



CO₂-EOR in the UK: Analysis of fiscal incentives

Final Non-Technical Report

30th April 2013

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The views and opinions expressed by authors in this publication are those of the authors and do not necessarily reflect those of the project sponsors.

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Caveat

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1 Background

Carbon capture and storage (CCS) is a technology that could reduce CO₂ emissions to atmosphere from power and/or industrial sources. CCS could provide up to 20% of global CO₂ emissions reduction required in 2050, potentially halving the costs of meeting climate targets both in the UK and internationally¹.

Several planned, and at least one operational, CCS projects in North America use captured CO₂ for enhanced oil recovery (EOR). The revenues from CO₂-EOR reduce the costs of CCS, create wealth, and support employment.

A recent techno-economic evaluation by Element Energy *et al.* for Scottish Enterprise identified several oilfields in the UK sector of the North Sea for which CO₂-EOR could provide permanent CO₂ storage capacity for CCS projects, and yield positive (i.e. favourable) net present value (NPV) from oil revenues under a wide range of plausible conditions². The economic impact for Scotland alone from the highest CO₂-EOR scenarios would be £2.7 billion in gross value added (GVA), generating hundreds of additional jobs in Scotland³.

A CO₂-EOR network in the US was kick-started in the late 1970s and remains sustained through a mix of fiscal incentives at State and Federal level. Recent economic modelling by Prof. Alex Kemp at Aberdeen University suggested that fiscal incentives could also drive CO₂-EOR investments in the UKCS³.

The SCCS CO₂-EOR Joint Industry Project accepted a proposal by Element Energy, supported by Dundas Consultants and Prof. Kemp, to quantify the potential impacts of fiscal incentives for CO₂-EOR in the UK Continental Shelf in detail, recognising the additional costs, complexities, uncertainties and longer-term liabilities faced by CCS projects involving CO₂-EOR.

The approach agreed uses financial modelling of investor behaviour and outcomes under a wide range of drivers, scenarios, sensitivities. The approach draws on published data and the team's data and models for oil and gas taxation, and understanding of CCS and CO₂-EOR. No confidential oil industry data have been used, and all results are therefore illustrative, based on generic assumptions.

This non-technical report represents part of the final deliverable from the Element Energy-led study.

Section 2 describes the benefits and challenges for CCS with CO₂-EOR.

Section 3 introduces previous experience of using of fiscal policy to stimulate new developments in the UK Continental Shelf and a variety of fiscal incentives to support CO₂-EOR.

Section 4 illustrates quantitatively the potential impacts of fiscal incentives for CO₂-EOR on uptake for several scenarios.

¹ IEA CCS Roadmap (2009)

² Element Energy *et al.*, 2012, Economic impacts of CO₂-enhanced oil recovery for Scotland, report for Scottish Enterprise

³ Kemp, A.G. and Kasim, S., 2012, The Economics of CO₂-EOR Cluster Developments in the UK Central North Sea/Outer Moray Firth

Section 5 highlights the revenues for Government, and the interaction between fiscal incentives for CO₂-EOR and the proposed Electricity Market Reform.

Section 6 presents Conclusions from the economic modelling

Finally, Section 7 provides Recommendations for Scotland and potential project developers who wish to maximise the opportunities from CO₂-EOR.

This non-technical report is supported by a confidential comprehensive Technical Report, with Appendices, prepared for the project sponsors that provide detail on:

- The current United Kingdom Continental Shelf (UKCS) taxation structure and how this has been modelled.
- The discounted cashflow modelling methodology and assumptions.
- Scenarios for CCS deployment using a cluster of CO₂-EOR fields.
- Comparison of the effectiveness and efficiencies of different structures and levels for fiscal incentives
- The interplay between offshore taxation regime and Electricity Market Reform (through the mechanism of CO₂ transfer pricing).
- The sensitivity of project NPV and Government revenues to key drivers.

2 The benefits and challenges for CO₂-EOR in the UKCS

DECC’s PILOT Task Force expects that CO₂-EOR will offer the highest theoretical potential for the UKCS, compared to alternative tertiary recovery techniques such as polymer and low salinity flooding technologies⁴.

The North Sea is a high and complex tax environment compared to general corporate taxation in the UK. Therefore the principal beneficiary of EOR would be the Governments of the North Sea region. The Element Energy study estimated that, under favourable scenarios, the Governments of the UK, Norway and Denmark, together could receive up to £22 billion of additional tax receipts if a substantial cluster of CO₂-EOR projects develops in the North Sea.

The window of opportunity for CO₂-EOR in the UKCS is limited by diminishing access to existing infrastructure. Current proposals for the UK’s CCS commercialisation competition imply that the earliest plausible start date for a CO₂-EOR project would be close to 2020⁵. The rate of growth of any CO₂-EOR industry in the North Sea would be heavily dependent on policies adopted by North Sea Governments, and the CCS and oil industries, expected oil prices during the 2020s and beyond, the predicted properties of the reservoirs themselves, and the economics of alternatives.

The combination of CCS with offshore CO₂-EOR is extremely challenging, as projects involve co-ordination of stakeholders in multiple industries, high up-front and operating costs, narrow windows of opportunity, and the need to manage multiple risks before final investment decision, during construction, operation and post-closure. (see Figure 1).

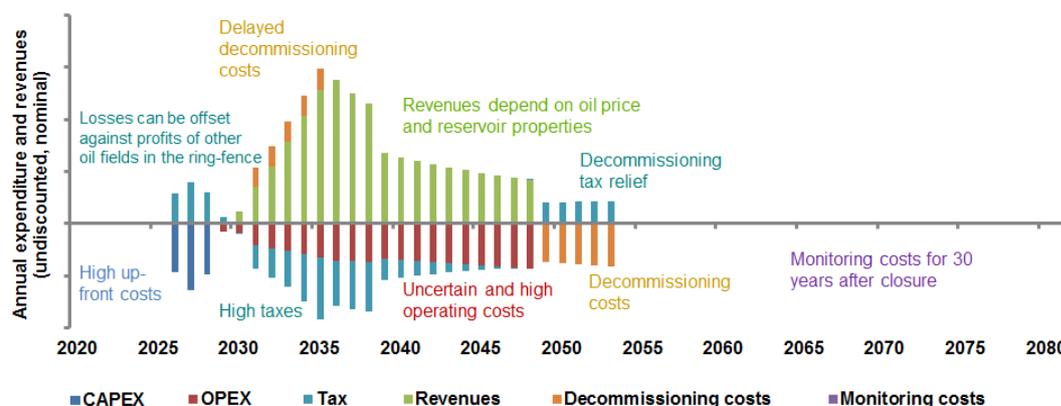


Figure 1: Illustrative cash flow of a CO₂-EOR investment for a developer, showing high up-front and operating costs, high taxes, complex decommissioning economics and long-term monitoring requirements.

The modelling carried out by Element Energy *et al*³, and by Kemp *et al*.⁴ demonstrated that under plausible market conditions, several EOR projects would be economic (i.e. NPV positive). However the CO₂-EOR projects would be unlikely to meet commercial investment criteria, particularly in the early years until CCS is proven. The typical central case NPV shortfall for the majority of fields is of the order of hundreds of millions of pounds, although there is also a requirement to manage downside risk exposures.

⁴ T. Garlick, DECC/Pilot EOR Workstream Update - Presentation delivered 23rd May 2012

⁵ DECC, 2012, Press release, http://tools.decc.gov.uk/en/content/cms/news/pn12_136/pn12_136.aspx

Importantly, lack of commercial investment in CO₂-EOR implies that the UK Government would miss out on potentially billions of pounds of tax receipts.

Previously, the UK has encouraged further development of technically or commercially challenging oil fields through amendments to the offshore fiscal regime. CO₂-EOR could also be supported through fiscal incentives as it contributes to storage of CO₂ that would otherwise be emitted to the atmosphere and provides environmental benefits compared to other oil production technologies. Wider benefits of increased oil production include contributions to improved security of supply, economic growth, balance of payments, jobs and efficient utilisation of resources.

3 Fiscal incentives for CO₂-EOR

Fiscal incentives for EOR were introduced in the 1980s at federal level in the US, and have since been playing an important role stimulating a CO₂-EOR market that is currently worth billions of dollars per year and establishing the existing CO₂ pipeline network, which transports more than 60 million tonnes of CO₂ per year⁶⁷. Several states in the US still have tax incentives for CO₂-EOR oil production. There is also a federal tax credit for injection of anthropogenic CO₂.

Although there is currently no incentive for CO₂-EOR in the UK, several fiscal incentives have been introduced recently for various oil production schemes, including late stage investments or “brown field developments”⁸. Also, since the 1970s, the structure of UKCS taxation has been adjusted by changing the headline tax rate or introducing additional tax incentives to reflect the market conditions. As Figure 2 shows, the UKCS taxation structure has been dynamic and it is possible to change the tax rates and introduce new fiscal incentives.

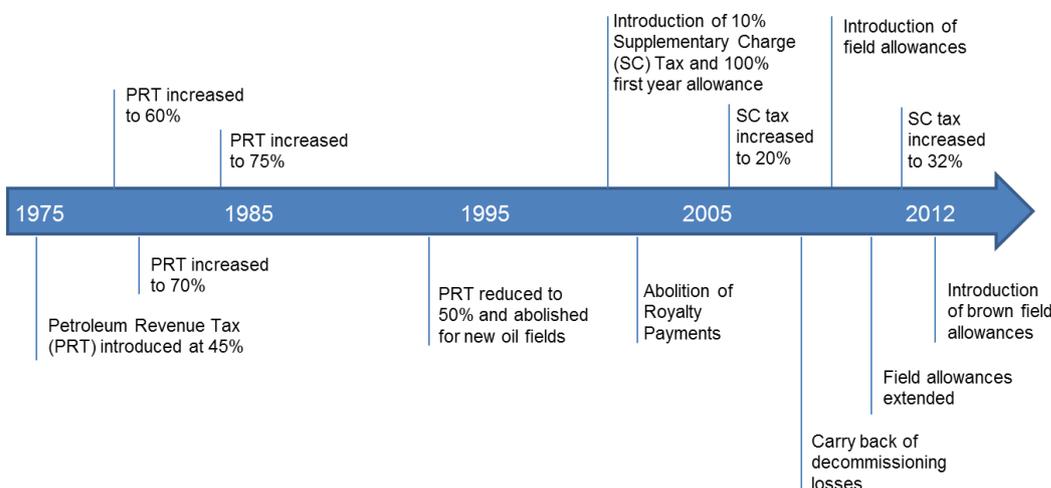


Figure 2: Simplified history of the UKCS taxation

Kemp *et al.* have explored how tax amendments for CO₂-EOR could help to kick-start investments⁴. Indeed modelling suggests that without any fiscal incentives, CCS projects with CO₂-EOR projects will fail to meet the investment criteria of commercial oil companies (at a screening oil price of \$90/barrel). This is true both in the 2020s for a “first-of-a-kind” project for which there will likely be a sizeable investor risk premium, and even in the 2030s by which time we would anticipate CCS with CO₂-EOR would have similar risk profile to other North Sea oil investments. Fiscal incentives are therefore needed for both the demonstration CO₂-EOR projects and the second-movers.

A variety of fiscal incentives could be introduced to support CO₂-EOR investment, including changing the headline tax rate for CO₂-EOR fields or introducing “field allowances”. Field allowance is a type of tax allowance, which reduces the amount of adjusted ring fence profits for the eligible company on which the company’s Supplementary Charge tax is charged. Several types of field allowances have been introduced in recent years, including ultra-heavy oil field, ultra high pressure/high

⁶ NEORI, 2012, CO₂-EOR: a critical domestic energy, economic and environmental opportunity

⁷ US Department of Energy, 2010, CO₂-driven Enhanced Oil Recovery as a Stepping Stone to What?

⁸ http://www.hm-treasury.gov.uk/press_78_12.htm

temperature field, small oil or gas field, deep water gas field, brown field, shallow water gas fields and West of Shetland.

If structured efficiently, field allowances encourage new investments and maximise tax receipts without incurring substantial deadweight losses. Field allowances could be flat (i.e. equal amounts for all eligible oil fields); or structured around field characteristics (e.g. field temperature, oil reserves, storage capacity) or costs of production (e.g. CAPEX/total incremental reserves). As each oil field has unique reservoir characteristics, different oil fields need different levels of incentive (the blue points in the graphs below show the amount of field allowance needed by different oil fields). Thus, a flat field allowance might be insufficient for some oil fields while over-subsidising others. Field allowances should therefore be structured in a way to maximise uptake and minimise dead-weight losses.

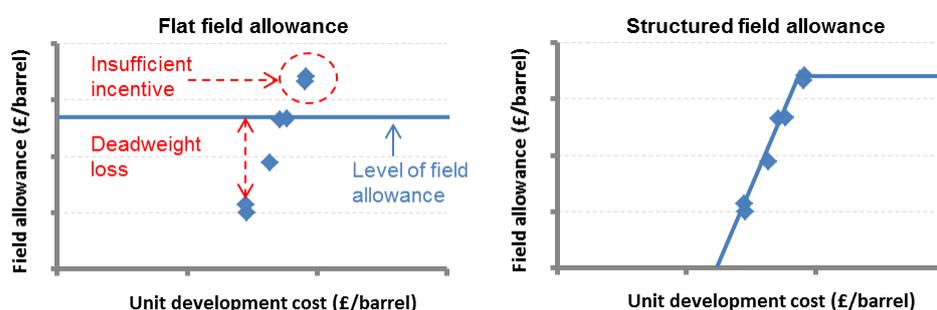


Figure 3: Different field allowance structures

Reducing the headline tax rate leads to high deadweight losses, which is why the UK Government has instead introduced new field allowances. Unlike field allowances, changing the tax rate does not have the flexibility to differentiate the levels of incentives available to different oil fields. The graph below shows the discounted profitability index (NPV/discounted CAPEX) of different oil fields under four illustrative scenarios and for this analysis we assume that all oil fields have to meet the same discounted profitability index threshold, which is a widely used oil industry KPI.

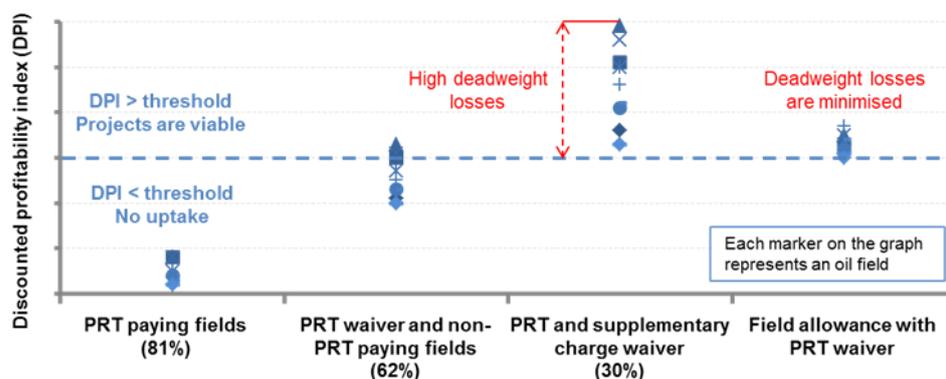


Figure 4: Comparison of changing headline tax rate and field allowances

Although reducing the headline tax rate from 81% to 30% by removing Petroleum Revenue Tax (PRT) and supplementary charge could make many CO₂-EOR projects viable, it also leads to very high deadweight losses. On the other hand, an efficiently

structured field allowance could minimise deadweight losses, while maximising uptake of CO₂-EOR. In addition to the field allowance, there might be other types of tax incentive (e.g. pay no tax until a certain return); however, this study focuses on allowances as these would be in principle an extension to the existing tax regime, particularly the brown field allowance. Various types of field allowances are examined in this study, including field allowances based on unit development cost (CAPEX/incremental oil production), unit technical cost (discounted costs/discounted oil production), discounted profitability index (NPV/discounted CAPEX), CO₂ storage and incremental oil produced (see Table 1 for a comparison of different types of Government interventions).

Table 1: Comparison of Government interventions

Intervention	Advantages	Disadvantages
Flat field allowance for CO₂-EOR	Targeted, transparent, in line with current practice for ultra-heavy oil fields.	Would be insufficient for some fields or excessive tax reduction could lead to deadweight losses.
Field allowance based on unit development cost	Targeted, transparent, in line with current practice for brownfield allowance. Minimises deadweight losses if structured efficiently.	Does not provide a strong incentive for cost reduction. Focus on CAPEX may distort investment in OPEX-heavy projects. Would require ex-ante agreement on predicted CAPEX and oil production.
Field allowance based on unit technical cost	Targeted, transparent, recognises that OPEX will have a material influence on costs.	Would require ex-ante agreement on predicted CAPEX and long-term OPEX, including CO ₂ transfer prices (if included).
Field allowance based on DPI	Minimises deadweight losses if investors have the same DPI threshold.	Would require ex-ante agreement on predicted CAPEX, OPEX, reservoir performance, discount rates and revenues. Information asymmetry creates risks of "gaming" these assumptions.
Field allowance based on CO₂ stored	Likely to lead to project designs that maximise CO ₂ storage. Could be extended to storage-only projects. Addresses market failure for storage.	Forecasting storage performance might be difficult. Does not lead to a focus on oil production, and therefore may not maximise tax revenues.
Field allowance based on forecast incremental oil	Transparent, in line with current practice for small field allowance.	Does not promote higher oil production. Would require ex-ante agreement on predicted oil production.
Reducing headline tax rate (Supplementary charge and/or PRT)	Simple, promotes investment in a field-neutral manner	Would be insufficient for some fields without additional tax incentives; however, could also lead to high deadweight losses.
Capital grants	Simple for commercial operators, common stimulus for new technology demonstration.	Requires up-front public subsidy. Unlikely to win environmental NGO support.
Low-interest loan	Use of lower public sector discount rates makes investment more attractive.	Loans not usually appropriate for new technologies with multiple and significant risks.
Create national CO₂ storage company that could co-invest in CO₂-EOR projects	Allows a much larger number of options for CO ₂ -EOR. Potential for a joint company with Norway and Denmark. Revenues could support nationally strategic investments. Addresses market failure for CO ₂ storage	Contrary to prevailing approach for major new UK infrastructure projects which are privately led.

The first offshore CO₂-EOR projects in the North Sea, potentially in the early 2020s, would incur substantial CO₂ supply and diverse regulatory and socio-political risks. Thereafter, assuming large scale CCS deployment, incentives could be reduced over time to match investor risk perceptions and thereby minimise deadweight losses.

Among the field allowances that are modelled, a field allowance based on unit development cost with PRT removal for the first projects appears the most efficient structure in terms of minimising deadweight losses. Although having a tax incentive based on a private sector KPI and estimation of unit costs faces challenges, it seems to offer a reasonable balance between incentives, efficiency and ease of application as it is very similar in structure to the existing brown field allowance.

The magnitude and the structure of the field allowance may create some implementation challenges. The scale of allowance would need to be more than three times the existing brown field allowance to maximise the CO₂-EOR uptake in the UKCS (~£170/tonne oil). The reason is that unlike most oil field development projects, CO₂-EOR is not only CAPEX intensive but also OPEX and fuel intensive, with revenues emerging over very long lifetimes (i.e. heavily discounted). Although the required amounts of field allowances are high, CO₂-EOR projects are able to bring billions of pounds of additional tax revenues for the Government, which will be illustrated in the next chapter.

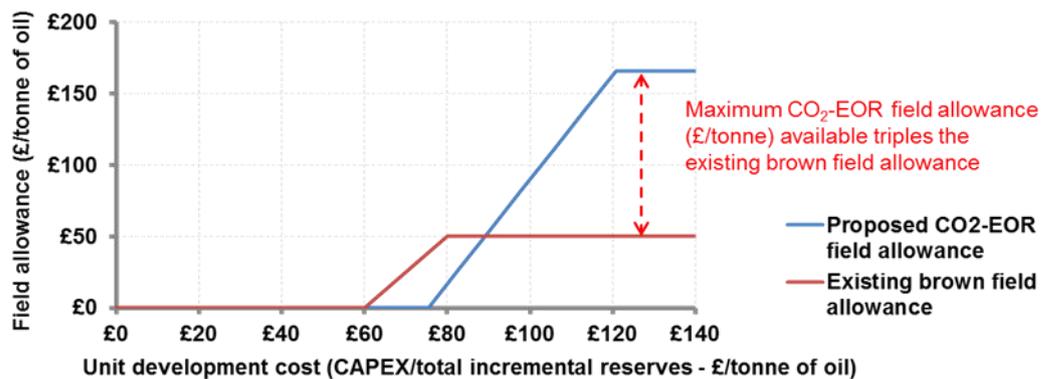


Figure 5: Comparison of the proposed CO₂-EOR field allowance with the existing brownfield allowance (£/tonne oil)

4 Scenarios for CO₂-EOR development in the UKCS

Scenarios provide the opportunity to examine multi-dimensional systems to understand where additional policies may be required to achieve desired outcomes, and to provide quantitative insight into the levels of policy outcomes that may be possible from different measures.

For the purpose of this study, we base our analysis on four potential deployment pathways for CO₂-EOR in UKCS, namely “Business-as-usual”, “Go-Slow”, “Pragmatic” and “Push”. These scenarios differ in the volumes of onshore CO₂ capture and the level of specific policy activity to support CO₂-EOR. The assumptions corresponding to each scenario are described in the Technical Report. In brief:

- The “**Business-as-usual**” scenario describes no Government fiscal incentives to support CO₂-EOR.
- The “**Go Slow**” scenario is intended to reflect a future in which there is a modest incentive for CCS with CO₂-EOR but limited CCS and hence CO₂ supply for EOR is limited, and introduced reactively after CCS is demonstrated.
- The “**Pragmatic**” scenario sees support for CCS with a specific field allowance introduced for CO₂-EOR.
- The “**Push**” scenario reflects a world in which public policymakers, CCS and oil industries and wider stakeholders (such as NGOs) co-operate to maximise the opportunities from CCS with CO₂-EOR.

The behaviour of different types of investors, which may have different attitudes to risk, expenditure and opportunities, are then investigated under these scenarios:

- The analysis suggests “mid-size” and “super-major” multinational oil companies are the most likely investors in CO₂-EOR in the North Sea.
- Super-majors have the necessary internal financial and technical resources to deliver the required investment, and many are strategically interested in developing CCS technology. However super-major oil companies are largely exiting the North Sea.
- Small oil companies are unlikely to have the capital available to fund CO₂-EOR projects.
- New entrants are disadvantaged, as incumbent UKCS oil and gas companies can offset the costs of CO₂-EOR investment against other UKCS activity, an option not available for new entrants.
- An additional theoretical potential investor is a national CO₂ storage company as a co-investor in EOR projects, which can make decisions on a pre-tax basis and operate with a public sector borrowing rate.

The table below summarises the types of Government interventions and main results in each CO₂-EOR deployment scenario. The number of fields meeting investor hurdle rate thresholds in each scenario is limited by the amount of CO₂ available for CO₂-EOR operations (up to 60 Mt/yr in the 2030s). Based on our deployment scenarios, a wide range of outcomes is possible, from no CO₂-EOR under business as usual, to up to six large-scale CO₂-EOR projects in the UKCS to the 2030s.

Table 2: Summary description of CO₂-EOR scenarios

CO ₂ -EOR policy scenario	Description of Intervention	CO ₂ supply available in the UK in 2030s	Number of fields meeting investor hurdle thresholds under central conditions (limited by CO ₂ supply)	Total NPV of the developers (Nominal, discounted at 10%)	Change in UK tax receipts relative to decommissioning (Real, discounted at 3.5%)
Business As Usual	No steps beyond CCS commercialisation and EMR.	Up to 6 Mt/yr	0	-	-
Go Slow	Field allowance capped at £600m	Up to 6 Mt/yr	1	£0.1 bn @ \$90/barrel £0.3 bn @ DECC Central	£0.3 bn @ \$90/barrel £1.0 bn @ DECC Central
Pragmatic	Generous field allowance based on unit development cost	Up to 18 Mt/yr	3	£0.5 bn @ \$90/barrel £1.0 bn @ DECC Central	£1.2 bn @ \$90/barrel £4.3 bn @ DECC Central
Push	Combination of PRT waiver (but keep PRT-level decommissioning relief) with field allowances and/or establish national CO ₂ storage company	Up to 60 Mt/yr	6	£1.5 bn @ \$90/barrel £3.0 bn @ DECC Central	£4.3 bn @ \$90/barrel £13.3 bn @ DECC Central

Figure 6 shows the UK incremental oil production profiles for the “Go Slow”, “Pragmatic” and “Push” scenarios. Under our assumptions, CO₂-EOR offers the opportunity to store up to 550 Mt of CO₂ in the “Push” scenario, while incremental UK oil production could be as high as 1 billion barrels. The oil production peaks in the 2030s in all three scenarios and there is an order of magnitude difference between the oil production amounts in the “Go Slow” and the “Push” scenarios.

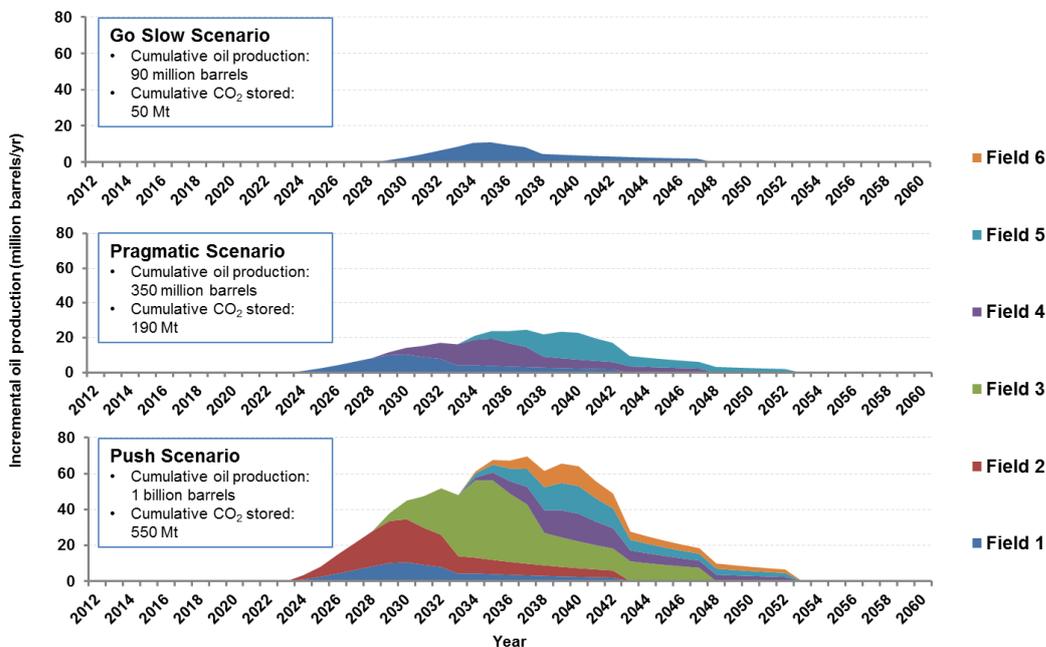


Figure 6: Predicted UKCS CO₂-EOR oil production for Go Slow, Pragmatic and Push CO₂-EOR scenarios in the UKCS.

Modelling suggests that EOR projects are able to meet the investment criteria of the medium-size multinational oil companies in the “Go Slow” and “Pragmatic” scenarios; however, super-major investment is needed in the “Push” scenario unless a national storage company is created by the Government. On the other hand, small oil companies and VC backed vehicles are unlikely to be involved in CO₂-EOR projects unless they partner with other investors. The potential NPV for an oil company developing a large CO₂-EOR cluster in the “Push” scenario could be £1.5 billion (nominal, 10% discounted, \$90/barrel).

5 Maximising Government Revenues

As discussed, the maximum level of field allowance needed for CO₂-EOR fields almost triples the existing brown field allowance; however, our analysis demonstrates that the Government interventions to support CO₂-EOR create positive Government revenues in all scenarios. The NPV of incremental tax revenues in the “Push” scenario is £4 billion (real, discounted at 3.5%) at an oil price of \$90/barrel, which rises to £13 billion using DECC’s central oil price scenario (\$135/bbl).

In the business-as-usual scenario, where there is no CO₂-EOR, the total non-EOR oil production from the candidate oil fields decreases over time and it is estimated that all oil fields are decommissioned in the 2030s. On the other hand, decommissioning operations are delayed until the 2050s due to the CO₂-EOR operations in the Go Slow, Pragmatic and Push scenarios. The columns in the graph below show the incremental cash-flow profiles of the Government, which are very similar to the cash-flow profile of a CO₂-EOR developer that invests in a cluster of CO₂-EOR projects.

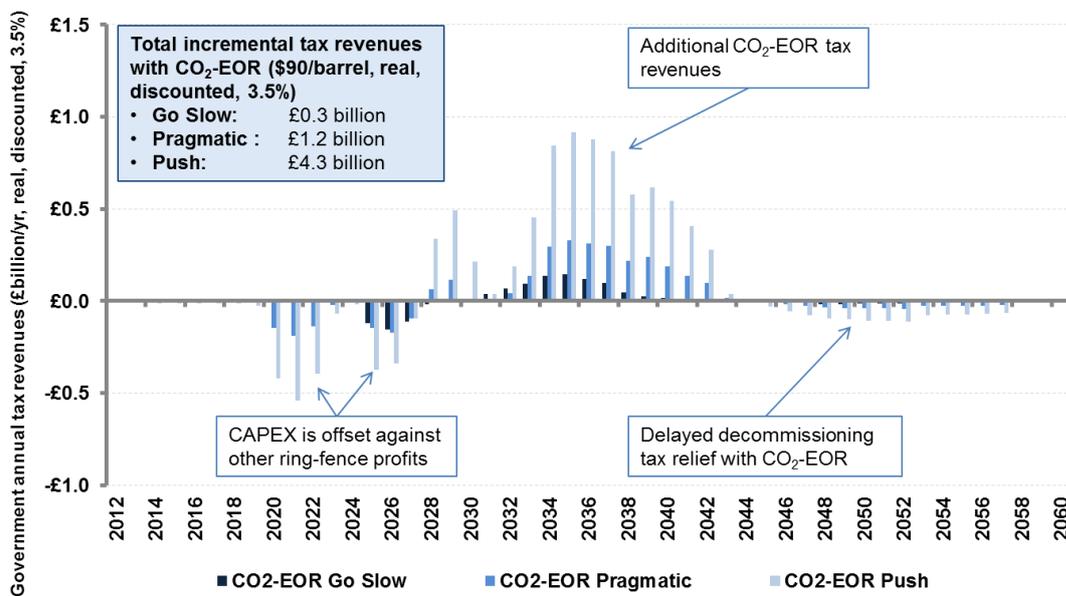


Figure 7: Government undiscounted cash flow based on tax receipts (positive) or offset taxes (negative) from CO₂-EOR project construction, operation and decommissioning.

Considering the market failures around CO₂ storage, a pro-active role by Government is not without merit. Several Governments deploy national oil companies, albeit with mixed success, to maximise oil revenues and correct market failures such as information asymmetries. This is not current practice in the UKCS but Government is already heavily investing offshore in decommissioning through the tax system. Due to the 100% first-year allowances available to oil companies, 62% of the CO₂-EOR capital expenditure can be offset immediately against other ring-fence profits of the oil companies. In other words, Government already pays 62% of the investment through receiving less tax. A hypothetical national “CO₂ storage company”, which could co-invest (or own existing platforms and wells in exchange for full decommissioning liability), could potentially be established in order to maximise public benefit beyond the “CO₂-EOR Push” scenario.

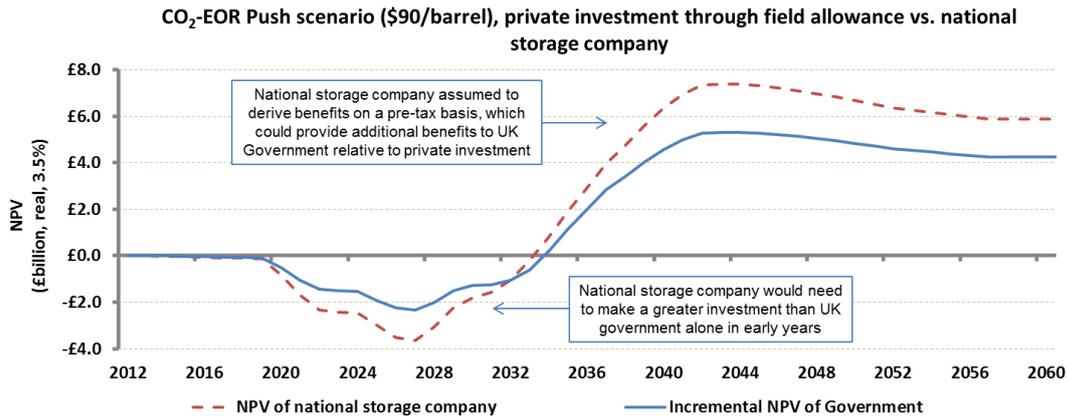


Figure 8: Comparison of UK Government NPV in the CO₂-EOR Push Scenario with the NPV of a hypothetical national CO₂ storage company under similar conditions.

As the graph above illustrates, the NPV profile of a national storage company is similar to the profile of incremental tax revenues of Government. The NPV of total incremental tax revenues for Government, which is £4 billion in the “Push” scenario, could increase to £6 billion if a national storage company is established (the NPV increases to more than £16 billion with DECC’s central oil price forecast). These estimates exclude administration costs but include 100% of the decommissioning costs. The profits of the national storage company could be used to fund additional CO₂ transport and storage infrastructure in the North Sea.

However, any one of a wide range of uncertainties (e.g. oil price, costs, reservoir performance, well performance, tax, CO₂ price and CO₂ supply) could eliminate these returns, resulting potentially in zero or even negative NPV scenarios. The sensitivity analysis demonstrates that among all uncertainties, both the developer NPV and the Government NPV are highly sensitive to oil price, EOR costs and reservoir performance.

Governments and oil companies are accustomed to oil price risk and high offshore costs; however, reservoir performance uncertainty represents one of the main challenges facing CO₂-EOR in the UKCS. Poor reservoir performance (i.e. less oil production for a certain amount of CO₂ injection) might lead to a loss for both the developers and the Government.

If an oil company invests in EOR but the project fails to be profitable (e.g. reservoir performance is less than expected), EOR losses could still be offset against other profitable oil projects. If the NPV of the tax revenues from the incremental oil production is less than the NPV of the EOR losses, which are offset against other profits, Government might end up having negative tax revenues. The graph below also illustrates that Government NPV is more sensitive to the reservoir performance compared to the developer NPV and Government tax revenues are negative if reservoir performance is less than 80%. Therefore, it is vital for the Government to ensure that EOR projects supported through fiscal incentives are technically and economically viable.

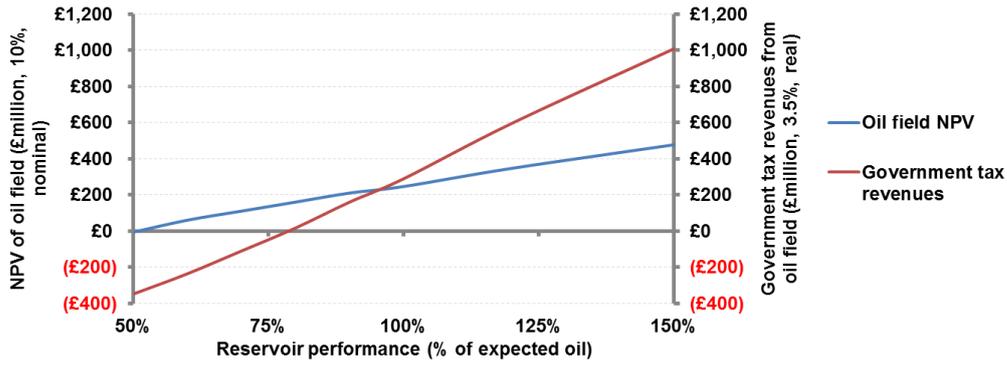


Figure 9: Reservoir performance sensitivity

The NPV of CO₂-EOR projects, and hence the fiscal incentives needed, depend also on the “CO₂ transfer price”. Under the current policy plans supporting CCS (e.g. Electricity Market Reform⁹), capture plants will be likely to pay a fee for CO₂ storage. On the other hand, oil companies pay a commodity price for CO₂ in the US. We were therefore intrigued to understand the impacts of average CO₂ transfer price on the economics of power stations and EOR projects in the UK. Note our analysis concentrates on steady supply of CO₂ – we have not considered the penalties for non-supply or non-delivery which will of course be a significant feature of any commercial agreement.

⁹<https://www.gov.uk/government/policies/maintaining-uk-energy-security--2/supporting-pages/electricity-market-reform>

Electricity Market Reform

The UK electricity sector will need an investment of more than £100 billion over the next decade as a result of plant closures, the need to upgrade the existing infrastructure and the need to meet challenges of energy security, climate change and energy affordability. The current Energy Bill contains the framework for the Electricity Market Reform (EMR), which is the Government’s initiative to ensure that necessary investments will be made. One element of EMR is Contracts for Difference Feed-in Tariff (CfD FiT), which will attract investment in CCS in the power sector.

Power plants will need to agree commercial terms with storage providers. This will likely be made through CO₂ transfer price between power plant and EOR/storage providers. CO₂-EOR projects in Texas have paid for supply of CO₂. Our modelling shows that only under very favourable cases, offshore UK CO₂-EOR projects in the North Sea could pay for CO₂.

Since both capture and CO₂-EOR need financial incentives, it will be imperative that the levels of feed-in tariff and any fiscal incentive for EOR are aligned, and reviewed periodically, to minimise market distortions. It will also be necessary to monitor potential interactions between different offshore incentives.

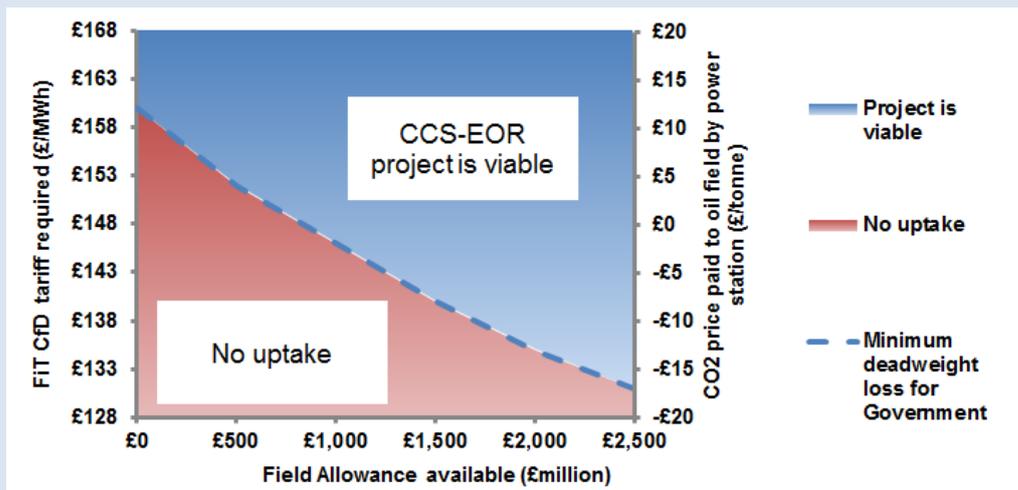


Figure 10: Illustrative interplay of onshore and offshore incentives for a network comprising an IGCC capture project with a CO₂-EOR project

Figure 10 illustrates that field allowances are linked to FiT CfD prices through the CO₂ transfer price. Based on our modelling of an illustrative simple CCS-EOR network, if there is no field allowance, oil fields need to be paid around £10/tonne by the power plants for the CO₂ storage in order to meet their investment criteria, which, in the absence of a capital subsidy could lead to a minimum FiT CfD price of £160/MWh needed by the power plant to be commercial. On the other hand, with a field allowance of £2 billion, oil fields are capable of paying almost £15/tonne for the fresh CO₂ and the power plant therefore needs a smaller FiT CfD price of £135/MWh. A “fair” solution, where there are no cross-payments between the electricity and oil markets is shown by the dashed line. Clearly this may be difficult to negotiate, particularly ex ante, unless all partners involved share data and economic/risk models. In a complex network with multiple coal, gas, biomass, industrial sources, a range of CO₂ capture technologies, CO₂ pipeline networks, CO₂ ships, and a mix of CO₂ stores and CO₂-EOR projects, determining “optimal” incentives will be challenging.

6 Conclusions

Techno-economic and financial modelling confirms that under a wide range of plausible assumptions CO₂-EOR projects in several fields can be economic (i.e. yield a positive post-tax NPV) but these projects typically have NPV shortfalls of £100s of millions relative to commercial benchmark investment criteria. These shortfalls imply likely under-investment in the UKCS under business-as-usual assumptions, assuming CCS technology is successfully deployed, with the UK Government missing out on significant tax receipts.

The modelling identifies a variety of potential fiscal interventions, with differing levels of complexity, that could support CO₂-EOR. The optimum Government intervention depends on a range of factors, including timing, the choice of oilfield, CO₂ supply, whether CCS and CO₂-EOR are mature technologies, and the type of investor, and the desire for fiscal efficiency.

Assuming CCS is successful, plausible scenario for CO₂-EOR project in the North Sea is one medium-sized field in the early 2020s, leading to a cluster of fields including some large fields by the 2030s. For this to happen, the first CO₂-EOR projects would need a substantial fiscal incentive to overcome an initial commercial investor risk premium. Thereafter, a CO₂-EOR network could be sustained with more modest fiscal incentives.

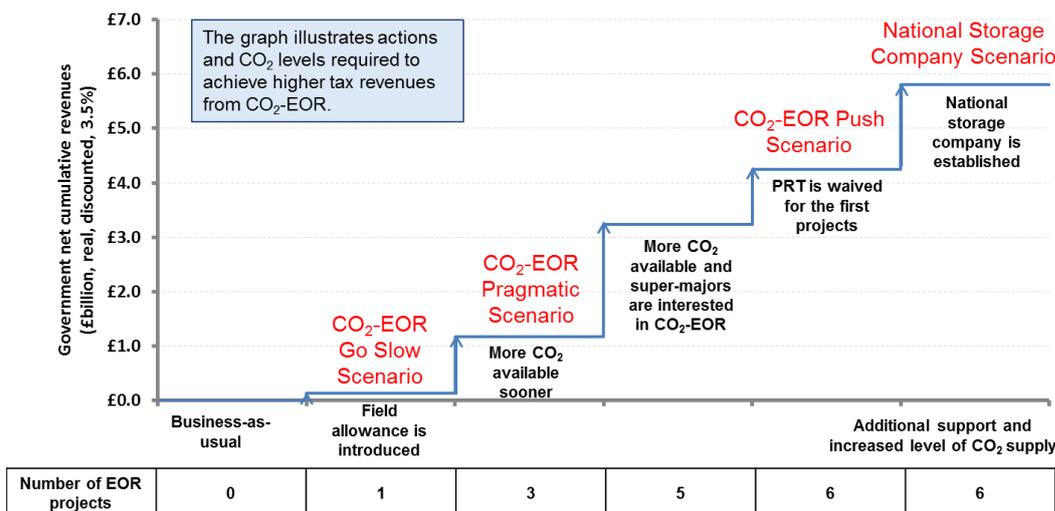


Figure 11: Strategy for maximising Government tax revenues from CO₂-EOR (assumes \$90/bbl)

The modelling suggests Government tax revenues would be maximised (£4 billion at \$90/barrel) with the introduction of an efficient CO₂-EOR field allowance, and with a specific additional incentive comparable to a PRT waiver for the first demonstration CO₂-EOR project.

With only a limited number of CO₂-EOR projects realistically likely to be implemented before the oilfields are decommissioned, it may be possible for these incentives to be negotiated reactively on a project-by-project basis, as appears to have been the case for other oil and gas field development projects. However, there currently appears little appetite among oil investors to develop CO₂-EOR projects, partly as a result of multiple failed attempts to develop CCS and CO₂-EOR projects in the North Sea. Given the long lead times and need to engage with providers of CO₂ generation, capture and transport infrastructure, an early and pro-active announcement of a specific fiscal incentive for CO₂-EOR by the UK Government would send a positive signal to both the oil industry and the

CCS industry. Any incentive would however need to be reviewed regularly as a function of market and regulatory conditions.

The sensitivity analysis demonstrates that, even with appropriate fiscal incentives in place, there is a very high sensitivity of revenues for both commercial oil developers and the UK Government to a range of factors. Most of these factors lie outside the control of either party, and include oil price, offshore capital and operating costs, reservoir performance.

Interestingly, the analysis reveals that if investment in CO₂-EOR is led by a hypothetical “National CO₂ Storage Company”, which would benefit from a public sector discount rate and base investment decisions on pre-tax NPV, revenues from CO₂-EOR could amount to £6 billion (at \$90/barrel). This option has not been examined deeply, but it could potentially address a number of market failures and support wider investment in CO₂ transport and storage infrastructure¹⁰.

Despite numerous desk studies, there remains an ongoing need to convince a highly sceptical audience that CO₂-EOR is feasible in the UK sector of the North Sea, and that the economics could be favourable for oil companies, Government, the CCS industry, and ultimately electricity consumers and shareholders. The recent publication of FEED studies for Longannet-Goldeneye and Kingsnorth-Hewett appear to have eliminated the analogous scepticism that large scale integrated UK CCS projects are technically feasible. Publication of details of a viable CO₂-EOR project would go a long way to move the debate forward.

¹⁰ Element Energy (2012) Analysis of Market failures and Business and Regulatory Models for CO₂ transport and storage (Confidential Report for the Energy Technologies Institute).

7 Recommendations

A logical pathway for public and private stakeholders wishing to develop fiscal incentives for CO₂-EOR specifically could involve the following sequence of actions:

1. As there are a number of potential routes to incentivise CO₂-EOR, each with different impacts, CCS projects and oil companies interested in CO₂-EOR should proactively initiate discussions with DECC and HMT/HMRC on preferred fiscal incentives for CO₂-EOR and supporting infrastructure.
2. CO₂-EOR project developers, Scottish Enterprise, and Scottish Government should encourage DECC, Crown Estate, Marine Maritime Organisation, National Grid Carbon, successors to the CCS Cost Reduction Task Force, and other interested stakeholders to include CO₂-EOR within the planning of transport and storage infrastructure.
3. CO₂-EOR project developers, Scottish Enterprise, and Scottish Government should work with other interested parties (UK Government, CCSA, The Crown Estate etc.) to quantify transport infrastructure requirements, assess business and regulatory models for CCS with EOR.
4. If an incentive for CO₂-EOR is introduced, potential competition impacts in power, carbon, oil and CO₂ storage markets from fiscal incentives for CO₂-EOR should be understood and periodically reviewed by academics, regulators and/or the Government.

The above recommendations focus on actions required to support the creation of fiscal incentives, if desired. Numerous other studies, including the recent Element Energy project for Scottish Enterprise, and parallel workstreams within the CO₂-EOR Joint Industry Project, document the wider actions needed to deliver CCS and CO₂-EOR, which are clearly essential for delivering the context for the scenarios envisaged in this report.

Although it does not arise directly from the technical analysis carried out in the report there are likely to be associated benefits if stakeholders carry out and publish a pre-FEED or appraisal level analysis for a cluster of CO₂-EOR projects in the UKCS, to refine estimates for costs and performance, and understand what technical requirements should be (The costs for this should be shared by oilfield owners, CCS industry partners, and interested public sector bodies. Since oil companies are unlikely to publish data of their own accord, appropriate incentives and safeguards may be required). Publication of details of a viable CO₂-EOR project would go a long way to move the debate forward; however, any such measure would face complexities such as how to generalise site-specific FEED, how to generalise numerous business assumptions, how to share data while protecting IP and commercial interests, and impartiality.

In addition, there is wider value in a shared understanding of which technology for EOR and the importance of clusters in shaping policy. The oil industry, academics, and DECC could work together, potentially through the PILOT Task Force to examine quantitatively and in detail the costs, benefits, risks and commercial requirements for a CO₂-EOR cluster of projects, compare these with other EOR options in detail, and quantify the optimum tax arrangements.

8 Acknowledgements

We thank SCCS, the Scottish Government, Scottish Enterprise, 2CoEnergy, Nexen, DECC, CCSA, National Grid Carbon, The Crown Estate and CO₂Deepstore for feedback obtained during the course of this study. Any conclusions and recommendations are those of Element Energy and not those of the stakeholders consulted.