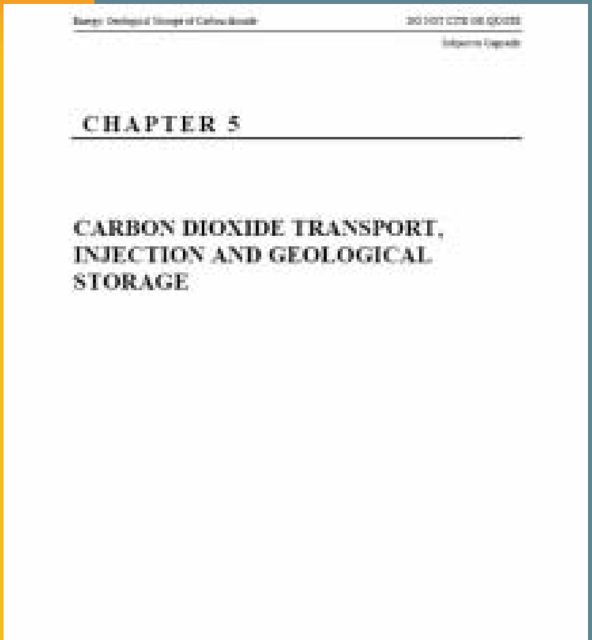
IPCC Guidance on Developing and Applying CCS Emission Estimation Methodologies in National Inventories of GHGs


CHAPTER 5

CARBON DIOXIDE TRANSPORT, INJECTION AND GEOLOGICAL STORAGE

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Introduction

- The 2006 IPCC Guidelines for National Greenhouse Gas Inventories (2006GL) give a complete methodology for CCS
  - ✓ Capture treated in the sector it may occur - volumes 2 & 3
  - ✓ Remaining emissions in CCS chapter in - volume 2
- This approach is consistent with the IPCC Special Report on CCS
- No “Tier 1” Methods available for storage – this must be based on site specific evaluation
  - ✓ There are demonstration projects but no wide scale use of CCS. Some technologies are well known
    - Use of CO_2 pipelines and associated equipment
    - Modelling and investigation of oil and gas fields

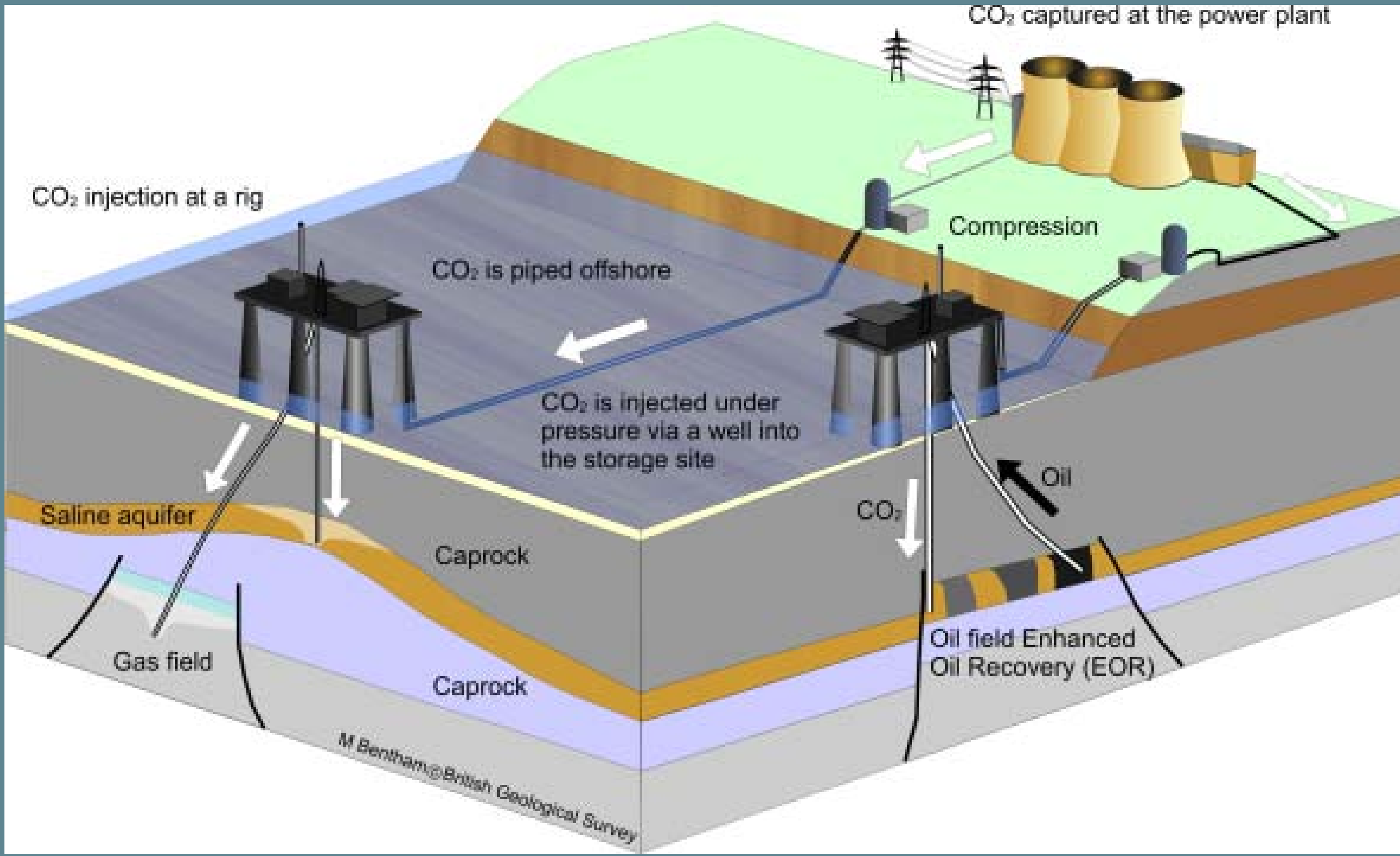
Consistency

- The approach adopted is consistent with the remainder of the 2006 guidelines,
  - ✓ in particular a fundamental principle that the inventory methods reflect the estimated actual emissions in the year in which they occur;
  - ✓ emissions are reported where they occur;
  - ✓ and in line with the approach used for the treatment of biogenic material.
- The methods in the 2006 Guidelines are compatible with the revised 1996 IPCC guidelines and subsequent good practice guidance.

Types of Storage

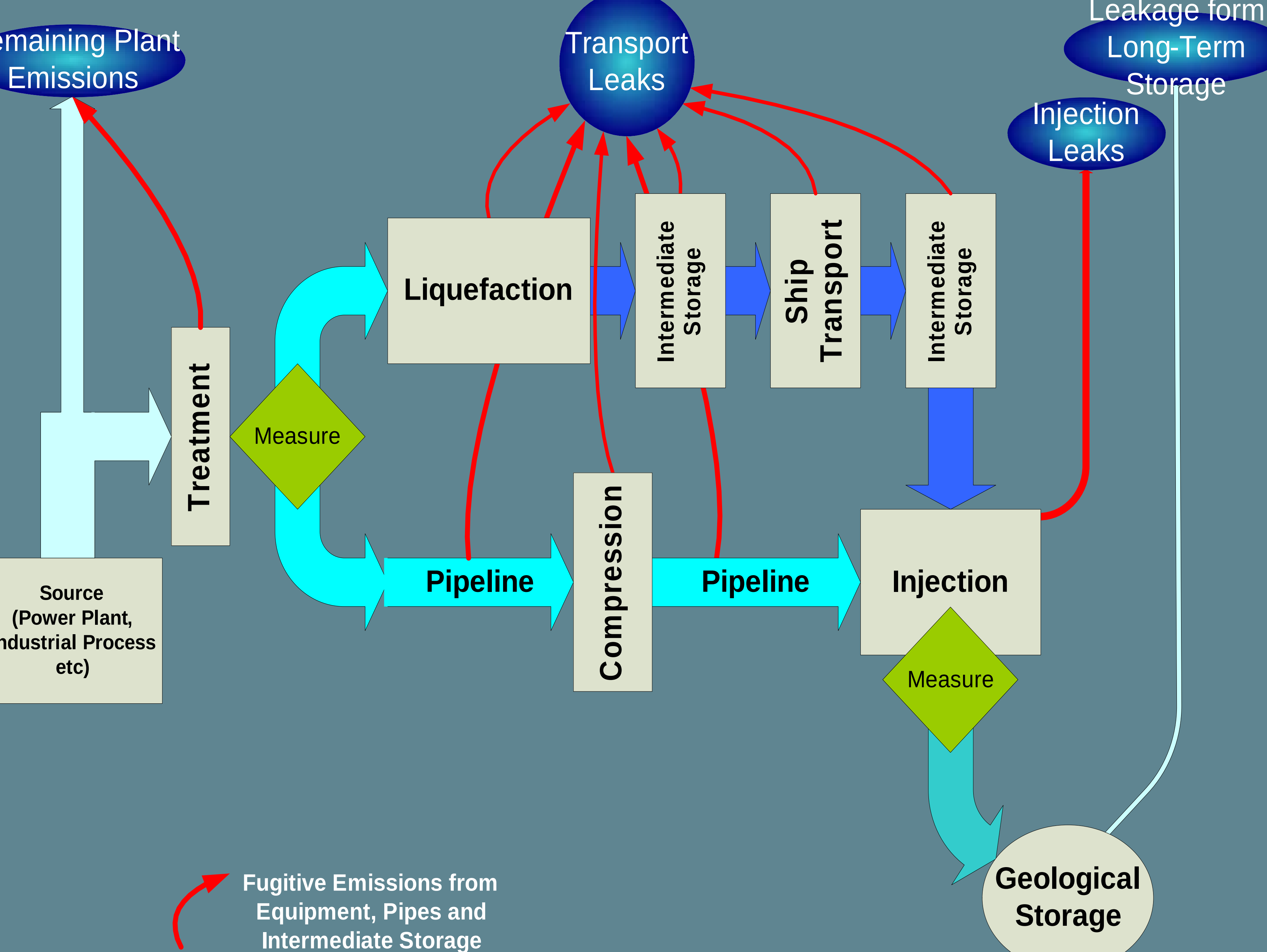
- The 2006GLs provide emission estimation guidance for the capture and transport of CO_2 and for geological storage.
- No emissions estimation methods are provided for any other type of storage option such as ocean storage or conversion of CO_2 into inert inorganic carbonates.
- Geological CO_2 storage may take place either at
  - ✓ sites where the sole purpose is CO_2 storage,
  - ✓ or in association with enhanced oil recovery (EOR),
  - ✓ enhanced gas recovery (EGR)
  - ✓ enhanced coal-bed methane recovery operations (ECBM)

CCS


CO2 captured at the power plant
CO2 injection at a rig
Compression
CO2 is piped offshore
CO2 is injected under pressure via a well into the storage site
Oil
CO2
Saline aquifer
Caprock
Gas field
Caprock
Oil field Enhanced Oil Recovery (EOR)
M Bentham@British Geological Survey

Source Categories for CCS

1C		Carbon dioxide (CO_2) capture and storage (CCS) involves the capture of CO its transport to a storage location and its long-term isolation from th atmosphere. Emissions associated with CO_2 transport, injection and storag are covered under category 1C. Emissions (and reductions) associated wit CO_2 capture should be reported under the IPCC sector in which capture take place (e.g. Stationary Combustion or Industrial Activities).
1C1	**Transport of CO_2**	Fugitive emissions from the systems used to transport captured CO_2 from th source to the injection site. These emissions may comprise fugitive losses du to equipment leaks, venting and releases due to pipeline ruptures or othe accidental releases.
1C1a	**Pipelines**	Fugitive emissions from the pipeline system used to transport CO_2
1C1b	**Ships**	Fugitive emissions from the ships used to transport CO_2
1C1c	**Other**	Fugitive emissions from other systems used to transport CO_2
1C2	**Injection and Storage**	Fugitive emissions from activities and equipment at the injection site an those from the end containment once the CO_2 is placed in storage.
1C2a	**Injection**	Fugitive emissions from activities and equipment at the injection site.
1C2b	**Storage**	Fugitive emissions from the end containment once the CO_2 is placed i storage.
1C3	**Other**	Any other emissions from CCS not reported elsewhere



emaining Plant Emissions
Transport Leaks
Leakage form Long-Term Storage
Injection Leaks
Liquefaction
Intermediate Storage
Ship Transport
Intermediate Storage
Treatment
Measure
Compression
Pipeline
Pipeline
Injection
Measure
Source (Power Plant, ndustrial Process etc)
Geological Storage
Fugitive Emissions from Equipment, Pipes and Intermediate Storage

Capture

- "Tier 3" method
- Measure amount captured
- Either
  - ✓ Measure residual emissions
  - ✓ Estimate emissions based on fuel carbon contents and subtract measured amount captured
    - Assumes everything not captured & measured is emitted
    - If fuel were biomass the estimated CO_2 emission = zero so emissions could be negative.

CO_2 Transport

- Pipelines
  - Leaks from compressors, temporary storage and other equipment
  - Existing CO2 pipelines so experience available
  - Can also use information from other gas pipelines
- Shipping
  - Leaks from equipment, compressors, liquefiers and storage
  - Leaks form ships not well known
- Trains and Road
  - Possible but unlikely given the large quantities likely to be captured
  - No methods in the guidelines

Default Factors

- Default tier 1 emission factors for pipeline transport of CO_2 from a CO_2 capture site to the final storage site
- Default factors based on length of pipeline
- Uncertainty a factor of 2

Value Gg per year and per km of transmission pipeline		
Low	**Medium**	**High**
0.00014	0.0014	0.014

Factors

- Emissions can be derived from emission factors for fugitive methane from pipelines and associated equipment

Energy: Geological Storage of Carbon dioxide DO NOT CITE OR QUOTE

Subject to Copyedit

5.4.1 CO_2 Transport by Pipeline

CO_2 Injection

- Includes all equipment at well head
  - ✓ storage facilities,
  - ✓ any distribution manifold at the end of the transport pipeline,
  - ✓ distribution pipelines to wells,
  - ✓ additional compression facilities, measurement and control systems,
  - ✓ wellhead(s) and the injection wells.
- Measurements at the wellhead of the injected fluid :
  - ✓ the flow rate,
  - ✓ temperature
  - ✓ pressure.
- The composition of the imported CO_2 commonly shows little variation and can be analyzed periodically using a gas chromatograph.

Estimating, Verifying & Reporting Emissions from CO_2 Storage Sites

Site Characterization	Confirm that geology of storage site has been evaluated and that local and regional hydrogeology and leakage pathways have been identified .
Assessment of Risk of Leakage	Confirm that the potential for leakage has been evaluated through a combination of site characterization and realistic models that predict movement of CO 2 over time and locations where emissions might occur .
Monitoring	Ensure that an adequate monitoring plan is in place . The monitoring plan should identify potential leakage pathways , measure leakage and /or validate update models as appropriate .
Reporting	Report CO2 injected and emissions from storage site

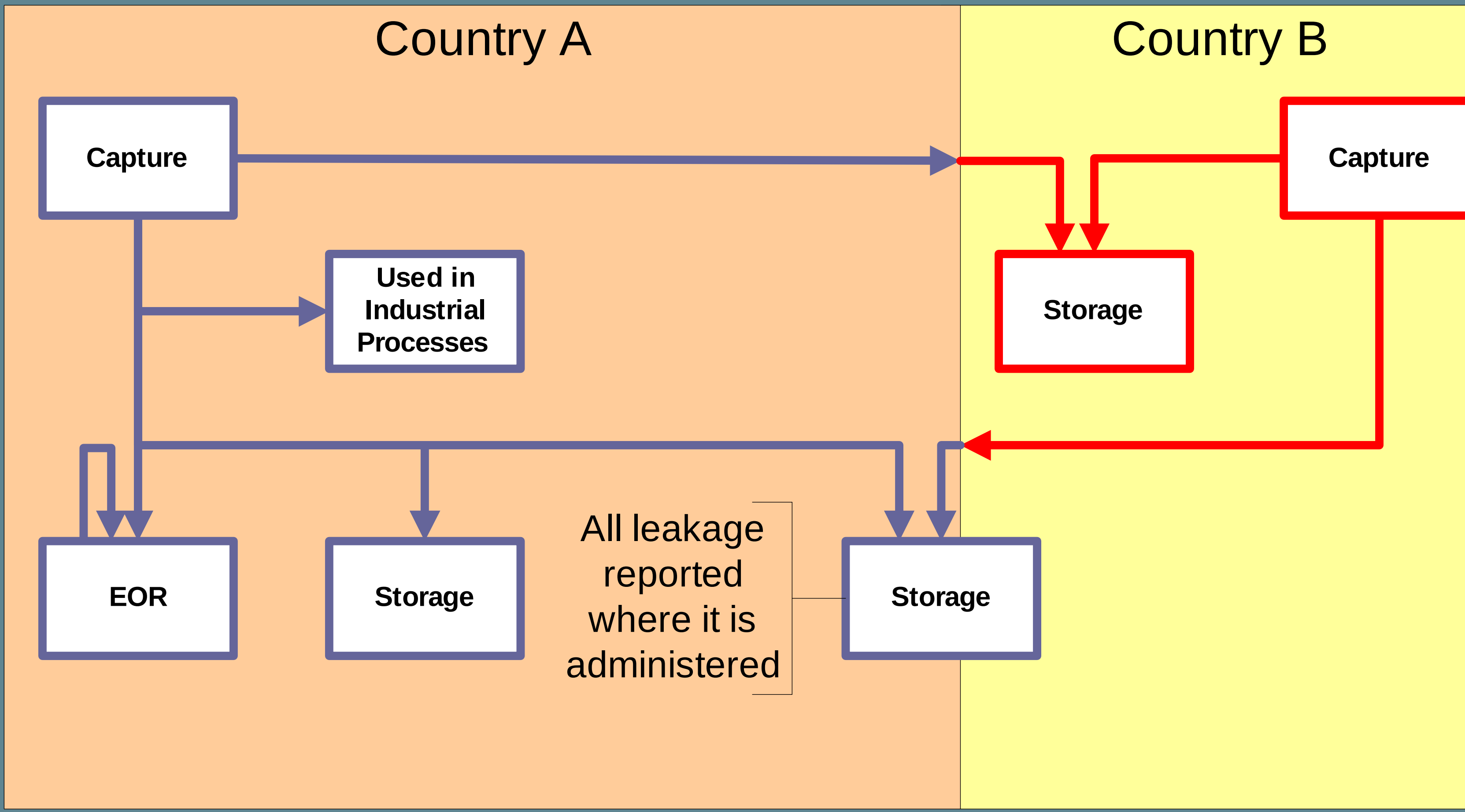
Potential Emission Pathways from Geological Reservoirs

Type of emission	Potential Emissions Pathways/ Sources
Direct leakage pathways created by wells and mining	Operational or abandoned wells
	Well blow-outs (uncontrolled emissions from injection wells)
	Future mining of CO_2 reservoir
Natural leakage and migration pathways (that may lead to emissions over time)	Through the pore system in low permeability cap rocks if the capillary entry pressure is exceeded or the CO_2 is in solution
	If the cap rock is locally absent
	Via a spill point if reservoir is overfilled
	Through a degraded cap rock as a result of CO_2/water/rock reactions
	Via dissolution of CO_2 into pore fluid and subsequent transport out of the storage site by natural fluid flow
	Via natural or induced faults and/or fractures
Other Fugitive Emissions at the Geological Storage Site	Fugitive methane emissions could result from the displacement of CH_4 by CO_2 at geological storage sites. This is particularly the case for ECBM, EOR, and depleted oil and gas reservoirs.

Reporting

- Complete national reporting includes
  - ✓ CO_2 from capture in the country
  - ✓ CO_2 leakage from all transport and injection in that country
  - ✓ CO_2 leakage from all storage sites in that country (wherever the CO_2 actually reaches the surface).
  - ✓ Imports and exports of captured CO_2.
  - ✓ Total CO_2 in storage should be reported in the accompanying documentation
- Quantities of CO_2 for later use and short-term storage should not be deducted from CO_2 emissions (except in the case of recovery of CO_2 for urea production – see guidelines).

Reporting


Country A
Country B
Capture
Used in Industrial Processes
Storage
Capture
EOR
Storage
All leakage reported where it is administered
Storage

Reporting

- In principal:

  $$Capture + Imports = Injected + Exports + Leaks$$

- Need to report all these quantities
- Need to understand any discrepancies
  - ✓ Uncertainties
  - ✓ Measurement errors
  - ✓ Intermediate storage/ stock changes
- Also need to keep record of amount stored

Conclusion

- The 2006 IPCC Guidelines provide a complete consistent methodology for CCS that is also compatible with the 1996 Guidelines
- This covers capture, transport, injection and geological storage
- Capture and transport have straightforward methods
- Storage require detailed site characterisation including modelling and monitoring
  - ✓ however this is unlikely to be a significant burden as this is likely to be required for regulatory as well as health and safety requirements
- Need to reconcile capture, storage, imports and exports.