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Opportunities For A CO2-Enhanced Oil Recovery Project In The North Sea: Analysis Of Profitability And Environmental Impact

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Summary

The economic and environmental impact of an integrated CO2-EOR project in the Buzzard field in the North Sea is investigated through a life cycle analysis, a standard economic analysis and a more advanced geo-economic simulation. Results show the benefits of combining EOR with CO2 storage. However, the current economic environment provides insufficient long-term outlooks to justify the investment.

Introduction

The EU has set ambitious goals on the reduction of CO_2 emissions into the atmosphere for limiting the effects of global warming. And while renewable alternatives are available in some cases, long-term storage of large quantities of produced CO_2 seems inevitable. Because the process of capturing, transporting and injecting CO_2 into a reservoir (CO_2 capture and storage, CCS) is costly and current revenues from the EU emission trading system (ETS) are insufficient to cover the expenses, the commercial deployment of CCS is delayed in Europe. A potential business case for CO_2 geological storage (CGS) is CO_2-enhanced oil recovery (CO_2-EOR), where CO_2 is used to drive out 5-15% additional oil after the application of primary and secondary recovery techniques. Within Europe, the North Sea is the main oil province with a high potential for CO_2-EOR. Earlier studies have concluded that offshore CO_2-EOR projects are a viable business case, but no investments have been made yet. Moreover, adversaries of this technology often point out that CO_2-EOR is not a climate-friendly solution because its goal is to increase and lock-in fossil fuel production.

Economic and environmental analysis

To investigate the potential of CO_2-EOR, an integrated geological, techno-economic and environmental analysis is made of a potential candidate for EOR in the North Sea: the Buzzard oil field (Roefs *et al.*, in press). A techno-economic spreadsheet calculation is made for different injection scenarios. A full-sized coal-fired power plant is assumed, producing about 4 $MtCO_2$/y, of which the Buzzard field can accept 2.9 Mt/y for EOR. A second injection location in an aquifer is also assumed. The market scenario is chosen at an oil price of 50 €/bbl, and an ETS price at 5 €/t. In parallel, a life cycle assessment (LCA) is conducted to compare the environmental impact, considering emissions from construction and operation, and refining of the produced oil (mainly CO_2, CH_4, NO_x and SO_x). Four scenarios are considered: CO_2 capture and storage (CGS) in an offshore aquifer; CO_2-EOR in the Buzzard field followed by emission into the atmosphere; CO_2-EOR and parallel aquifer storage; and CO_2-EOR and parallel aquifer storage, with a continuation of storage in the Buzzard field after the cease of oil production. For the first time such an integrated economic and environmental analysis is made comparing CGS and EOR.

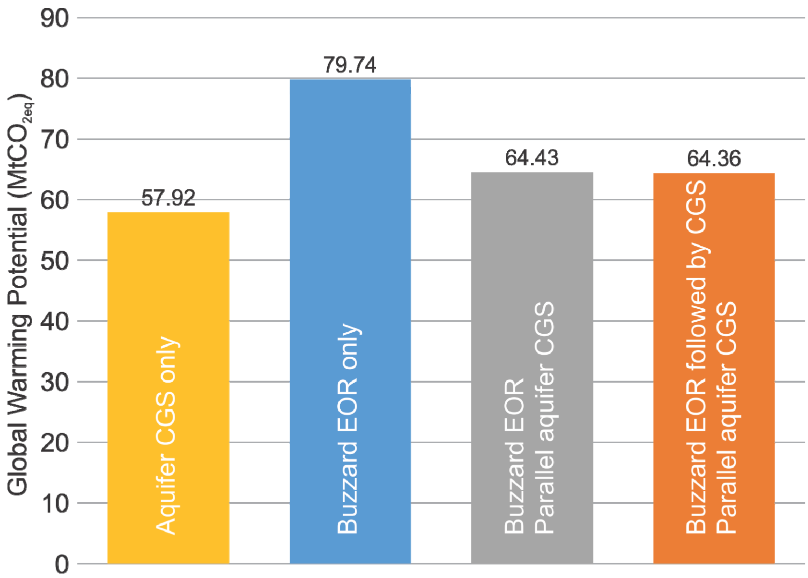

Figure 1 *Global warming potential of a CO_2-EOR project for the four LCA scenarios.*

Results show that the scenario with only CGS has the lowest global warming potential (GWP), but the project value is negative (-800 M€) and thus does not provide a viable investment option (Figure 1). The scenario with only EOR has the highest project value (>500 M€), but also has the highest GWP, 22 $MtCO_2$eq more than the storage-only scenario. The results for the third and fourth scenario are very similar, with a GWP of 7 $MtCO_2$eq more than the storage-only scenario, and a project value of

207 and 220 M€ respectively. This shows that CO_2-EOR can be a viable investment that, when combined with CO_2 storage, only has a minor additional environmental impact over a storage-only project. EOR can thus also serve as an enabler for CGS, with a widespread storage deployment when the necessary infrastructure is in place. It is also beneficial to use the depleted oil field for storage (fourth scenario) over aquifer storage (third scenario), because the necessary infrastructure is already present. From a sustainability perspective this also makes sense, as it allows for a more efficient use of geological resources.

Geo-economic simulation

The analysis shows that even at low oil and CO_2 prices, EOR projects can be viable. Since no projects are (soon becoming) operational, other factors are influencing the economic viability too. A more advanced geo-economic analysis is therefore performed with the PSS simulator from the point of view of an investor for the Buzzard field. In a more realistic approach, investment decisions are simulated, considering limited foresight generated by market and reservoir uncertainty. Results show that an increased hurdle rate (HR) results in a lower chance of a negative project value (Figure 2, Welkenhuysen *et al.*, in press). A hurdle rate of 12% removes all project risk, but also eliminates potentially viable projects. At an oil price of 50 €/bbl, the threshold for EOR investment occurs at 0 €/tCO_2 (excluding capture cost). This is too much to be covered by the current CO_2 market price of around 15 €/t (June 2018).

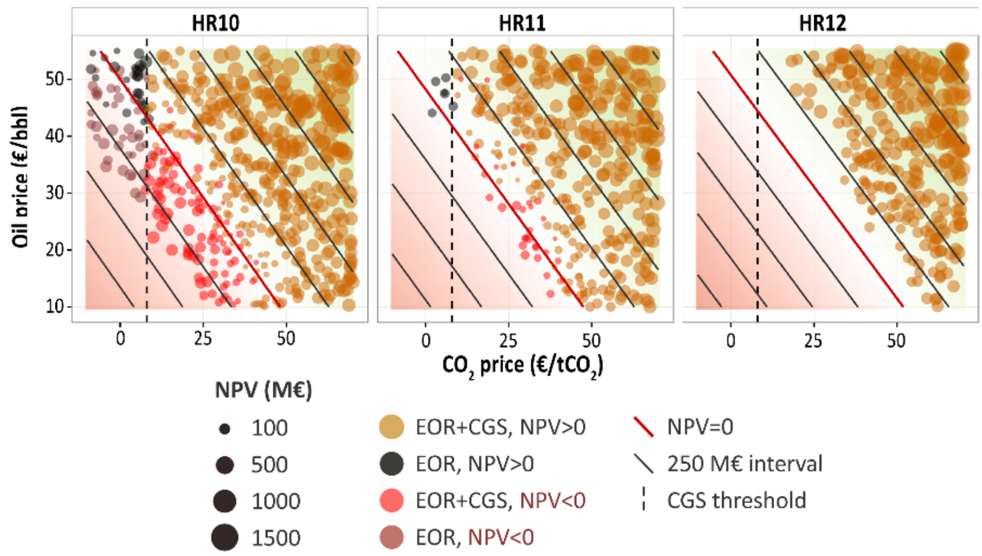

Figure 2 *Results of the PSS IV simulation of the Buzzard field for different hurdle rates (HR10, HR11 and HR12). Negative project values in red/brown are possible because of the limited foresight: a project evaluated as viable may end up uneconomic due to uncertainty at the time of the final investment decision. To the right of the dotted vertical threshold line are projects with CGS after the EOR phase.*

Conclusions

CO_2-EOR in the North Sea does not come forward as commercially viable from this study, where, in comparison to state-of-the-art assessments, more realistic economic and geological uncertainties are used. It does, however, have strategic and environmental benefits compared to a situation where oil is imported into the EU. In that context, incentives to reduce the cost and/or risk could be justified. Future research will focus on the establishment of contractual agreements between the parties, including uncertainty in the environmental analysis, and the scarcity cost of storage capacity as a limited commodity will be taken into account.

Acknowledgements

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