Advancing Well Integrity Screening for CCS Applications: WISCoS, A Comprehensive Tool for Risk Assessment

Introduction

An increasing number of oil and gas reservoirs are being shut down or approaching the end of their productive lifetime, presenting an opportunity for Carbon Capture and Storage (CCS) in the depleted reservoirs (DOE, 2017). The existing wells in these assets present both an opportunity and a challenge, as they might provide potential CO_2 or brine migration pathways (Gasda, et al., 2004; Watson and Bachu, 2009). The integrity and remediation of inaccessible abandoned wells is recognized as a potential showstopper for CO_2 storage in depleted reservoirs (Holloway et al., 1996; Carey, 2013; Sminchak et al., 2016; Wiese et al., 2019). On the other hand, wells that are still accessible i.e. active and/or suspended with a wellhead in place, could be considered for re-use for CO_2 storage (e.g., as monitoring or injection well), which might provide an opportunity for cost savings.

In the North Sea region, CCS licencing requirements are country specific and outlined in the Storage Licence Application (SLA) process. CCS operators should comply with those requirements and provide a detailed risk assessment of the wells that pose a risk of leakage. The lack of standardization in the SLA process across the North Sea countries has led to similar, yet different interpretations of well integrity risks.

The WISCoS project (Well Integrity Storage Complex Screening) was initiated to address the lack of standardization, by developing a standalone well integrity tool to assess the state of each well irrespective of its current use (e.g. active, suspended, or plugged and abandoned) by creating a common approach to well integrity assessment for CCS SLA application. The tool is developed as a QGIS plugin and partially based on existing methodologies from REX-CO2 (well reuse) (Pawar et al., 2021) and TOPHOLE (legacy wells) research projects (Emmel and Dupuy, 2021). The tool is divided into four sections: data input, visualization, barrier assessment, and results/risk assessment.

This abstract will provide an overview of the Minimum Viable Product (MVP), the first version of the tool, with the final version planned to be released by the end of Q1 2025.

Methodology and approach

WISCoS is a JIP initiative led by TNO and SINTEF with project structure divided into several work packages, focusing on the development of a standardized well integrity framework translated into a software tool as a vehicle for its application.

The first step in framework development is the understanding of the regulatory and SLA requirements, and review of the latest well integrity and design requirements, which are now based on the ISO 16530-1:2017. Additional standards such as NORSOK D-010:2021+AC2:2021 and the latest well decommissioning for CO_2 OEUK guidelines will be used for detailed barrier validation and acceptance criteria. NOGEPA excludes CCS, however it is in the process of being considered for well barrier assessment. While these standards differ in some technical details, they share a common set of requirements about how the well has to be abandoned, however, the tool will be set to adapt to a specific standard as needed.

The second step in framework development involves the identification of relevant data for the complete well integrity assessment, which are the first input fields in the tool (Figure 1). This includes general information about the storage complex and about the wells penetrating the caprock. In addition, the following well inputs are required: accessibility from surface and wellhead status, directional survey, PPFG and/or FIT/LOT data, casing and cement specification, obstructions in the well and existing sidetracks, lithological profile alongside the well and nature of the expected formation fluids.

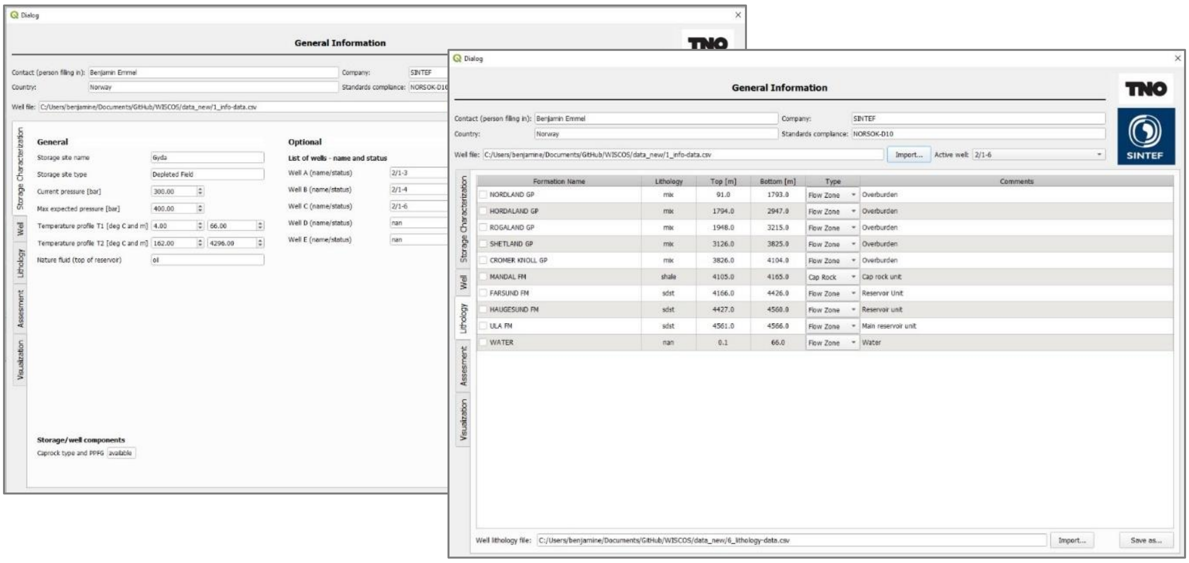

Figure 1 Example data input tabs about the storage complex (left) and well lithology (right). Provided information will be used to create a database, visualizations and in the barrier qualification process.

Based on the provided data, the tool generates simple well schematics with lithological column and key barrier elements to be assessed. In the case of multiple wells, the tool has the capability to visualize multiple wells side by side by creating simplified well plumbing diagrams (Figure 2).

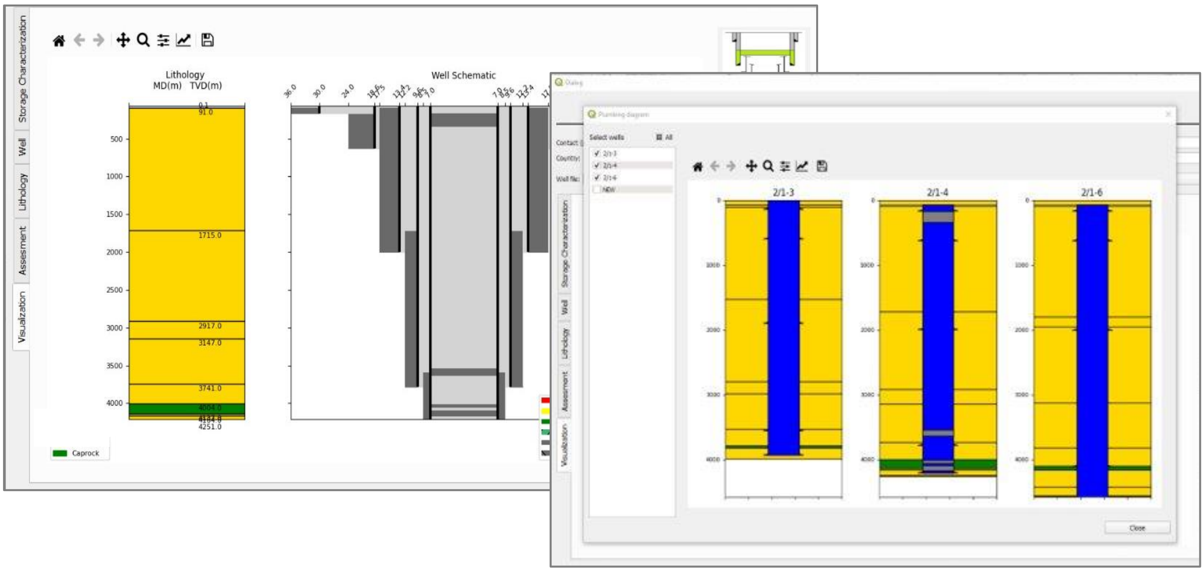

Figure 2 Well schematics are created based on the information provided in the previous step. The user can input the data about the casing specification, cement, plugs, lithology and obstructions in the well. The tool converts this information into well schematics plotted against lithology (left) and to create simple plumbing diagrams (right).

The next section addresses the well integrity evaluation. In the WISCoS tool, this is a two-step process, where the user first screens the well barrier elements (WBEs) against the minimum qualification requirements (NORSOK D-010, OEUK guidelines or NOGEPA), and thereafter a risk assessment is developed. The screening process focuses on the barrier elements that constitute the rock-to-rock seal, which in the case of a P&A well, are a sealing formation, annular cement, internal plug and if present, natural sealing formations. For each WBE, a dedicated screening workflow is defined and visualized in the form of decision trees which are then used to define the logic in the back-end of the tool. The outcome of the first screening step is whether the barriers are qualified, or not qualified (Figure 3).

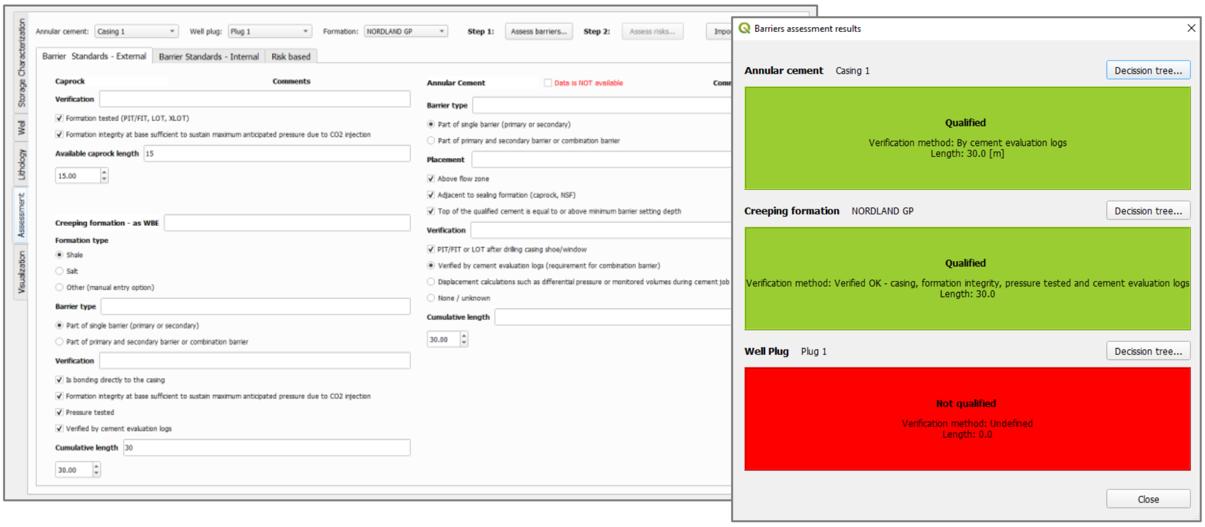

Figure 3 Barrier assesment in the MVP version of the tool is based on the verification methods, and acceptance criteria defined in the above mentioned well integrity standards. The outcome of the assessment is binary: whether the barrier is qualified or not. The final version of the tool will include the risk based approach for the non-qualified barriers.

In case the barrier element is not qualified a risk based assessment approach will follow. For example, primary risk factors for annular cement could include, but not be limited to: the interpretation and type of bond logs, presence of defects (mud channels, gas migration chimneys, liquid filled micro-annulus), leak evidence alongside its nature, fluid type and rate. Secondary risk factors for annular cement may include the well inclination, mud density during the drilling, cementing method, cement type and setting type, etc. Each primary and secondary risk factor comes with weights and scores which are defined by the JIP participants based on industry best practices. The risk based approach, with weights and scores and the risk profile presented through a bow-tie diagram and/or a potential leakage pathways diagram, are not part of the MVP version but are planned for the final version of the tool.

The tool will be tested on several case studies provided by the project partners, specifically aiming at reservoirs with a CCS potential and wells with different complexities. This would allow to improve the tool through an iterative process and make it compatible with different well design and integrity challenges.

Conclusion

This extended abstract showcases a novel approach to well integrity screening that integrates visualization and barrier assessment while adhering to SLA process requirements. The developed framework is incorporated into a user-friendly QGIS plugin, enabling visual representation of wells, rapid barrier qualification, and risk-based assessments. This innovative approach benefits operators and regulators in the CCS application process by providing a standardized and efficient method for risk assessment.

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