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Features, Events and Processes of geological hydrogen storage: Which pose highest risk for leakage? A three-scenario analysis: Depleted Gas Fields, Porous Aquifers and Salt Caverns.

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The role of hydrogen as a potential renewable energy storage vector is essential for carbon emission reduction and a corresponding low-carbon renewable energy supply and demand in the future. The geological storage of hydrogen is central to a steady transition from carbon emitting fuels to renewable energy resources as an off-grid energy supply, supporting intermittencies from renewable technologies. The depletion of gas reservoirs (DGRs) creates potential for hydrogen storage, whilst porous aquifers (PAs) and salt caverns (SCs) also provide the necessary conditions for potential hydrogen storage plays. However, the containment of hydrogen is challenging, and leakage from store has adverse economic and environmental consequences.

This project has examined and investigated risks associated with the components required for subsurface storage in three geological scenarios, and their relevant influences on the assessment of the long-term security of hydrogen in the subsurface. The construction of a database using a Features Events, Process (FEP) model comprising all concomitant aspects of hydrogen storage enabled the identification of key factors contributing to hydrogen leakage from geological stores. Information on the geological storage of hydrogen is sparse, hence the various risks associated with geological storage facilities were drawn from other subsurface operations (Nuclear Waste Storage and CO_2 storage) to develop a generic FEP database. The final database contains a comprehensive overview of risks involved in a hydrogen storage operation and forms the basis of an expert elicitation.

The identified risks were then incorporated within an expert elicitation exercise to quantify and analyse risks in terms of the severity of leakage extent, the probability of their occurrence over time, and those of high impact. Discrepancies in expert opinion emphasised high uncertainty risks that may contribute to leakage across the three subsurface storage facilities. The assessment of risks across three scenarios enabled comparisons of the confidence in their security to be made. A total of 12 risks were highly ranked in impact and uncertainty across two or more geological scenarios and were put forward for enhanced prevention, operation and monitoring strategies.