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Stable large-scale CO_2 storage in defiance of an energy system based on renewable energy - Modelling the impact of varying CO_2 injection rates on reservoir behavior

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The IPCC Report 2014 strengthens the need for CO_2 storage as part of CCS or BECCS to reach ambitious climate goals despite growing energy demand in the future. The further expansion of renewable energy sources is a second major pillar. As it is today in Germany the weather becomes the controlling factor for electricity production by fossil fuelled power plants which lead to significant fluctuations of CO_2-emissions which can be traced in injection rates if the CO_2 were captured and stored.
To analyse the impact of such changing injection rates on a CO_2 storage reservoir. two reservoir simulation models are applied:
a. An (smaller) reservoir model approved by gas storage activities for decades, to investigate the dynamic effects in the early stage of storage filling (initial aquifer displacement).
b. An anticline structure big enough to accommodate a total amount of $\geq$ 100 Mega tons CO_2 to investigate the dynamic effects for the entire operational life time of the storage under particular consideration of very high filling levels (highest aquifer compression). Therefore a reservoir model was generated.
The defined yearly injection rate schedule is based on a study performed on behalf of IZ Klima (DNV GL, 2014). According to this study the exclusive consideration of a pool of coal-fired power plants causes the most intensive dynamically changing CO_2 emissions and hence accounts for variations of a system which includes industry driven CO_2 production. Besides short-term changes (daily & weekly cycles) seasonal influences are also taken into account.
Simulation runs cover a variation of injection points (well locations at the top vs. locations at the flank of the structure) and some other largely unknown reservoir parameters as aquifer size and aquifer mobility.
Simulation of a 20 year storage operation is followed by a post-operational shut-in phase which covers approximately 500 years to assess possible effects of changing injection rates on the long-term reservoir behaviour.
The cyclic injection operation has an impact on the requirements of the facility design. To define the design basis for the aboveground installations only wellhead pressures are to be considered. For this reason the calculated bottom hole pressures need to be transferred into wellhead pressures. This is done by the application of thermodynamic models which include all relevant processes associated with the fluid flow through production or injection strings.
Finally, a commercial analysis is carried out which is based on a total cost estimate (CAPEX & OPEX). The outcome of this analysis demonstrates required certificate prices to reach the common return targets of an industrial project.
References
DNV GL, " CO_2 Transport Infrastructure in Germany - Necessity and Boundary Conditions up to 2050", IZ Klima, Berlin, 2014, http://www.iz-klima.de/.