



## Off-shore enhanced oil recovery in the north sea: matching CO<sub>2</sub> demand and supply given uncertain market conditions

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### Introduction

CO<sub>2</sub> enhanced oil recovery (CO<sub>2</sub>-EOR) entails the injection of CO<sub>2</sub> in mature oil fields in order to mobilize the oil. In particular, the injected CO<sub>2</sub> reduces the oil's viscosity and acts as a propellant, resulting in an increased oil extraction rate (Leach et al., 2011). Given uncertainty in both oil price and CO<sub>2</sub> price under the EU ETS system, aim of this study is to analyze under which economic conditions a CO<sub>2</sub> exchange can be established between a CO<sub>2</sub> supplier (an electricity producer for whom CO<sub>2</sub> is a by-product) and a CO<sub>2</sub> user (an offshore oil company that exploits oil fields in the North Sea and needs CO<sub>2</sub> for enhanced oil recovery).

### Methodology

A techno-economic simulation tool, PSS IV, was developed to provide investment decision support on integrated CO<sub>2</sub>-EOR projects (Welkenhuysen et al., 2014). Until now, a fixed onshore supply of CO<sub>2</sub> was presumed. An economic optimization model is now developed for both the CO<sub>2</sub> producer and the CO<sub>2</sub> user. Because net present value and discounted cash flow methods are inadequate to deal with issues like uncertainty and the irreversibility of an investment decision, the real options theory is applied (Dixit and Pindyck, 1994). The way in which cooperation between the companies can take place, will be studied using game theoretical concepts (Lukas and Welling, 2014). Economic and technical data on CO<sub>2</sub> capture are available from the PSS database (Piessens et al., 2012). Data on EOR performance, CO<sub>2</sub> requirements and various costs are taken from literature (BERR, 2007; Klokk et al., 2010; Pershad et al., 2012).

### Results/Findings

It will be shown what the impact of price uncertainty is on the investment decision of the electricity producer to capture and sell CO<sub>2</sub>, and on the decision of the oil producer to make the necessary investments to inject CO<sub>2</sub> for enhanced oil recovery. Based on these results, it will be determined under which economic conditions a CO<sub>2</sub> exchange and transport can take place. Furthermore, also the role of the ETS system will be discussed. In an initial stage, only the CO<sub>2</sub>-price and oil price market uncertainties are considered. In a further stage, uncertainties from the supply side (technology) and EOR (geological) will be added.

### References

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