IEAGHG Information Paper 2017-IP63; CSLF Report on Offshore CO_2-EOR

One of the benefits of enhanced oil recovery using carbon dioxide (CO_2-EOR) is that it can it lead to the permanent storage of CO_2 and also generate revenue from increased oil production. There are, however, substantial barriers to its implementation, especially offshore. This led the Carbon Sequestration Leadership Forum (CSLF) to set up a task force in November 2014 to identify technical barriers, R&D requirements and opportunities for offshore CO_2-EOR. This initiative was a follow-up to earlier task forces on issues related to sub-seabed storage of CO_2 and the conversion of CO_2-EOR projects for CO_2 storage.

This latest CSLF report[1] provides an overview of the current technology status, technical barriers, and research and development (R&D) opportunities associated with offshore CO_2-EOR. It describes: the differences between on and offshore CO_2-EOR; a summary of the global potential and economic viability; a description of the Brazilian Lula project, the world's first offshore CO_2-EOR project; technological advances that could lead to cost reduction; supply chain requirements; monitoring, verification and accounting (MVA) issues; and regulatory requirements.

Experience from the giant Lula field, operated by Petrobas, has shown that there are no substantial barriers to the implementation of the technology in challenging offshore environments. However, this project did benefit from adaptation of the high CO_2 content in the associated natural gas which was re-injected rather than vented to atmosphere. Crucially the entire recovery operation, and design of the offshore production facilities, factored in CO_2-EOR right from the start.

Although Lula is particularly suited to the use of miscible fluid methods for EOR especially CO_2 its development presented significant challenges and risks. It is located 230 km from the coast in 2,200m of water. Consequently substantial recovery would be necessary to justify the investment necessary for such a location. The presence of CO_2 in the produced fluids resulted in the necessity to select corrosion-resistant materials in wells, flowlines, risers and in the processing plant itself.

The use of CO_2 in EOR needs to be carefully planned to take account of reservoir petrophysical conditions. Early breakthrough into production wells is always possible causing loss of oil recovery. Corrosion, scale and wax deposition, asphaltene precipitation and hydrate formation during walter-alternating-gas cycling are also possible potentially reducing the economic viability of the field. Despite these conditions no major operational problems have been detected.

The lack of offshore CO_2-EOR projects elsewhere appears to be caused by several barriers. CO_2-EOR requires high investment costs, CAPEX, and operational costs, OPEX, to modify and then use CO_2 on production facilities. Loss of production and therefore revenue during modification also needs to be factored in. Reservoir performance even for well characterised mature reservoirs may still be subject to uncertainties. Aside from technical issues the supply of CO_2 still remains a major hurdle coupled with the lack of realistic business models that can take account of fluctuating oil prices and variable or very low CO_2 costs. There are also remaining uncertainties around the regulatory framework for the shipment and use of CO_2. It is not clear what requirements different jurisdictions will place on monitoring injected CO_2. Then there is the challenge of monitoring CO_2 in the subsurface offshore.

The report makes a series of key recommendations to implement what could be a highly beneficial route to develop CO_2 storage. CSLF propose that governments and industry should work together to

[1] Enabling Large-scale CCS using Offshore CO2 Utilization and Storage Infrastructure Developments. CSLF Offshore CO2-EOR Task Force, 8 November 2017

increase the pace of deployment primarily through high-level political initiatives. One consequence of inactivity will lead to missed opportunities for instigating CO_2-EOR as fields get more mature and uneconomic. Supply of CO_2 is another fundamental area that needs to be addressed. The report advocates the establishment of plans for regional hubs to link and transport point-sources of CO_2. A network offers multiple sources of CO_2 and at lower cost compared with one-to-one source-sink scenarios; however, the significant upfront investment to build networks will require committed co-ordination between industries, commercial sectors and regional authorities. There are some preliminary feasibility studies of such systems, most notably around the Gulf of Mexico and for the North Sea. The establishment of offshore CO_2 networks will necessitate risk and cost-shared partnerships and will need to include realistic fiscal incentives.

CO_2-EOR by its very nature means that additional equipment and modifications are needed to separate CO_2 from the produced oil and gas and to make existing wells and pipes resistant to CO_2 corrosion. The CSLF report has highlighted the importance of new technological development, for example better mobility control or sub-sea separation systems. The viability of pre-existing pipelines should also be considered. Further modification of regulations will be necessary to cover sub-surface monitoring requirements during EOR operations and post-closure. Guidelines on the transfer of an operational production site into a CO_2 storage site will also need to be formulated.

This report provides a definitive account of the potential for CO_2-EOR offshore and the direction of travel that is required to deliver it. It can be downloaded from the CSLF website at:

https://www.cslforum.org/cslf/sites/default/files/documents/OffshoreEORTaskForce-FinalReport.pdf

IEAGHG was a contributor to the report, providing relevant IEAGHG reports (3 reports and 2 papers are cited, see below) and IEAGHG was lead author for Chapter 8 on regulations. The two papers cited cover the implications of regulations that govern CO_2 storage. In one of the three reports (IEAGHG 2015) there is a definitive reference to monitoring techniques that are used to track CO_2 in the deep subsurface below 800m and at shallow depths close to or at the sea bed. The ability to monitor CO_2 using a spectrum of techniques enables operators to demonstrate compliance with predicted migration or modification of initial simulations. The monitoring techniques can also be used to detect the presence of leaks. Both these key areas are the subject of continuous investigation via the IEAGHG storage networks. The economic evaluation conducted by IEAGHG (IEAGHG 2016) highlighted the oil price and cost of CO_2 under hypothetical conditions that would be necessary to implement CO_2-EOR. The favourable economic conditions that could lead to offshore CO_2-EOR will require fiscal incentives which are not covered in the CSLF report. IEAGHG has recently commission a new study on the viability of established offshore oil and gas production facilities for handling CO_2 (Re-Use of Oil and Gas Facilities for CO_2 Transport and Storage). It is scheduled for completion in the Spring of 2018. For more detailed background please refer to the following reports.

1. IEAGHG, 2009. CO2 Storage in Depleted Oilfields: Global Application Criteria for Carbon Dioxide Enhanced Oil Recovery, Report 2009/12, December 2009. http://www.ieaghg.org/docs/General_Docs/Reports/2009-12.pdf
2. IEAGHG, 2015. Offshore Monitoring for CCS Projects, Report 2015/02, May 2015. http://www.ieaghg.org/docs/General_Docs/Reports/2015-02.pdf
3. IEAGHG, 2016. Regional assessment of barriers to CO2 enhanced oil recovery in the North Sea, Russia and the GCC states. IEAGHG Report 2016/11, October 2016. http://www.ieaghg.org/publications/technical-reports/129-publications/new-reports-list/718-2016-11

4. Dixon, T., A. Greaves, J. Thomson, O. Christophersen, C Vivian, C., 2009. International Marine Regulation of CO_2 geological storage. Developments and implications of London and OSPAR. GHGT-9. Energy Procedia 1 (2009), 4503–4510.
5. Dixon, T., S.T. McCoy, I. Havercroft, 2015. Legal and Regulatory Developments on CCS International Journal of Greenhouse Gas Control 40 (2015) 431–448

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