Probabilistic Modelling of Methane Leakage through Legacy Wells in the North Sea

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The integrity of legacy wells in the North Sea is a key factor in preventing methane emissions from subsurface reservoirs. The growing number of wells approaching abandonment and the significant climate impact of methane require a standard framework for evaluation of leakage potential. This study introduces a probabilistic modelling framework to evaluate methane migration pathways and quantify leakage risks associated with compromised wellbore systems in depleted hydrocarbon fields. The framework integrates parameter uncertainty through Monte Carlo simulations, enabling the assessment of a wide range of scenarios related to wellbore integrity, material degradation, and subsurface heterogeneity.

This work introduces a framework to capture multiphase flow under representative North Sea pressure and temperature conditions. It includes the evaluation of case studies from selected wells in the North Sea. The framework yields probability distributions of methane leakage volumes and breakthrough times into the overburden layers and the seabed, enabling quantitative assessment of leakage likelihood and associated uncertainties across different well configurations.

The proposed framework provides a physically consistent and computationally efficient basis for evaluating methane leakage risks through legacy wells in the North Sea. The approach supports regulatory compliance and contributes to the development of predictive tools for assessing the origin and migration of methane in offshore environments.

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