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Efficiency and impacts of hythane (CH4+H2) underground storage

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The foreseen increase share of renewable energy production requires energy storage to mitigate shortage periods of energy supply. Hydrogen is an efficient energy carrier that can be transported and storage. A very promising way to store large amounts of hydrogen is underground geological reservoirs. Hydrogen can be stored, among other options, as a mixture of natural gas and less than 20% of hydrogen (hythane) to avoid damages on the existing infrastructure for gas transport. This technology is known as power-to-gas and is being considered by a number of European countries (Simon et al., 2015).

In this study, the feasibility of a deep aquifer to store CH4-H2 mixtures in the Lower Triassic of the Paris Basin is numerically analyzed. The solubility of gas mixture in the groundwater is extremely low (Panfilov, 2015) and, therefore, gas and water are considered immiscible and non-reactive. An immiscible multiphase flow model is developed using the coefficient-form PDE interface of the finite element method code, COMSOL Multiphysics.

The modelled domain is a 2D section of 2500 x 290 m resembling the Lower Triassic aquifer of the Paris basin, consisting of 2 layers of sandstone separated by a layer of conglomerates. The domain dips 0.5% from east to west. The top of the aquifer is 500 m-deep and the lateral boundaries are assumed to be open. This case is considered conservative compared to a dome-like geological trap, which could be more favorable to retain higher gas concentration. A number of cycles of gas production and injection were modelled. An automatic shut-down of the pump is implemented in case pressure on the well exceeds an upper or lower threshold. The influence of the position of the well, the uncertain residual gas saturation and the regional flow are studied.

The model shows that both gas and aquifer properties have a significant impact on storage. Due to its low viscosity, the mobility of the hythane is quite high and gas expands significantly, reducing the maximum gas saturation during injection/production cycles. The storage efficiency is hindered by inactivity periods. Furthermore, the gas fate is extremely affected by regional groundwater flow.

References

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