered in BGS report – not detailed
- Definition of ‘significant’ adverse effects

➢ Uncertainty

NSBTF Workshop – Monitoring marine leakage (May 08)

- Over 40 different potential measurement techniques were identified
- Detection - would there be bubbles?

Conclusions:

- Biological monitoring – need baselines, how over large area?
- Grab sampling simplest way to detect community impacts
- Gaps in understanding species' sensitivity - What is 'significant' impact ?
- Potential recovery ?
- What physiological traits makes organisms vulnerable or tolerant to CO2 ?
- Examples of established techniques exist in oil and gas industries.
- Pressing need to field test existing instruments and techniques in order to assess their suitability for use in the marine environment for leak detection and quantification. => Enhance pH meters.

IPCC Guidelines for GHG Inventories

- Apr 2006
- Vol 2 Energy, Chp 5 - *CO2 Transport, Injection and Geological Storage*
- Each site will have different characteristics
- **Methodology**

  Site characterisation – inc leakage pathways

  ↓

  Assessment of risk of leakage – simulation / modelling

  ↓ ↑

  Monitoring – monitoring plan

  ↓

  Reporting – inc CO2 inj and emissions from storage site

- For appropriately selected and managed sites, supports **zero leakage** assumption unless monitoring indicates otherwise

IPCC Guidelines for GHG – cont.

Monitoring Plan

- Measurement of background fluxes of CO_2
- Continuous measurement of CO_2 injected
- Monitoring of injection emissions
- Periodic monitoring of CO_2 distribution
- **"Monitoring to determine CO_2 fluxes through seabed or ground surface, including through water sources"**

- Post-injection monitoring – as above, linked to modelling, may be reduced or discontinued once CO2 stabilises at its predicted long-term distribution
- Incorporate improvements in technologies and techniques over time

Monitoring technologies – Annex 1

- Deep subsurface technologies
- Shallow subsurface technologies
- Surface / water technologies

EU Monitoring

- CCS Directive's monitoring – to detect leakage and impacts
- ETS Directive's monitoring – to quantify leakage

ETS Directive

To strengthen, expand and improve the ETS from 2013

CCS

- Can already be included in Phase II (2008-2012) by 'opt-in'
- CCS fully included from 2013
  - Site and operation will need to comply with CCS Directive
  - **Needs monitoring and reporting guidelines**
- No free allocation to CCS (same as electricity)
- Separate permitting of capture, transport and storage
- If any leakage – surrendering of allowances

EC's Draft MRG

- By Ecofys with ECN, input from working groups

Leakage from storage:

- CO2 emitted [t CO2] = F_{CO2} * T

  F CO2 = average mass flow of CO2 leaked per hour [t CO2/h]

  T = timespan over which leak is estimated to have occurred [h]

  T shall be estimated as the timespan since

  a) the last date when no emissions from the source under consideration were reported;

  b) the date the CO2 injection started; or.

  c) other evidence providing insight into the date the leak started.

- But: necessary level of industrial experience not available for CO_2 storage -> development of MRG approaches for leakage currently not possible

=> EU 'Scientific Body' to evaluate and issue opinion on quantification

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General - www.ieagreen.org.uk

CCS - www.co2captureandstorage.info

- **GHGT-9**
- **16th – 19th November 2009**
- **Washington D.C.**
- **www.mit.edu/ghgt9**