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Protocols and Strategies for a Monitoring Plan

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European Regulatory Regime

OSPAR Guidelines (preserving the offshore environment)

EC Directive on Underground CO₂ Storage

EC Directive on the Emissions Trading scheme

*Plus national transpositions*
The Core Monitoring Programme

To meet the regulatory requirements of a conforming site (i.e. one that behaves as expected during its lifetime).

It is aimed at performance verification, the management of any site-specific containment risks identified in the Framework for Risk Assessment and Management (FRAM) and the detection of performance irregularities including early warning of potential leakage.

Comparison of actual site behaviour with modelled behaviour (model verification) and calibration of predictive modelling.

Demonstration of no detectable leakage.

Effective monitoring of identified containment risks (e.g. wellbores).

Indication of any performance irregularities, in particular those that may become significant, leading to a risk of leakage or a risk to the environment or human health.

MONITORING THAT WILL BE CARRIED OUT AS PART OF ROUTINE SITE OPERATION
The Additional Monitoring Programme

To meet the requirements of a storage site that does not perform as expected i.e. one in which irregularities have become significant.

Address possible range of significant irregularities and the needs of any associated remediation actions.

Provision of additional data to re-design or re-calibrate predictive models.
Provision of information for remediation actions and assess their efficacy.
Measurement of leakage for emissions quantification under the ETS.

PORTFOLIO OF TOOLS HELD IN RESERVE FOR USE IN THE EVENT OF A SIGNIFICANT IRREGULARITY
SITE CHARACTERISATION
Static site properties
Dynamic performance predictions

Framework for Risk Assessment and Management

Core monitoring plan to meet regulatory requirements and cover site-specific risk management

Additional monitoring plan targeted on potential significant irregularities and associated remediation actions

Do irregularities lead to potential leakage / emissions?

yes  emissions measurement
no

Full monitoring plan [core + additional]
Typical North Sea storage site - Core Monitoring

- Sampling / logging
- injected CO₂
- CO₂ plume
- Downhole pressure and temperature
- Bubble-stream detection
- 3D (2D) time-lapse seismic
- Seabed imaging
- core monitoring
- abandoned well(s)
- sandstone reservoirs
- siltstones and mudstones
- Chalk

1.5 km – 3 km
Typical North Sea Storage site - Additional Monitoring

- CO$_2$ injection well(s) 1.5 km – 3 km
- Injected CO$_2$
- Seawater
- Salt
- Gas plume in watercolumn
- Gas in the sediments
- Temperature, °C
- THT = 50 °C
- THT = 40 °C

[Diagram showing the storage site with CO$_2$ injection and monitoring parameters]
Typical North Sea Storage site - Emissions Measurement

- Seawater
- CO₂ injection well(s) 1.5 km – 3 km
- Injected CO₂
- Salt
- Typical North Sea Storage site
- Emissions Measurement
- Gas plume in watercolumn
- 39 ppm methane
- Gas in the sediments
- 3 km
Summary

Relatively restricted suite of tools

Focused wholly on regulatory requirements
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