WHEN WILL LEGACY WELL LEAKAGE (RISK) IN CO_2 STORAGE SITES REQUIRE WELL INTERVENTION?

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FORCE Workshop, Nov. 19 2025

CONTEXT AND CHALLENGE

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- Measures to improve the integrity of P&A wells with potential for leakage can be challenging and involve very high costs.
- CCS is a low-margin business – a need to plan for well intervention for any situation with risk of leakage along a legacy well will significantly impact project economics.
- In a CO_2 storage context, small leaks will have small environmental consequences.
- The HSE risk and cost of well intervention will normally be disproportionate to the corresponding avoidance of negative effects.

ADDITIONAL CONSIDERATIONS

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1. Ambitious targets for CCS in Europe, but lack of attractive business case.
2. Legacy wells are prevalent in most sedimentary basins, but not necessarily P&A'd with consideration for CO_2 storage.
3. Overarching regulatory requirement – **environmentally safe geological storage of CO_2** → level does not call into question the purpose of the Directive for the storage site concerned.
4. A restrictive interpretation of 'environmentally safe' (with attention only to local impacts) will increase overall costs to society and/or reduce utilization of storage resources.
   - Restrictive criteria increases unit cost of storage.
   - Non profitable conditions → more public support to achieve desired scale.

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Purpose: Interpret updated EU-guidance on risk management to derive criteria for deciding when *risk of leakage* associated with a P&A well (exposed to effects from geological storage of CO_2) can be regarded as acceptable without taking measures to strengthen the well's integrity.

EU GUIDANCE

Annex I, Step 3.3.4: risk characterisation

Risk should be characterised and placed in one of two categories:

Insignificant risks: do not call into question the purpose of the CCS Directive for the storage site	**Significant risks:** must be reduced to insignificant through implementation of risk reducing measures

- The determination significant vs insignificant risk is ultimately subjective and depends on the risk appetite of the entities that are exposed to risk or will bear responsibility for managing the risk.
- Not transferable between sites: a leakage risk scenario with the same likelihood and potential magnitude of leakage may be an insignificant risk at one site and a significant risk at another site.
- The aggregate risk profile for the project should not outweigh project benefits.

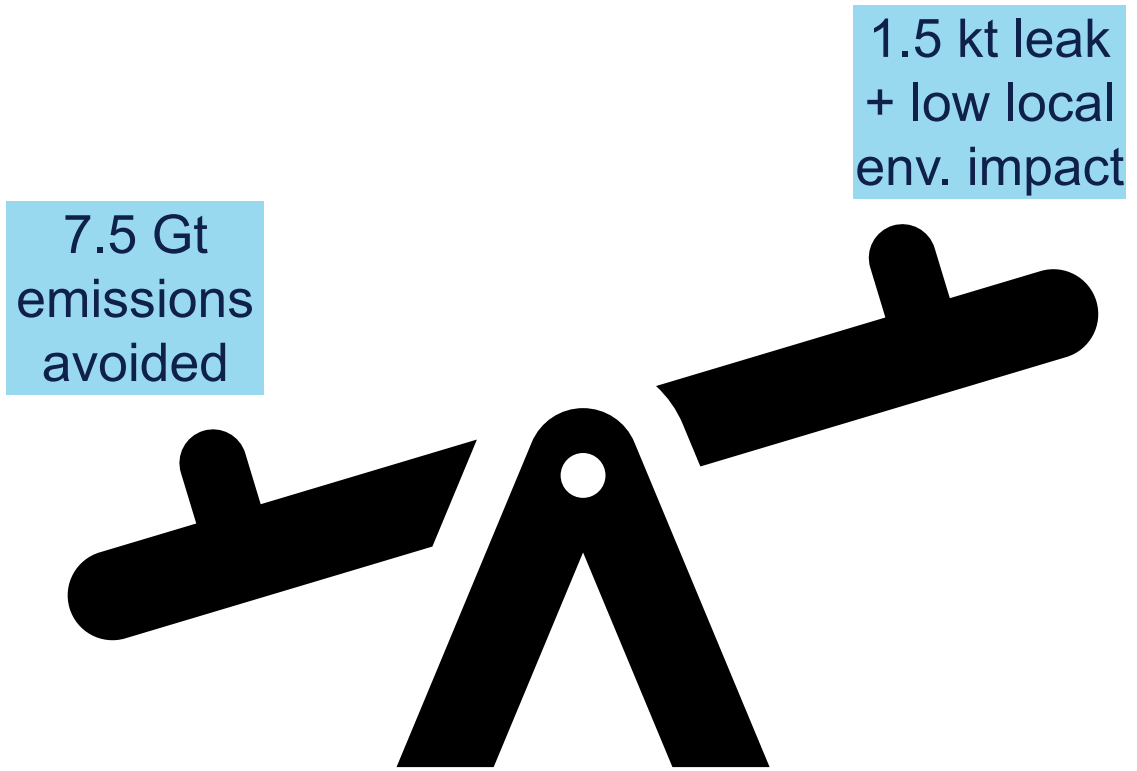
How to compare risk profile and project benefits

Since many risk scenarios for CO_2 storage projects have very low likelihood of occurring, it is recommended to compare risk and benefits by considering a portfolio of identical projects:

1. Perform a project-specific risk assessment
2. Establish project risk profile (leakage and consequences to human health and the environment)
3. Establish project benefit related to human health and the environment, incl. CO_2 emission reductions
4. Assume a portfolio of, e.g., 100 identical projects
5. Assume that each risk scenario identified occurs at the assessed frequency in each individual project, and that the assessed impact occurs
6. Evaluate the cumulative damage and cumulative benefit from the portfolio
7. Determine if the damage outweighs the benefit or vice versa

Determination of acceptable risk levels
Example: Project CoCo – offshore storage

- CoCo: 3 injection wells for 3 Mtpa storage, 25 yr
- Risk characterisation estimates that:
  - Likelihood of leakage per well during life of project is 1%
  - If leakage occurs:
    - Magnitude of cumulative leakage per well is <500 t
    - Flora can be affected in a radius of 100 m around the well, but no high value resources. Environmental impact = low
- Principle: 100 projects with identical risk profile:
  - 3 wells will experience a leak during project lifetime
  - Cumulative leakage is <1500 t and environmental impact = low
  - Cumulative storage = 7.5 Gt



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APPLICATION TO LEGACY WELLS IN NCS CONTEXT

CRITERIA FOR DECISION: NO WELL INTERVENTION

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1. Insignificant leakage risk: Combination of likelihood and HSE impact is ‘low’ in project specific circumstance.

2. Added HSE risk is offset by the benefit of (increased) stored volumes.

DETERMINING RISK SIGNIFICANCE

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Consequence: For expected leak rates for scenarios with CO_2 leakage to seabed along an offshore P&A well,

- a pH-change sufficient to cause environmental impact will only occur in a small local disc with radius up to a few 10s of meters around the well;
- all CO_2 will be dissolved in the water column within 1-2 m above seabed.

Likelihood: Assess the likelihood of leakage (or formation fluid release) based on the characteristics of each well, and the presence of driving forces.

Risk: Deploy the project specific risk evaluation criteria to determine if environmental risk is significant.

Project specific risk evaluation criteria

		CONSEQUENCE				LIKELIHOOD				
						A: Remote	B: Unlikely	C: Possible	D: Probable	A: Certain
		Health and safety (HS) and Environmental protection (E)	Cost (Commercial readiness)	System Performance	Schedule to start-up of operations	Very unlikely to occur during project, no knowledge of similar event occurring in the CCUS industry or in related activities	Unlikely to occur during project, similar event has not occurred in previous CCUS projects by ECO2S team, but has occurred in the CCUS industry or in related activities	Somewhat likely, 50/50 chance of occurring during project, similar event has occurred in previous CCUS projects by ISC team	Likely to occur during project, event expected to occur in similar projects	Very likely to occur during project, event is a common occurrence in similar projects
CONSEQUENCE SEVERITY	E: Very high	HS: On-site exposures/injuries leading to significant irreversible health effect or off-site exposures/injuries leading to irreversible health effect. E: Pe environmental damage, extensi required. Environment restore		Major failure in containment or						25
	D: High	HS: On-site injuries/exposures l term or irreversible health effe limb, hearing loss) with absen more than 5 days. E: Severe e damage. Remediation measu Environment restored 2-								20
	C: Medium	HS: Lost time event/on site inj temporary disability and absenc to 5 days, or affecting daily life than five days. E: Damage managed by Comp teams, env. restored < 2								15
	B: Low	HS: Minor injury or health eff recordable, reversible health e treatment and affecting work such as restricting work act activities for up to 5 days. E: D lasting effect.								10
	A: Very low	HS: Slight injury or health effect – Reversible health effect not requiring treatment, and not affecting work performance/daily activities. E: Damage contained within premises.	Less than $10 k	Minor or routine maintenance that does not interrupt CCTS activities.	Less than 1 month	1	2	3	4	5

To be proposed by operator and discussed and calibrated with competent authority

BALANCING RISK AND BENEFITS

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Guidance document to the CCS Directive on risk management:

The risk of negative impacts of CO_2 geological storage activities to human health or the environment should not outweigh the expected benefits to the social good, including from the emission reductions obtained.

Legacy well leakage risk must be offset by the benefit of increased stored volumes that is achieved by exposing each well to effects from the CO_2 geological storage project.

CONSIDERATIONS FOR FURTHER RISK REDUCTION

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Even if the criteria for no well intervention are met, there may be an opportunity for further risk reduction by **well intervention or other measures**. Well intervention should only be required if the following conditions are present:

a. Associated impacts are low (e.g., emissions, H&S, local env. disturbance);
b. Likelihood of success is high; and
c. Cost and practicality is not disproportionate to the expected risk reduction.

RISK CONSIDERATIONS NORTHERN LIGHTS

Northern Lights JV DA
Byfjordparken 15
4007 Stavanger

Oslo, 30.04.2025

Deres ref.:
Jarle Idsøe-Jakobsen

Vår ref. (bes oppgitt ved svar):
2025/2685

Saksbehandler:
Bjørn A. Christensen

Vedtak om tillatelse til injeksjon og lagring av CO_2 – Northern Lights JV DA

Vi viser til søknad datert 9. desember 2022 og tilleggsinformasjon gitt i e-poster av 20. juni 2023, 27. juni 2023, 3. oktober 2023, 5. januar 2024, 8. januar 2024, 7. mars 2024, 13. mars 2024 og 8. mai 2024.

Text within injection license:

- A release of CO_2 or formation water along any of the legacy wells to seabed will only have potential for very local impact. Any environmental impacts will have low severity.
- 4 of the 5 relevant legacy P&A wells have effective primary and secondary barriers. The fifth well has only one barrier, but is unlikely to be reached by the CO_2-plume, even if injected volumes is increased to 180 Mt. The likelihood of any such release is therefore low.

→ No need for well intervention as a preventive measure.

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