Legacy-well assessment through the lens of best practice, guidelines, and international standards for CO_2 storage

FORCE CCS Legacy Wells Workshop
Stavanger, Norway

David Buchmiller and Johnathon L. Osmond

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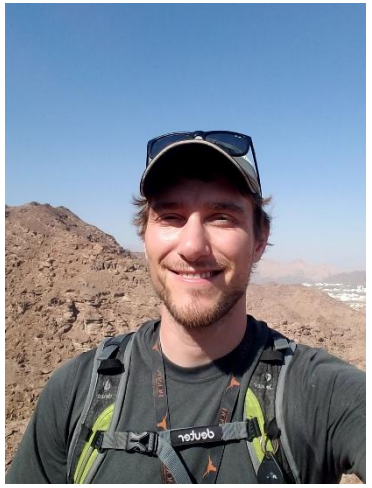
- Introduction, David, Johnathon & DNV
- Legacy wells approaches using international standards and guidelines
- Case studies
- Reflection

About the presenters

David Buchmiller – DNV Energy Systems, Norway

20 years of experience within well integrity disciplines, with extensive focus on well related topics in CO_2 storage. Background:

- CO_2 storage assurance projects
- Joint industry projects (JIPs) on CO_2 wells
- Well plug and abandonment projects and rule development
- Well integrity case studies and assurance



Johnathon Osmond – DNV CCUS Venture, Norway

12 years of experience in CO_2 storage site characterization and derisking, focus on migration and containment. Background:

- Onshore and offshore CO_2 storage developments internationally
- Oil and gas exploration projects
- Research and public sectors (CO_2 storage, trap / seal analysis, induced seismicity, outcrop studies, 3D modelling)
- Geophysical data acquisition

Keys to CO_2 storage success

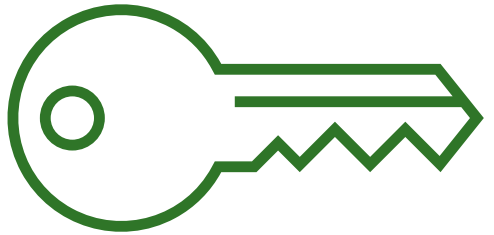
Capacity

Injectivity

Containment

Monitorability

Stakeholders



CO_2 storage assurance
Background of project experience

DNV with decades of experience in CO_2 storage projects:

- **Storage certification** projects according to DNV and ISO standards, ranging from Shell Quest and before to multiple ongoing international and North Sea projects
- **Independent due diligence** on behalf of asset buyer or sellers to assess and validate technical robustness
- **Independent evaluations** and **storage risk assessments**
- **Joint Industry projects** and **international guidance and standards development** on CO_2 storage

Demonstration in Cottbus, Germany against Vattenfall's CCS plans, primarily storage.
Credit: GuenterHH, flickr.com

- **Stakeholder and liability assurance**
- **Minimizing and mitigating risk**
- **A robust validation by experts prior to key decision gates**
- **Demonstrable adoption of International best practice**

Stakeholders, risks, and use of standards/guidelines

- Many stakeholders associated with CO_2-storage projects, including those funding the project
- Satisfying the 5 keys to CO_2 storage success (e.g., stakeholders) requires risk management
- Risk profile and perception are influenced by many factors, evolve over time
- Accepted standards, guidelines, and practices support project development and effective risk management
- Adherence provides assurance for stakeholders and helps secure project funding

Stakeholders

- Project developers and partners
- Funding agencies and insurers
- Regulators and policy makers
- NGOs and interest groups
- General public
- Other

Risk consequence categories

- Environmental/health
- Technical
- Financial
- Reputational/social
- Regulatory/legal
- Safety/security

Factors influencing risk perception

- Jurisdiction
- Storage concept
- Project setting / environment
- Public awareness and opinion
- Industrial/organizational track record
- Other

Addressing risk communication and perception

Standards and guidelines improve assessments and communication of risk, influencing risk perception

Benefits

- Usage shows proactiveness
- Demonstrates completeness and consistency
- Provides transparency, builds trust
- Sets structure, common / standardized format between projects
- Allows for easier comparison
- Helps present risks in appropriate detail (not too optimistic or technical)
- Fosters mutual understanding of risks between stakeholders
- Enables informed decision-making (e.g., financial)
- Reduces scepticism that things may be overlooked or hidden
- Generates documentation and “proof”

Common use of standards and guidelines

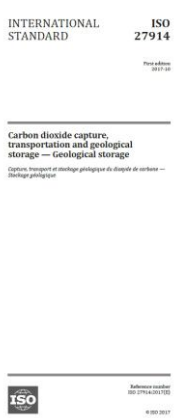
- Design and development in accordance with certain standards, guidelines, etc.
- Third-party validation and support:
  - Reviews
  - Due diligence
  - Certification or verification
  - Risk assessment
  - Competent persons reporting (CPR)
  - Ad hoc advisory scopes and deliverables

CO_2 storage standards and guidelines

- Projects anchored by regulation and policy (e.g., the EU CCS Directive)
- Several recognized standards, guidelines/guidance, and recommended practices available
- Provide common working frameworks for project development and verification
- Are useful tools for stakeholder holder engagement around project details, such as risks and risk management

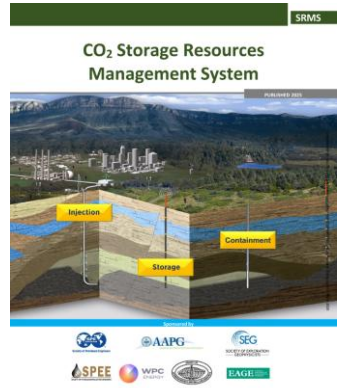
Key documents for CO_2 storage
- EU guidance documents 1–4
- ISO 27914
- DNV-RP-J203
- SRMS (and its guidelines)

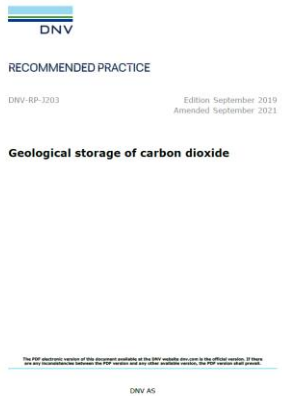
DIRECTIVE 2009/31/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL
of 23 April 2009
on the geological storage of carbon dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006



INTERNATIONAL STANDARD ISO 27914

Carbon dioxide capture, transportation and geological storage — Geological storage





DNV

RECOMMENDED PRACTICE

DNV-RP-J203

Edition September 2019
Amended September 2021

Geological storage of carbon dioxide

DNV AS

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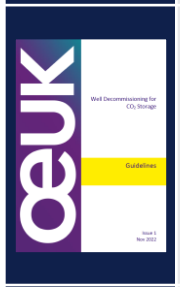
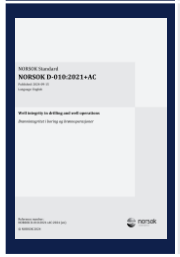
Legacy well regulatory considerations

Havtil Norwegian Ocean Industry Authority	CO_2 safety regulation § 11	The consequences for the well barriers of existing wells in the CO_2 storage complex shall be accounted for.
	CO_2 safety regulation § 17	For comments on the provision, reference is made to the guidelines for the provisions in Chapter VIII of the Facilities Regulations and Chapter XV of the Activities Regulations.
North Sea Transition Authority Guidance on Applications for a Carbon Storage Permit November 2023 – Version 2	Sec 61	Particular attention should be paid to decommissioned wells or wells that have yet to be decommissioned that penetrate or are near to the storage site or complex.
	Sec 124	In particular, the NSTA would require the appropriate and necessary evidence and analysis to be provided in a Storage Permit Application to enable it to reach a determination that there is no significant risk of leakage from all abandoned legacy wells at the time of permitting. If this can't be demonstrated to the NSTA's satisfaction, then dependent on the well risks identified in the risk assessment, such abandoned legacy wells may be required to be remediated.
	Sec 3.3.7. Presence and condition of natural and man-made pathways	The risk assessment of relevant legacy wells within and outside the storage complex should be based on available data on the status and condition of all wells. It should follow the guidance provided in applicable regulations, guidelines or standards: • [ISO 27914:2017] • [DNV-RP-J203] • [OEUK Guidelines: Well Decommissioning for CO2 storage, 2022]

Legacy-well standards

Standard		Reference	DNV interpretation related to legacy wells
	ISO 27914 (2017) *Update expected in 2026	Section 5.2	Site screening should consider the mechanical integrity of legacy wells.
		Section 5.3	Site selection should consider containment of CO_2 plume via legacy wells.
		Sections 5.4.6, 7.6.2, and 7.8.2	Legacy wells should be identified and properly evaluated relative to the potential for a leakage risk and associated impacts with well risk assessment.
		Section 7.7.1	Considerations for converting existing wells should be undertaken with careful evaluation.
		Section 9.4.2	Specific monitoring needs for a project related to legacy well integrity.
	DNV-RP-J203 (2021)	Section 7	Provide evidence that legacy wells will function within specific limits with an acceptable level of confidence when exposed to the effects of CO_2 storage.
		Section 7	Well qualification through evaluation of risk and well integrity status of legacy wells based on current status and future use in CO_2 injection and storage.
		Section 7.5	Evaluation of the likelihood of success of qualifying legacy wells for CO_2 storage projects.
		Section 7.6	Evaluation of the need for mitigation or modifications of the wells for CO_2 storage projects.
	OEUK Well Decommissioning for CO_2 Storage (2022)	Section 4.2	Verification of permanent barrier(s) for CO_2 storage. • Operational and verification means of permanent well barrier assurance, also relevant for 4.3.
		Section 4.3	Verification of legacy well barriers via identification and risk assessment of legacy wellbore integrity via potential leakage paths / routes for CO_2 or other reservoir fluids. Risk assessment process to be complete and systematic and include historic perspective and possible long-term effects of CO_2 plume on the legacy wells. • Describes three (3) possible methods: qualitative, structure / semi-quantitative, quantitative.
	NORSOK D-010 (2021)	General Section 10	Not specific to CCS legacy well evaluation, however P&A principles as described in section 10 and in EAC tables are used in CO_2 legacy well risk assessments.

Value of standards

What standards provide us

High-level work process on legacy well

- Identification and mapping
- Risk evaluations
- Remediation considerations

Key considerations to include:

- Specific well barrier evaluations
- Effects of CO_2 plume and reservoir fluids
- Information quality

What standards do not provide us

- Systematic and aligned risk analysis methodology
- Many options / possibilities exist
- Aligned method on risk interpretation
- What is low/medium/high
- Clear thresholds / acceptance criteria
- Direct requirements on MMV or project viability

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Case studies

Background

- Due to project confidentiality clauses, specific project details, diagrams and information is not shared.
- Key considerations for legacy wells are focused on herein.
- The use and benefits of of standards is emphasized.
- This presentation does not intend to communicate favoritism or criticism to any project, operator, supplier, consultant or research institute.

Source: INEOS(2025). Location of Project Greensand.

Case study A
Non-European project: 3rd party assurance

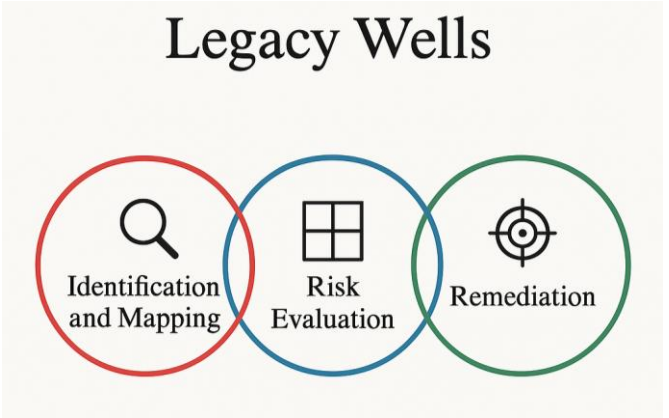
HISTORY:

As part of a DNV assurance of CO_2 storage Site Feasibility and Site Endorsement, the field in question had several high-risk legacy wells, located directly within the CO_2 plume / area of review:

- The CO_2 storage operator was also the operator of the legacy oil and gas wells, which in this case were decades old exploration wells. Screening identified these select legacy wells as high risk, while others were de-risked and screened out. The operator was able to group the wells, such that analyses could focus on the worst-case well.
- The operator and another independent analysis house conducted **quantitative well impact analysis** and **semi-quantitative probability analysis** as a basis for the **legacy well risk assessment**.

TAKEAWAYS:

- A standardized approach was used to demonstrate low risk results, both from probability and impact assessments, allowing the legacy well risks to be managed.
- Quantitative risk studies can assist in risk mitigation and substantiate decisions to not proactively remediate legacy wells.



Source: DNV

Case study B
European project: 3rd party assurance

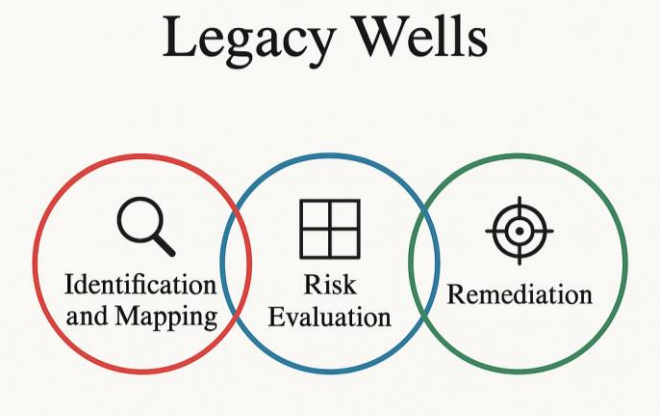
HISTORY:

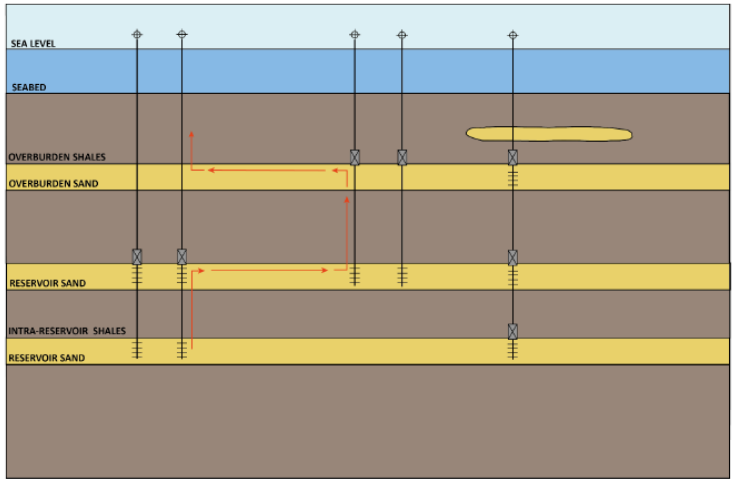
As part of a DNV assurance of CO_2 storage Site Feasibility and Site Endorsement, the field in question had multiple legacy wells:

- The CO_2 storage operator was not the operator of the legacy wells. However, through data acquisition and project dialog, sufficient information was obtained on the wells.
- A consultant performed assessment of the legacy wells containment according to:
  - OEUK Well Decommissioning for CO_2 Storage / OEUK Well Decommissioning Guidelines.
- The standardized results from the assessment were fully traceable, and provided sufficient evidence of wellbore containment through the legacy wells, which could be cross-examined and verified.

TAKEAWAYS:

- The OEUK Guidelines **provided clear guidelines for assessing and verifying** the suitability the legacy wellbore permanent well barriers.





Source: OEUK (2022). For illustrative purposes.

Case study C
Transactional due diligence

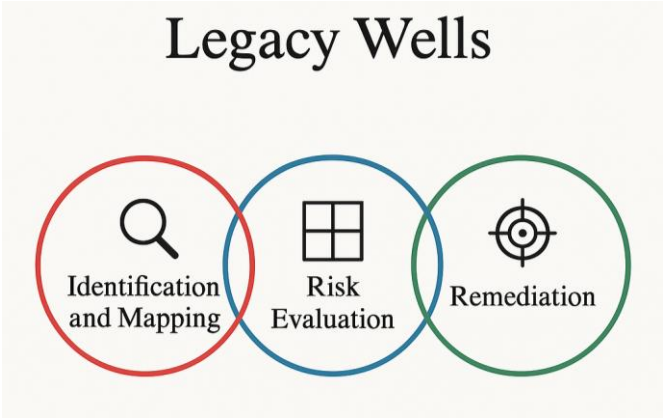
HISTORY:

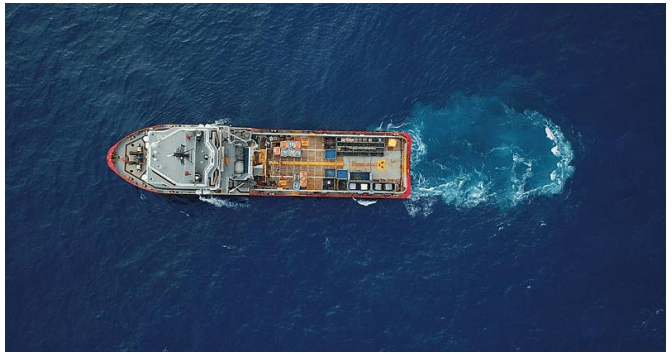
As part of independent review of a CO_2 storage project for a potential buyer, legacy well project risks were reviewed on a high level:

- The base case for the CO_2 storage included remediation of one (1) high-risk legacy subsea well. The subsea well's wellhead had been removed as part of the exploration drilling campaign and initial studies had confirmed the location of the legacy well.
- There was a preliminary plan and budget for well access (connectability) and wellbore remediation to restore / install permanent well barriers.
- The plan lacked contingencies, should well access, barrier placement and verification and other well work prove challenging. This fiscal uncertainty had not previously been considered.

TAKEAWAYS:

- The scope of legacy well remediation can be underestimated.
- Provisioning budgets for the legacy well remediation prior to CO_2 injection start-up is a more proper remediation strategy, although project developers prefer a "monitor and see" approach to reduce CAPEX.





Source: DNV

Reflections

Reflections

- Standards provide high-level guidance on what needs to be done, not how or what is good enough.
- Lack of aligned risk framework and acceptance criteria in standards / guidelines:
  - Industry says it should come from regulators, regulators say it should come from industry.
- Many different project specific approaches exist:
  - Varying solutions proposed, level of detail performed in risk and decision-making assessments.
- The vast majority of the technology exists today, the challenge will be making the solutions cost competitive and efficient for CCS.
  - Applies also to legacy well risk assessment, where refinement and adaptation of Oil and Gas well risk assessments can be built upon.

Thank you!

FORCE CCS Legacy Wells Workshops
Stavanger, Norway

David.Buchmiller@dnv.com
Johnathon.Osmond@dnv.com

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