



# Characterisation of European CO<sub>2</sub> storage

**Dry-run licence applications**

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# Motivation

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- To date, one application has been made for a storage permit under the Storage Directive
- Demonstration projects are working towards submitting permits
  - But are not yet ready
  - Regulators are not able to receive applications in some MS
- The process of permit development needs to be tested at credible sites
  - ‘Low’ risk dry-run environment without the constraints of commercial projects
  - Allow testing of permitting in future storage situations (onshore and in saline aquifers)
  - Allow testing and refinement of the SiteChar workflow



# Objectives

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- To develop credible storage permit applications
- To ensure site characterisation is fit for purpose and complies with the regulatory requirements
- To evaluate 'Dry-run' storage licence application documents from selected sites evaluated by a separate team



# Scope of licence applications

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- Two teams have produced credible, if limited, licence applications with ‘research-level’ resources
  - Detailed permit applications are not produced
  - Includes most of key elements required by the Storage Directive
  - Key issues that should be addressed are identified.
- Based on existing data
  - No additional exploration, injections tests, core analysis or new site characterisation has been undertaken
- Out of scope:
  - Full Environmental Impact Assessment
  - Provision relating to the acceptance and injection of CO<sub>2</sub>
  - Details of financial security
  - A provisional post-closure plan
  - Provisions for reporting

# Comparisons between Vedsted and Moray Firth – permitting perspective

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## Outer Moray Firth

- Offshore
- Identified from previous regional reviews of UK northern North Sea storage targets
- ‘Theoretical’ study
  - Low risk – can try different permitting scenarios
  - No acquisition of new data
  - Range of injection scenarios
- Risks addressed in SiteChar:
  - Definition of storage complex
  - Caprock integrity
  - Potential for seismic monitoring

## Vedsted

- Onshore
- Previously applied for licence prior to Directive to promote dialogue with Regulators
- Real project, now stopped
- Application fits predefined concept & original licence application
- Baseline monitoring data acquired
- Risks addressed in SiteChar :
  - Oil well integrity and abandonment status
  - Regional pressure responses and management



# Site Characterisation

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- Both projects consider an injection test would be needed.
  - To assess proof on injectivity, reservoir connectivity and pressure response.
  
- Would operators be willing to drill and core new appraisal wells in order to secure a storage permit?
  - Do final investment decisions require that permits are in place first?
  - Prefer indirect assessment of existing or newly acquired seismic.



# Storage Complex Boundary

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- Since pressure responses have been shown to extend far beyond the field boundaries at many sites, this would require impractically large storage permit areas.
- The pressure footprint has not been considered.
  - There is little consensus on the thresholds above which effects should be included.
- Informal discussion with regulators indicate that the pressure footprint might receive lower emphasis in defining the complex boundary.
- Complex defined by maximum extent of plume
  - including CO<sub>2</sub>-saturated formation water
  - plus a margin to enable monitoring
  - to reflect inherent uncertainty in predictions
- Storage complexes may overlap petroleum licences in the North Sea



# Interactions with other users

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- The nature and extent of interactions with other users is a key consideration for regulators.
- Assessing future interactions may be challenging for operators
  - E.g. future operations (HC production and/or other storage) may impact on the risk profile of a project.
- The 'state owner of the resource' may be best placed to take an overview
- The Competent Authorities may need to undertake its own risk assessment and supporting investigations, to provide guidance to operators, including around third party access.



# Pressure management & water disposal

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- Disposal of clean water offshore is not considered particularly challenging, as it is widely practised in HC production.
- Volumes of produced water for pressure management in the North Sea have not been estimated.
  - For comparison, 175 million m<sup>3</sup> of produced water were discharged in UK waters in 2011
  - Moray Firth estimated similar volumes produced as CO<sub>2</sub> injected
- At Vedsted, pressure management was not necessary, since pressures were limited to 85% of lithostatic.
- Disposal of produced waters may be significantly more challenging onshore than offshore,
  - A key topic in the storage and environmental permits for onshore sites.



# Permit performance conditions (PPCs)

- Define limits to site behaviour which, if exceeded, indicate that a significant irregularity or leakage has occurred.
  - Identified through Risk Assessment
  - Inform the Monitoring Plan
  - Trigger Corrective Measures if exceeded
  - Indicators will be in the Corrective Measures and Post-Closure plans
  - Enable site closure

Blake Field	
PPC1	<b>Environmental or human health will not be adversely affected by the storage operation</b>
PPC2	<b>CO<sub>2</sub> will not pass beyond the Storage Permit Area boundaries</b>
PPC3	<b>CO<sub>2</sub> plume shows migration within expected modelled behaviour</b>
PPC4	<b>Pressure changes will remain within predefined/predicted ranges</b>
PPC5	<b>Geomechanical integrity of site will be maintained</b>
PPC6	<b>Cost per tonne will remain within a set limit</b>



# Recommendations on PPCs

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- PPCs should be linked to the specific risks they address
  - To demonstrate that the risk register, PPCs, corrective measures plan and monitoring plan are closely integrated.
- PPCs should be written with positive phrasing as the permits will be public documents.

# Additional conclusions for permit applications

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- Iterative and continuous discussions with CAs would increase likelihood of successful applications.
- Clear evidence base must be included to support case for safe and permanent storage.
- Prime objective for Outer Moray Firth was maximising storage potential
  - This may not always be the case with costs and risk reduction being additional objectives
- Justifications for locations and re-use of wells for storage must be carefully made as legacy HC production wells may be suboptimal.
- Conditions under which permits should be changed (to reflect changes in operation) should be agreed.



# Post-injection period

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- SiteChar permits have 20-year post-injection periods
- If sites are performing as expected, operators likely to wish to transfer responsibility as soon as possible.
  - Both sites predict reaching safe steady-states quickly.
- Any uncertainty in this may delay Final Investment Decision.
- Crucial to agree, during permit negotiations, exact evidence required to enable site closure and transfer of responsibility.
- It is currently assumed all sites will be closed and infrastructure removed.
  - It may be beneficial for some sites to be kept open. CA may wish to extend storage life.



## Some questions...

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- Should authorities consider the extent to which a store is utilised, if 'full' capacity is not to be exploited?
  - Projects may be considered in a regional development context
  - May require operators to provide data to allow such an assessment
  - Mothballing of sites rather than full closure
- How should regulators and operators take into account potential pressure impacts on other sites (HC or CO<sub>2</sub>)?
  - Leave operators to come to agreement
  - Should regional pressure be monitored, or managed?



# Summary

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- Site characterisation undertaken at varying levels on credible storage sites.
- Site characterisation objectives:
  - Reduce risk and uncertainty: implies these should be known *before* detailed characterisation is undertaken
  - Provide sufficient evidence to demonstrate permanent, safe storage.
  - Enable cost-effective project design
- Dry-run permitting process has identified approaches to demonstrating safe and permanent CO<sub>2</sub> storage.
- Recommendations arising from the dry-run process will provide guidance to operators and regulators on site characterisation and the SiteChar workflow.