Environmental and Operational Performance of CO_2-EOR as a CCUS Technology: A Cranfield Example with Dynamic LCA Considerations

GCCC Publication Series #2019-30

V. Nunez-Lopez
R. Gil-Egui
S.A. Hosseini

Keywords: CO2-EOR, storage, economics

Cited as:
Nunez-Lopez, Vanessa, Ramon Gil-Egui, and Seyyed A. Hosseini, 2019, Environmental and Operational Performance of CO2-EOR as a CCUS Technology: A Cranfield Example with Dynamic LCA Considerations, GCCC Publication Series #2019-30, originally published in *Energies,* 12(3), 448.

Abstract

This study evaluates the potential of carbon dioxide-enhanced oil recovery (CO_2-EOR) to reduce greenhouse gas emissions without compromising oil production goals. A novel, dynamic carbon lifecycle analysis (d-LCA) was developed and used to understand the evolution of the environmental impact (CO_2 emissions) and mitigation (geologic CO_2 storage) associated with an expanded carbon capture, utilization and storage (CCUS) system, from start to closure of operations. EOR operational performance was assessed through CO_2 utilization rates, which relate usage of CO_2 to oil production. Because field operational strategies have a significant impact on reservoir engineering parameters that affect both CO_2 storage and oil production (e.g., sweep efficiency, flood conformance, fluid saturation distribution), we conducted a scenario analysis that assessed the operational and environmental performance of four common and novel CO_2-EOR field development strategies. Each scenario was evaluated with and without stacked saline carbon storage, an EOR/storage combination strategy where excess CO_2 from the recycling facility is injected into an underlying saline aquifer for long-term carbon storage. The dynamic interplay between operational and environmental performance formed the basis of our CCUS technology analysis. The results showed that all CO_2-EOR evaluated scenarios start operating with a negative carbon footprint and, years into the project, transitioned into operating with a positive carbon footprint. The transition points were significantly different in each scenario. Water-alternating-gas (WAG) was identified as the CO_2 injection strategy with the highest potential to co-optimize EOR and carbon storage goals. The results provide an understanding of the evolution of the system's net carbon balance in all four field development strategies studied. The environmental performance can be significantly improved with stacked storage, where a negative carbon footprint can be maintained throughout the life of the operation in most of the injection scenarios modelled. This information will be useful to CO_2-EOR operators seeking value in storing more CO_2 through a carbon credit program (e.g., the 45Q carbon credit program in the USA). Most importantly, this study serves as confirmation that CO2-EOR can be operationally designed to both enhance oil production and reduce greenhouse gas emissions into the atmosphere.