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Hydraulic interactions of subsurface reservoirs used for excess energy storage

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Excess electricity produced from renewables can be converted into CH_4 by consuming CO_2 and H_2 by means of the Power-to-Gas (PtG) technology [1]. Previous work indicates that subsurface storage of CO_2 and CH_4 can meet the projected energy storage requirements [1] [2]. However, gas mixing occurs if both gases are stored in the same reservoir [3], and energy is lost if CH_4 is used as cushion gas when both gases are separately stored in different reservoirs [2]. Therefore, an innovative approach to overcome the limitation of aforementioned storage schemes is introduced in this study. For that purpose, the focus is on a double reservoir setting in one anticline system as it is commonly found in, e.g., the Northern German Basin. Here, the confining layer and preexisting or artificial hydraulic connections between the two reservoirs enable the operator to reduce energy losses and avoid gas mixing. We have elaborated a numerical multiphase flow model including the wellbore systems and reservoirs to study the fluid flow and beneficiary effects of pressure interaction between both reservoirs. Based on the geological and operational data of our regional showcase in Germany [4] [5], the energy storage efficiency is quantified, and the potential benefits of the proposed storage scheme are evaluated. It shows that the production of CH_4 increases by 68% over twenty years of injection and production. Furthermore, the factors that affect storage efficiency are analyzed to provide information for the optimization of PtG-based subsurface energy storage systems. The simulation can be applied to different geological systems and for parameter sensitivity studies to reduce energy losses and improve storage efficiency.

Keywords: Power-to-Gas; Subsurface gas storage; Carbon dioxide; Methane

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