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Application of smart proxy model for multi-optimization of CO_2-EOR design in farnsworth unit with production-injection well conversion

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ABSTRACT

CO_2-Enhanced Oil Recovery (CO_2-EOR) is an effective development strategy and an economically viable CO_2 storage method for a mature oil field. In this study, a smart proxy model (SPM) was constructed to establish the optimal development strategies in Farnsworth Unit (FWU) considering CO_2 storage and oil production with the production-injection well conversion. An SPM was constructed with the results of 16 reservoir simulations and was validated with an R^2 values of 96.3 % and 97.5 % for the CO_2 storage and oil production, respectively. The obtained Pareto front indicates a range of the optimized CO_2 storage and oil production. In addition, the maximum CO_2 storage case shows 260 % and 61.1 % of the CO_2 storage and oil production of the base case, respectively. When the maximum oil production is targeted, the CO_2 storage and oil production are respectively 66.5 % and 111.3 % of the base case. It was concluded that the SPM is effectively applicable for multi-objective optimization with fewer simulation runs and shorter time. In addition, the well conversion is a viable method to improve both the CO_2 storage and oil production in the FWU during CO_2-EOR process.

1. Introduction

Global CO_2 emissions from energy have reached 37 billion tonnes (Gt) in 2022 (IEA, 2023). As the CO_2 concentration in the atmosphere has significantly increased, geological CO_2 storage has gained importance as the most feasible method to sequestrate massive amount of the CO_2 (Song et al., 2023). CO_2 storage aims at a porous, permeable, and confined geological structure such as a depleted hydrocarbon reservoir and a saline aquifer. According to the International Energy Agency (IEA), there are 5 large geological CO_2 storage projects that are injecting and storing 7 $MtCO_2$/year (IEA, 2020).

Although the capacity of the Carbon Capture, Utilization and Storage (CCUS) projects currently being constructed, designed, or operated is 361 Mtpa, the rate of carbon storage must increase to meet the climate target (Global CCS Institute, 2023). Therefore, studies have been conducted to improve the technological level and to reduce the cost of CCS projects (Lu et al., 2021; Song and Wang, 2021). In addition, there are governmental efforts to attract interests for more CCS projects with financial incentives such as carbon credit market in EU and 45Q tax incentives in the U.S. This is primarily because preparing and operating CCS requires cost, which may not be economically viable with the financial support from the government.

CO_2 Enhanced Oil Recovery (CO_2-EOR) method, which injects CO_2 into a mature oil field to improve oil productivity, has stored more CO_2 than any other industrial process, as it was found that most of the injected CO_2 remains in the reservoir after the process (Núñez-López and Moskal, 2019). Moreover, the estimated CO_2 storage capacity in the U.S. in means of CO_2-EOR is estimated as of 274–479 billion tons (National Petroleum Council, NPC, 2021). Although the financial support is only given for the amount of CO_2 injected that originates from anthropogenic sources, one may argue that the process is still emitting CO_2 by producing underground hydrocarbons.

CO_2-EOR+ (or CCS-EOR) is distinguished from the conventional CO_2-EOR, as it is designed to intentionally increase the amounts of CO_2 stored (IEA, 2015). According to IEA, if 600 kg or more CO_2 is injected to produce 1 bbl of oil, more CO_2 is removed from the atmosphere, as approximately 500 kg of CO_2 is generated from oil production operation and combustion of produced oil (IEA, 2018). Therefore, CO_2-EOR can be an economical alternative for CO_2 storage when properly designed to achieve the multiple objectives the maximum injected CO_2 and oil

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