Regulatory framework and environmental monitoring strategy: a risk-based approach

Laurence Pinturier, Northern Lights project
Agenda

→ Short overview of project
→ Regulatory framework
→ Environmental risk assessment & Monitoring Strategy
Langskip - Northern Lights

**CO₂ capture**
Capture from industrial plants. Liquefaction and temporary storage.

**Transport**
Liquid CO₂ transported by ship.

**Receiving terminal**
Intermediate onshore storage. Pipeline transport to offshore storage location.

**Permanent storage**
CO₂ is injected into a saline aquifer.
Where?
Regulatory framework

→ Norwegian regulations – Based on the EU CCS Directive*
  • CO₂ storage regulation
  • CO₂ safety regulation
  • Pollution regulation

→ Risk-based framework
  • Plan for development, installation & operation
  • Permits for injection & storage
  • Permits for taking into use facilities

-→ Monitoring plan
  • Conformance & containment
  • Response plan

Overall monitoring plan

Ship and land facility monitoring

Regular inspection and test of pipeline and subsea installation

Well operations monitoring

Environmental monitoring: Triggered monitoring plan

Active and passive seismic monitoring of the underground
Environmental Risk Assessment

- Best practice guideline from DNV ECO2 project

- Hazard scenarios extracted from
  - Containment risk analysis
  - Pipeline rupture analysis
  - Onshore risk analysis

- pH changes as a proxy for effect assessment

- Resource mapping based on available data (large dataset)
Environmental Risk Assessment
main conclusion

**Pipeline**
- Small size hole to full rupture
- Several vulnerable resources identified inshore
- Low environmental risk for small leakage on seabed
- Low to moderate risk at the sea surface for large rupture

**Storage complex**
- Injection wells, legacy wells and geological pathways
- No vulnerable resources identified
- Influence area limited
- No CO₂ reaching sea surface
- Low risk

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**Table 6-2: Env. Risk Storage complex**

<table>
<thead>
<tr>
<th>Probability</th>
<th>Consequences</th>
<th>Environmental consequences</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Negligible/low</td>
</tr>
<tr>
<td>Unlikely (≤1%)</td>
<td>3, 4, 5, 6, 9, 10, 11, 12, 13</td>
<td>1, 2, 6, 7</td>
</tr>
<tr>
<td>Possible (1 – 10%)</td>
<td>15–16, 21–27</td>
<td>28, 29, 30, 31, 33, 34, 35, 36, 37, 38, 39, 40</td>
</tr>
<tr>
<td>Likely (≥10%)</td>
<td></td>
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</tr>
</tbody>
</table>

17 Common guillemot (Uria aalge), 18 Puffin (Fratercula arctica), 19 Common tern (Sterna hirundo), 20 Velvet guillemot (Cersteelula grylle), 21 Northern fulmar (malaexula glacialis), 31 Black guillemot (Uria aalge), 42 Other

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* ENVIRONMENTAL RISK ANALYSIS AND STRATEGY FOR ENVIRONMENTAL MONITORING –EQUINOR, 2019-0745, rev1, DNV*
Environmental monitoring strategy

- **Public attention**
- **Non containment**
- **Mitigating actions** (ref primary monitoring strategy)

**Exposure below effect levels on biota**
- No effect monitoring of biota
- Water column monitoring
- Modelling
- Low frequency

**Exposure of resources of low sensitivity/value**
- Habitat/community monitoring
- Water column monitoring
- Low frequency

**Exposure of resources of high sensitivity/value**
- Habitat/community/Species monitoring
- Water column monitoring
- Higher frequency

Review strategy and plan every 5 years, or based on experience from events
## Identified vehicles and sensors

<table>
<thead>
<tr>
<th>Location</th>
<th>ROV-design</th>
<th>AUV-design</th>
<th>Supplementary Monitoring Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Location</strong></td>
<td>ROV study with hydroacoustic equipment</td>
<td>AUV study with hydroacoustic equipment</td>
<td>Surface vessels with hull mounted hydroacoustic equipment</td>
</tr>
<tr>
<td></td>
<td>Applicability: 3</td>
<td>Applicability: 3</td>
<td>Applicability: 3</td>
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<tr>
<td></td>
<td>Maturity: 3</td>
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<tr>
<td><strong>Verification</strong></td>
<td>Direct targets in the gas bubbles</td>
<td>Transect examination as close to the source as possible</td>
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</tr>
<tr>
<td></td>
<td>-Flux chamber</td>
<td>-pO2 / pCO2 sensor</td>
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<tr>
<td></td>
<td>-pCO2 sensor</td>
<td>-pH sensor</td>
<td>-pH sensor</td>
</tr>
<tr>
<td></td>
<td>Applicability: 3</td>
<td>Applicability: 2</td>
<td>Applicability: 2</td>
</tr>
<tr>
<td></td>
<td>Maturity: 3</td>
<td>Maturity: 2</td>
<td>Maturity: 2</td>
</tr>
<tr>
<td><strong>Quantification</strong></td>
<td>Direct targets in the gas bubbles</td>
<td>Establishment of model</td>
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<td></td>
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<td>-pH sensor</td>
<td>-pH sensor</td>
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<tr>
<td></td>
<td>Applicability: 3</td>
<td>Current Measurements</td>
<td>Current Measurements</td>
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<tr>
<td></td>
<td>Maturity: 3</td>
<td>Applicability: 2</td>
<td>Maturity: 2</td>
</tr>
<tr>
<td><strong>Effects</strong></td>
<td>Transect examination as close to the source as possible</td>
<td>Transect examination as close to the source as possible</td>
<td>Ocean acidification program</td>
</tr>
<tr>
<td></td>
<td>-pO2 / pCO2 sensor</td>
<td>-pO2 / pCO2 sensor</td>
<td>Establishment of model</td>
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<td>-pH sensor</td>
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<td></td>
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<td>Maturity: 3</td>
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<td>Biodiversity measurements - through sediment monitoring (M-300)</td>
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<td>Applicability: 3</td>
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<td></td>
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</tbody>
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Baseline surveys and data

→ No planned environmental survey before injection
  • Seabed surveys
  • 4 D Seismic baseline
  • Regular environmental sediment monitoring in the area
  • Extensive databases for O&G risk assessment

→ Consider field test of instrument/underwater vehicles
  • Improve simulation model for underwater CO₂ release
  • Qualify/test instrument for CO₂ detection & quantification (vehicle and sensor)
Summary Environmental monitoring strategy NL

Strategy defined based on risk as per regulation

Triggered plan in case of irregularities /potential leakages

Plan to be submitted to the authority as per permit approval