Energy Policy 101 (2017) 123–137

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Off-shore enhanced oil recovery in the North Sea: The impact of price uncertainty on the investment decisions

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ARTICLE INFO

Keywords:
CO2 enhanced oil recovery
Uncertainty
Real options analysis
Investment decision

ABSTRACT

Although CO_2 Capture and Storage (CCS) is considered a key solution for CO_2 emission mitigation, it is currently not economically feasible. CO_2 enhanced oil recovery can play a significant role in stimulating CCS deployment because CO_2 is used to extract additional quantities of oil. This study analyzes the investment decision of both a carbon emitting source and an oil company separately by adopting a real options approach. It is shown that when uncertainty is integrated in the economic analysis, CO_2 and oil price threshold levels at which investments in CO_2 capture and enhanced oil recovery will take place, are higher than when a net present value approach is adopted. We also demonstrate that a tax on CO_2 instead of an emission trading system results in a lower investment threshold level for the investment in the CO_2 capture unit. Furthermore, we determine a minimum CO_2 selling price between the two firms and show that CO_2-EOR has the potential to pull CCS into the market by providing an additional revenue on the capture plant. However, when CO_2 permit prices are above an identifiable level, the EU ETS does not necessarily result in the adoption of CCS and stimulates oil production.

1. Introduction

There is a wide range of ways to reduce greenhouse gas emissions. In the case of CO_2, large-scale reductions can be achieved by e.g. increasing energy efficiency, by applying renewable energy sources, or by CO_2 capture and geological storage (CCS). CCS consists of separating the CO_2 from the flue gas of large industrial plants and transporting it to a suitable underground reservoir for long-term storage (IPCC, 2005). The International Energy Agency (IEA, 2014) considers CCS as a key solution for CO_2 mitigation, covering 14% of total reductions needed by 2050 for the 2-Degrees Scenario. However, a rapid adoption of CCS is not expected due to high investment costs in conjunction with low CO_2 permit prices (Abadie and Chamorro, 2008). Nykvist (2013) shows that if this technology is to be pursued, more demonstration plants are required, pilot plants should be scaled up, and both public funding and the CO_2 emission price should increase. Another way to enhance the viability of CCS, is the effective use of CO_2. For instance, all major new CCS projects in the US are conditioned on enhanced oil recovery (EOR) (Krahe et al., 2013; Nykvist, 2013). EOR is the recovery of additional oil to the oil produced by pressure depleting (pumping) at the production well. CO_2 enhanced oil recovery (CO_2-EOR) entails the injection of CO_2 in mature oil fields in order to mobilize the oil. In particular, the injected CO_2 reduces the oil's viscosity and acts as a propellant, resulting in an increased oil extraction rate (Leach et al., 2011). CO_2-EOR is considered to play a significant role in stimulating subsequent CCS deployment (Scott, 2013). As regards the deployment of CO_2-EOR in North western Europe, the situation is different to that in North America as Europe's oilfields are mostly located offshore and the thicker, compartmentalized reservoirs could result in a less effective sweeping of the reservoir with CO_2 (Scott, 2013). The main challenge however is the lack of sufficient quantities of readily available CO_2 (Awan et al., 2008). Although in both the UK and the Netherlands, demonstration projects were envisaged, they failed to secure funding, leaving North Sea CO_2 -EOR an open question (Scott, 2013).

1.1. Previous studies on the techno-economic feasibility of CO_2-EOR

There are various techno-economic analyses that study the eco-

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http://dx.doi.org/10.1016/j.enpol.2016.11.034
Received 4 December 2015; Received in revised form 21 November 2016; Accepted 22 November 2016