Improving the Regulatory Framework, optimizing organization of the CCS value chain and financial incentives for CO_2-EOR in Europe

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Abstract

This article provides recommendations for improvements of the regulatory framework that is deemed necessary to facilitate the establishment of CO_2 value chains in the near term. The recommendations address liability issues, cross border regulations and emission trading schemes (like EU ETS). Recommendations for an overall organization of the value chain in terms of access rights, trans-boundary transport and storage of CO_2 and rules for utilization/capacity allocation are also made.

A range of financial incentives for CCS and CO_2 for EOR are reviewed. The article also analyses how Member States could use regulations to require CO_2 for EOR and to stimulate third party access when assessing the oil field operator's Plan for Development and Operation (PDO). Additional revenues to the State arising from the increase of oil produced through CO_2 for EOR could be earmarked to future investments in CCS.

To encourage a wide portfolio of CCS projects, it is preferable to establish an incentive scheme common to all CCS projects. However specific time-limited incentives for CO_2 for EOR projects could be considered as a fall-back. Such incentives should be carefully considered as they could result in delaying the transition to a low carbon economy at a later stage than necessary.

Keywords: Regulatory Framework, Cross Border Regulations, Emission Trading Schemes, Enhanced Oil Recovery, Carbon Capture and Storage, Third Party Access, Incentives, Storage Directive

1 Preface

The research this article is based upon has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement n∘ 218868 (The ECCO project). The

ongoing ECCO project is working on early opportunities for establishing a CCS value chain in Europe.

CCS is entering its Demonstration phase, and is thus currently not economically viable in Europe. Such projects will more likely only develop in the near term if petroleum companies are given sufficient incentives, are imposed regulations or requirements to initiate such projects or if oil prices rise to, and stays at levels where further extraction from mature fields are considered as economic. The two first mentioned scenarios require the support of governments in the form of incentive schemes and/or regulations.

An opportunity to achieve CCS in a faster and more economical way is to use the captured anthropogenic CO_2 as a resource to enhance petroleum production. The deployment of this *early opportunity* [1] has the potential to kick off the full deployment of CCS [IPCC, 2005]. CO_2 for EOR/EGR makes CCS projects profitable, or, for low oil prices at least less costly [Klokk et al., in press].

The aim of this article is to provide recommendations for improvements to the regulatory framework that are deemed necessary to facilitate the establishement of CO_2 value chain in the near term within Europe (EU members and Norway). Therefore, the current EU regulation is reviewed together with alternative approaches that are found in other commodities or similar situations around the world.

The article has excluded all life cycle analysis in terms of emissions and costs relating to construction of the value chain. It also excludes economic analysis of the incentives and their interaction.

Incentives for EOR/EGR [2] projects with no intention for permanent storage of CO_2 are not analysed, and only the use of anthropogenic CO_2 for EOR is considered.

2 CO_2 for EOR

Enhanced Oil Recovery (EOR) and Enhanced Gas Recovery (EGR) using CO_2 is a hydrocarbon recovery process that involves the injection of CO_2 to flood mature reservoirs and produce petroleum substances that would otherwise remain unrecoverable [3].

Studies estimate that an incremen-

[1] *Early opportunities* are described in the SRCCS as projects that are likely to *involve CO_2 captured from a high-purity, low-cost source the transport of CO_2 over distances of less than 50 km, coupled with CO_2 storage in a value-added application such as EOR [enhanced oil recovery]*

[2] In the following text it is not distinguished between EOR and EGR and they are both referred to under the term EOR. Whenever the term EOR is used it is referring to EOR activities with CO_2 injection

[3] Under primary recovery methods, less than 20% of the resources are recovered from a reservoir on average globally

tal[4] oil recovery of 3-23% is achievable by CO_2 for EOR, depending on lithologies and heterogeneity of the producing reservoir[Ferguson et al., 2009, Aam et al., 2010, Akervoll and Bergmo, in press, Holt and Lindeberg, 2003, Fox and Morgan, 2003, DOE, 2006, Sengul, 2007]. The use of anthropogenic CO_2 for EOR/EGR not only contributes to increase the ultimate oil recovery of mature oil fields but also contributes to significantly reduce emissions of GHG. CO_2 in EOR operations could be permanently stored at a greater proportion under suitable CO_2 pricing conditions or under stricter CO_2 emission regimes[5].

By increasing the ultimate oil recovery, governments increase their revenues through taxes and royalties[6]. The additional revenues generated from CO_2-EOR could accelerate the selection of storage sites and the development of infrastructure and at the same time reduce investments by re-using the existing CO_2-EOR facilities when (if) converting to a

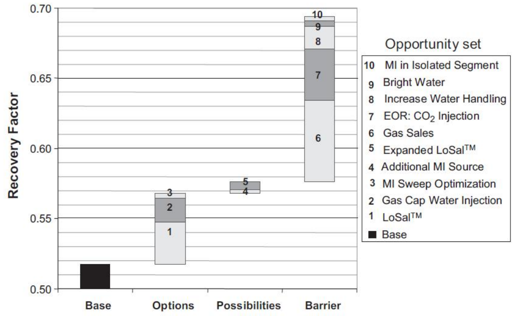

Figure 1. Smalley et al. [2009] evaluated a suite of methodes for maximizing recovery for oil fields based on reservoir technical limits. In the suggested opportunity set for a mature field case study CO_2 injection contribute to an increased recovery factor of approximately 4%. The term ‘barrier‘ refers to e.g. commercial barries to progressing such opportunities

CCS project[7]. Added recoverable petroleum resources increase the security of energy supply by reducing the need for hydrocarbon import. EOR could also contribute to decrease the need for new petroleum exploration acreage.

CO_2-EOR would also present an early opportunity for CCS deployment by stimulating the entire CCS chain. The additional revenues generated from EOR for the CCS chain include an accelerated CCS learning curve (achieving early maturing of CCS-related technologies and most likely also lowering costs), further strengthening of the CCS market and promotion of manufacturers of capture technologies etc. to step in and compete for contracts.

[4] Incremental oil recovery is the additional oil recovered by CO_2-injection. Historically most EOR projects use water and/or fossil gas injection to increase petroleum production, but exceptions are e.g. the Forest Reserve and Oropouche fields in Trinidad which are producing oil using industrial waste CO_2 [Mohammed-Singh and Singhai, 2004] and in North America where 1.5% of the CO_2 for EOR come from industrial sources [Moritis, 2009]

[5] up to 100% of the injected CO_2

[6] E.g. in Norway there is a 78% tax on petroleum production

[7] Additional revenues to the State could be earmarked for further investments in CCS like infrastructure, or be allocated to environmental investments

2.1 *Economics of CO_2-EOR for CCS* [8]

A prerequisite to make CCS projects viable is to create sufficient value for delivered CO_2 to justify the costs of capture and transport and subsequently a market for CO_2 storage. CO_2 for EOR is currently not undertaken in Northern Europe because:

(1) There are no low-cost and large-scale available sources of pure CO_2 to enable CO_2-EOR to take place on a commercial scale
(2) The major operators in the North Sea are divesting from mature areas (e.g. the North Sea) in order to divert their available investment capital to expand their presence on other markets and acquire 'fresh' reserves. These major operators are being replaced by smaller tail-end companies which do not have the required business strategy nor the capital to invest in CCS-based EOR.
(3) Oil and gas price volatility has created a significant risk discount in petroleum companies' cost-benefit analysis of EOR
(4) Petroleum companies demand a higher rate of return than many other sectors, notably the utilities that would be involved in CO_2 capture
(5) The price of EU emission unit allowances (EUAs) under the EU Emission Trading System fails to provide a significant incentive

Additional economic factors that could influence CO_2-EOR investment decisions for a specific site are 1) the value of postponement of CO_2 storage, 2) the value of abandonment (vs further investments) and 3) delayed income in terms of down-time while installing EOR equipment.

2.2 *EOR projects versus CCS projects*

Different drivers apply to non-EOR CCS and EOR projects:

(1) In non-EOR CCS projects the prime objective is to store CO_2 and therefore to maximize the volume of CO_2 stored. Non-EOR CCS projects are incentivised by the EU ETS by considering that the CO_2 stored is not emitted

[8] Leach et al. [2010] shows however that, for an individual project, policies which raise the cost of CO_2 emissions, whatever effect they may have on other forms of sequestration or abatement, will not induce large increases in EOR-based sequestration. Another publication by Klokk et al. [in press] also concludes that the main value drivers for CO_2-EOR are the oil price and the EOR ratio. On the other hand there are examples of 'non-investment' in economically viable CO_2-EOR projects. E.g. Aam et al. [2010] refer to a 2004 study of CO_2-EOR at the Gullfaks field which indicated a break-even of 26-33\$/bbl (the oil price in 2004 was 30-48\$/bbl, 2010 oil prices are 70-90\$/bbl)

(2) CO_2-EOR projects aim to maximize the production of oil and gas and to minimize the amount of injected CO_2 [9]. The oil or gas field operator has to ensure that it is possible to obtain a secure and stable long term supply of CO_2. Thus, in EOR projects CO_2 storage is an incidental outcome of the activity rather than its prime objective.

Incentive schemes for CCS need to take account of both these drivers.

3 Current legal regime for CCS activities in EU

3.1 CO_2 storage in EU legislation

Directive 2009/31/EC on the geological storage of CO_2 (hereafter 'the Storage Directive') focuses mainly on storage issues. It provides a legal framework for the management of environmental and health risks related to CO_2 storage, including requirements on permitting, composition of the CO_2 stream, monitoring, reporting, inspections, corrective measures, closure and post-closure obligations, transfer of responsibility to the State and Financial Security (FS). The Storage Directive also amends a number of other EU laws with a view to removing existing legal barriers to the geological storage of CO_2[EU, 2010]. The Storage Directive leaves the detailed implementation to Member States (MS) and relies heavily on national competent authorities, the identity of which remains unclear in most Member States.

Just as for a non-EOR CCS project, the initial site selection would have to respect the provisions of Article 4 of the Storage Directive, demonstrating that under the proposed condition of use there is no significant risk of leakage and no significant environmental or health risk. The same monitoring techniques would be employed.

3.2 CO_2 for EOR under the EU ETS

A crucial element of the ETS directive is that it incentivizes CCS by counting the stored CO_2 as an emission reduction under the ETS [10].

In order for CO_2 injection for EOR to benefit from not having to surrender EUAs, the CO_2 injection must comply with the Storage Directive [11]. The EOR site operator therefore has the choice to either qualify as a storage site operator under the Storage Directive or surrender EUAs for the injected CO_2.

If the EOR facility is licensed as a storage facility it will have to com-

[9] Provided that CO_2 most likely has to be purchased

[10] *... allowances will not need to be surrendered for CO_2 emissions which are permanently stored ...*[EU, 2009]

[11] In practice, EOR-fields have the advantage of a proven seal which has retained oil over millions of years and therefore also a good chance of meeting the criteria for permanent storage

ply with all requirements in terms of site selection and monitoring. Rules on leakage are however applied differently to take account of the expected breakthrough of CO_2 under oil or gas extraction. Indeed, additional emission sources of CO_2 generated by EOR will have to be reported and accounted for in the national emission inventory [12].

The different parts of the CCS value chain are included in the Monitoring and Reporting Guidelines under the ETS Directive (as revised by Commission Decision 2010/345/EU). This means that each party transfers its ETS obligations to the next part of the CO_2-EOR value chain.

3.2.1 Cross-border projects

Clear rules should be provided in order to identify to which State a facility would have to surrender allowances in case of leakage. Different rules might be necessary to cover situations of leakage occurring in cross border pipelines, in cross border storage site and through transport by ship. Agreements between competent authorities in the concerned MSs could solve such issues.

Cross-border pipelines and storage sites
Any leakage points in pipelines or at cross border storage sites are assumed to be easily identified with proper monitoring. The facility operating in the State where leakage occurs would therefore be liable to surrender allowances to that State. For a cross border storage site with several CO_2 injection points in several States, a joint liability could be established between the different storage operators based on injected CO_2 volumes in each State (for leakages others than at the point of injection).

Ships
CO_2 emissions from shipping is not yet covered by the EU ETS. However, transport by ship of captured CO_2 within a CCS chain would have to be included in order to maintain the integrity of the chain. The European Commission has signaled their willingness to include this on a project by project basis, as mandated by the ETS Directive Art. 24a.

Assuming that satisfactory monitoring for the detection and quantification of leakage are in place, the question is to which State the ship would have to surrender allowances. One possible solution could be that allowances should be surrendered to

[12] The Directive's recital 20, second sentence: *In that case, the provisions of this Directive concerning leakage are not intended to apply to quantities of CO_2 released from surface installations which do not exceed what is necessary in the normal process of extraction of hydrocarbons, and which do not compromise the security of the geological storage or adversely affect the surrounding environment. Such releases are covered by the inclusion of storage sites in Directive 2003/87/EC of the European Parliament and of the Council of 13th October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community, which requires surrender of emissions trading allowances for any leaked emissions*

the flag State, although this would pose a problem if the flag State is not covered by the EU ETS.

A more simple solution would be to require the surrendering of allowances to the exporting MS. Ships would need to provide a financial guarantee upon leaving port, which would be cancelled only upon certified delivery to a licensed storage site.

3.2.2 *Use of buffer locations*

The use of buffer locations to receive and store supplies of CO_2 which cannot be accommodated at the time for EOR is likely to happen in several CO_2 for EOR projects. For a large scale CCS chain including several EOR sites and at least one aquifer storage, the main purpose of the aquifer storage could be to permanently store access CO_2 that cannot be used for the CO_2-EOR operations. This raises legal issues, particularly as the Storage Directive does not address this issue specifically.

Buffer locations can be different in nature, have different purposes and be more or less integrated with EOR facilities. The regime of buffer locations and their interface with the EU ETS system is briefly discussed below.

Temporary storage of CO_2 for EOR can be done in 1)subsurface aquifers, 2)depleted oil and gas fields, 3)salt domes or in 4)tanks or ships. Temporary storage of CO_2 in aquifers presents challenges in the sense that once injected, the CO_2 will be economically and technically difficult to extract for future use in EOR facilities [13] . Depleted oil and gas fields, adjacent EOR projects or salt domes for buffer purposes might be more economic and technically feasible. The economic aspects of ships as buffer storage are covered by e.g. Apeland et al. [in press].

For all these alternatives, buffer locations should be considered as licensed facilities under the EU ETS scheme in the sense that any leakage arising from them would require surrendering of EUAs. As long as the CO_2 is temporarily stored in a buffer location, the CO_2 should not be considered as stored and the CO_2 producer should not be released from his obligation to surrender allowances. The operator of the buffer will be liable for surrendering EUAs equivalent to the net flow into the buffer in the course

[13] E.g. because 1)Extraction of CO_2 from a buffer aquifer at some later point in time might require a production well at a location different from the injection well as the injection point most probably will be down and away from the penetration of the aquifer seal to minimize risk of leakage. For shorter time frames one could possibly produce some 'dry' CO_2 by injecting and producing CO_2 in the same well. 2)CO_2 produced from a buffer aquifer would have to be dried and re-compressed to re-introduce into a pipeline. 3)Reservoir simulations of withdrawal of CO_2 from an aquifer model show that limited amounts of CO_2 can be backproduced (e.g. [Akervoll and Bergmo, in press] suggests that around 20% of the injected CO_2 can be backproduced)

of each reporting period under the ETS Directive.

If CO_2 is re-produced from a buffer location (to be re-stored), this re-production should not be considered as an 'emission' in itself unless there is effectively a leakage during the process.

3.3 Long term liability and site transfer

When an oil or gas field is depleted after CO_2 for EOR activities, the operator can either 1) decide to transfer it to a subsequent storage operator who will operate the site exclusively as a CO_2 storage site, or 2) decide to close the field following field-closure procedures.

The Storage Directive provides that the transfer of liability to the State occurs a minimum of 20 years after site closure and/or when the CO_2 condition is stable [14]

[14] According to article 18, the responsibility for the storage site is transferred 1) if when all available evidence indicates that the stored CO_2 will be completely and permanently contained 2) a minimum period of 20 years has elapsed, 3) financial obligations have been fulfilled 4) the site has been sealed and the injection facilities have been removed

3.4 Liabilities (environmental damage, health and property damage)

The potential liability of operators involved in the CCS chain can not only be limited to their compliance with the EU ETS scheme (liability for climate change).

The operator is also liable for damage to the local environment under the Environmental Liability Directive 2004/35/EC (ELD) [15]. The operator can also be liable under national legislation for aspects not covered by the ELD. In practice, this could conceivably mean e.g. the decontamination of land and water [16] in case of leakage from a CO_2 storage site.

4 Incentives to promote CCS projects

EOR should have less need for incentives than other large-scale CCS projects. However, the current lack of EOR projects in Europe means that there is a case for specific EOR incentives. If, politically, general CCS incentives are not feasible, specific incentives for CO_2 for EOR projects should be considered as a fall-back for a given time [17]. They should however

[15] ELD applies only in narrow circumstances and provides that liability is statute barred after 30 years

[16] of toxic substances due to chemical reactions triggered by the CO_2

[17] The initial timeframe should be clearly defined so that the industry can use it as basis for investment decisions

be reconsidered in light of oil and gas price development and introduction of more general CCS incentives.

4.1 General CCS incentives

The EU ETS is currently the main instrument to incentivise CCS. But at present it is not sufficient to make CCS projects commercially viable. Subsidies for CCS are therefore also provided by the EU to CCS demonstration projects in the form of the NER 300 (300 million EUAs under the ETS New Entrants Reserve 2013-2020) and the European Energy Programme for Recovery (EEPR). Altogether this could represent about 6 billion EUR, but it is legally limited to cover maximum 50% of the net CCS costs calculated over a 10-year period. It is expected that EOR projects will be represented in the first tranche of NER 300 funded projects to be selected in 2011.

The Netherlands, Norway and the UK have also pledged significant funding for specific demonstration plants, but no MS have adopted a general incentive scheme targeted at CCS. Additional incentives are therefore needed.

There is an infinite number of incentives that could be imagined. Three key factors should be kept in mind regardless of the scheme.

(1) Incentives need to be predictable. The volatility of EUA prices reduces its effectiveness as a driver for EOR. [Abadie and Chamorro, 2008] showed that the lower CO_2 price volatility the earlier investments happen. The same study suggested that one way of lowering the CO_2 price volatility is to stabilise a carbon price floor by using a combination of EU emission unit allowances (EUAs) and a carbon tax (see Fig.2)
(2) The high capital expenditure of CCS projects mean that early provision of support can reduce overall costs significantly. This needs to be weighed against the risk that provision of support prior to actual CCS means lower incentive for performance
(3) A challenge the first generation of CCS projects may face is banks with little appetite for lending. As financing by equity has a higher cost of capital [18] than debt, this may increase the overall cost of capital significantly. Loan guarantee schemes may be a particularly cost efficient way for governments to deal with this

There is a range of alternative ways to stimulate investments in CCS - without putting the burden on public budgets. Two options are explained below to illustrate [19] .

[18] Particulary in the petroleum sector that would be involved in EOR

[19] Other possible instruments which are available but not covered in this text could be commitments based on agreements, stimulation of commercial projects by tendering with unprofitable peak coverage, mandatory CCS, etc.[Dessens, 2010]

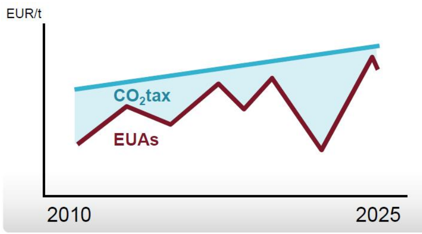

Figure 2. Stabilising a carbon price floor using a combination of EUAs and carbon taxation

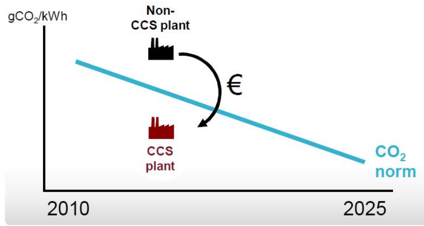

Figure 3. The 'bonus-malus' scheme is establishing a 'shadow' carbon price for the power section without taxing it

4.1.1 The Netherlands' CCS Task Force recommendation of a 'bonus-malus' scheme

To stimulate CCS investments without draining public funds, a bonus-malus scheme directed towards CO_2 producers could be introduced. The initiative comes from the Dutch government-appointed CCS Task Force which gave its advice in April 2010 on how to incentivize CCS. The recommendation mentions several possible options, but favours a 'bonus - malus' scheme combining

(1) a CO_2 emission 'norm' (grams per kilowatt-hour); and
(2) creating economic incentives for reducing CO_2 emissions below this norm

In other words, an ordinary subsidy scheme would be introduced to reward power plant emitting under a specific 'norm' (bonus) while in parallel, a penalty - malus - for power plants emitting above the norm would be introduced (see Fig.3) [20] .

The challenge is however to establish the appropriate level of the CO_2 norm so that 'bonus' and 'malus' balance out. The risk is that if the norm is put too high, too many plants would be eligible for the 'bonus' and be a drain on public coffers, while if it is too low it would effectively serve as an extra tax on the power sector with 'malus' outweighing 'bonus'.

The advantage of this scheme is that it creates a long-term predictability for a high price on CO_2 emissions in the power sector, combined with a mechanism to automatically recycle revenues back to the sector.

[20] Say a CO_2 norm of 350g/kWh is established and the cost of abating one tonne of CO_2 with CCS is 50 EUR, while the EUA price is 20 EUR. In that case, a power plant reducing its emissions below 350 to 150g/kWh will get an extra 'bonus' of 30EUR/t of CO_2 'saved' below the 350g norm (number of 'saved' tonnes = 200g(350 minus 150)*kWh produced). A plant emitting 750g/kWh would under already adopted EU ETS rules, pay for the emission allowances (20EUR/t in our example). In addition it would pay 30EUR/t for CO_2 emitted above the norm (400g(750 minus 350)*kWh produced)

4.1.2 Forward Capacity Market dedicated to low carbon electricity generation

Gottstein and Schwartz [2010] have described how a Forward Capacity Market (FCM) for electricity generation (covering all kinds of power generation) has created the required predictability for large investments in liberalized electricity market in the US.

An FCM is an administrative market, where the body responsible for the good operation of the system (in Europe known as the Transmission System Operator 'TSO') requests bids from power utilities for electrical output capacity (measured in watts). Utilities thus get paid not only for the electricity delivered to customers but also for the capacity (watts) made available to the system to prevent black-outs. The TSO recycles the cost of these payments to the utilities themselves, as each of them has to share the costs according to its market share. In other words, redistribution happens among the utilities themselves to incentivise the construction of new capacity.

If a FCM was dedicated to low carbon electricity generation for any sources not already covered by support mechanisms (such as feed in tariffs or green certificates), it would stimulate CCS investments by providing predictability for CCS investors. The originality of that system is that payment for electric capacity (not production) may be particularly relevant for CCS coal plants, which will not in the future be guaranteed to operate in baseload mode, and therefore not receive enough revenues through electricity production to recoup their high capital expenditure.

4.2 Specific incentives to promote CO_2 for EOR

If general CCS incentives are not politically feasible, specific incentives for CO_2 for EOR projects should be considered as a fall-back for a limited time period.

4.2.1 Tax incentives

Petroleum production is generally taxed more than other economic activities. This makes tax incentives particularly attractive for stimulating EOR. As when establishing any subsidy scheme, it is important to avoid a tax incentive that exceed what is necessary to trigger EOR.

Tax incentives should be designed to give to petroleum companies a tax reduction corresponding to their associated actual costs of capturing, transporting and storing each ton of CO_2 minus the benefits of EOR. This principle should be the basis when establishing the details of tax incentives.

In 1979, the USA introduced a 'tertiary incentive' scheme to maximise crude oil production from older oil fields and to reduce the costs associated with implementation of CO_2 for EOR projects. The incentive scheme was done through the following mechanism: a) a volume price exemption b) exemption from tax profit c) exemption on all oil produced from a CO_2 flooded reservoir [21] . Similar incentives or modalities to assess taxes could be introduced in Europe.

Below is a description of options that could be considered:

(1) Tax exemption: [22] Companies would be granted a reduction of taxes for all oil and gas produced through CO_2 for EOR (production from new fields as well as increased volume from existing fields). An alternative is to apply tax reductions only to a specific volume of oil produced through CO_2 for EOR [23] . Tax exemptions could be combined with 'negative tax' for companies without sufficient revenues to benefit from the tax exemption. For the Norwegian Continental Shelf (NCS) Aam et al. [2010] recommend additional regulation and incentives like e.g. a payment scheme for the tax value of pilot costs to increase oil recovery. This is similar to the current NCS payment system for exploration costs working to ease the investment risk associated with exploration drilling for companies that without sufficient taxable revenues.
(2) Shorten depreciation time: a license can also be given the opportunity to increase depreciation charges on investments directly tied to the use of CO_2 for EOR. This gives a lower taxable income in the period from initial investment to full write down and consequently a lower up-front taxation, although it is dependent on sufficient taxable income.
(3) Tax credit: a tax credit (15% in Texas) could apply to all costs associated with installing the CO_2 flood, CO_2 purchase and CO_2 operating costs for injection. This gives greater certainty to the operator.
(4) Modification of the basis on which the tax is assessed: Taxation based on achieved oil or gas price in the market place (instead of averaged prices) offers another measure that might reduce the petroleum companies' risk. This would enable companies to hedge their production and reduce further risk by selling oil on forward contracts without being taxed based on a potentially higher average fixed price assessment than actually achieved

4.2.2 Earmarked revenues

Additional revenues to the state arising from the increase of oil produced through CO_2 for EOR could be earmarked to be used for further in-

[21] ex in Texas where there is a severance tax exemption on all the oil that is produced from a CO_2 flooded reservoir
[22] general tax exemption or volume exemption
[23] This alternative carry the risk of measures resulting in a transfer of assets from the state to companies for high profit projects which would have been completed regardless of incentives

vestments in CCS [24]. For example to finance the establishment of pipeline infrastructure, to finance research, site selection and characterisations, monitoring improvements etc.

4.2.3 Regulations - Integrate EOR in the Plan for Development and Operation (PDO)

Regulatory requirements aimed at incentivizing investments in CO_2 storage could work better for CO_2-EOR projects than for non-EOR projects due to the higher margins in the oil and gas industry.

The petroleum concession system could give the authority a legal basis for controlling each phase of the petroleum activity, from the opening of an area to its closing. It is particularly through the PDO that the authority has the possibility to control and command the development of a petroleum deposit and to require the use of CO_2 for EOR.

In practice, such requirement could be difficult to impose on a general basis as CO_2 for EOR requires a solution to several technical and economic issues, e.g. where the CO_2 can be sourced, the commercial conditions of CO_2 purchased and the transport of CO_2. However, in the early phase of CCS development, the authorities should at least set a condition in the PDO that the injection of CO_2 for EOR has been assessed and considered. If the assessment reveals that there is a potential for such use, the competent authority should then ensure that suitable space on the installation is set aside for the equipment necessary to perform injection and to capture and recycle CO_2. This condition would be an 'EOR ready' category similar to the 'capture ready' referred to in the storage directive article 33 [EU, 2010]. If for any reasons, a licensee decides not to start EOR using CO_2, the authority should be able to use its legislation to require a higher recovery rate.

Authorities could also use the PDO to set a certain time-limited price ceiling for the CO_2 delivered at the well site. Even if that price is lower than the cost of CO_2 capture and transport it would bring down the funding gap for CCS.

For already existing fields the question is whether the authorities can require injection of CO_2 after the PDO approval. Such a post-approval requirement can prove difficult to put into practice.

4.2.4 Regulation at international levels

The Clean Development Mechanism (CDM), is one of the three mechanisms provided under the Kyoto Protocol (beside the ETS and the Joint Implementation (JI)). CDM is a project-based mechanism allowing companies to get extra credit by investing in projects in non-Annex I countries and allows developed countries to offset their CO_2 emissions

[24] Such hypothecation has proven unpopular with certain governments for oil tax revenues or equivalent

by funding CO_2 emission reducing projects in developing countries. CDM can play a significant role as a financial incentive for CCS projects in developing countries and should be strategically utilized to effectively support such projects and the subsequent technology transfer[Bellona, 2007, MIT, 2007].

The inclusion of CCS under CDM requires that CCS is recognized as an environmentally safe and sound technology [25] . For further details the reader is referred to Annex II of the EB50 Report [UNFCCC/CCNUCC, 2009] [26] and WorsleyParsons et al. [2009].

5 Organization of the value chain

CO_2 for EOR would present an early opportunity for CCS deployment by stimulating the entire CCS chain.

When EOR is combined with permanent storage, the oil field operator would be the ultimate CO_2 purchaser. If the CCS value chain is vertically integrated [27] it could simplify the nature and number of contractual engagements and simplify issues on transfer of liabilities.

[25] Decision 17CP.7 in the Kyoto protocol - Article 4, paragraph 5 of the Convention and Article 10

[26] The paper addresses possible positive and negative implications of technical, environmental, methodological, legal and market issues

[27] i.e all or several part of the CCS chain are handled by the same company

Alternatively, in order to avoid a situation of ownership structures resulting in competition distortion, it could be considered to organize the value chain through a company with no commercial interests in the CO_2 market [28] .

5.1 Stimulate CCS through the regime of Third Party Access

The Storage Directive provides the principle of open access to transportation networks as well as storage sites (principle of Third Party Access (TPA)).

Although the Storage Directive is based on the environment chapter of the EU treaties, it also contains rules on TPA to ensure competition, similar to other liberalized infrastructure. This consideration might influence the way rules on TPA have to be interpreted.

The three main issues addressed in the Directive will be discussed below: 1) the determination of who is entitled to access 2) the scope or limitations of access right 3) the terms and conditions for access. The coordinated operation and development of the network (System Operator) will also be discussed.

[28] as the case for the electricity and gas markets

5.1.1 *Access rights to transport and storage networks*

The Storage Directive does not specify who is entitled to access transport and storage networks [29]. This is left to MSs to decide. Indeed, *MSs shall take the necessary measures to ensure that potential users are able to obtain access to transport networks and to storage sites for the purpose of geological storage of the produced and captured CO_2 in accordance with paragraphs 2, 3 and 4* (article 21). Potential users could thus include all the entities involved in the CCS chain, from the CO_2 producer through the transport operator to the storage operator.

Art. 21 of the Storage Directive lists the valid derogations when designing the regulatory regime for TPA. An operator could refuse TPA based on:

- Technical reasons - if there is an incompatibility of technical specifications which cannot be reasonably overcome. Denial due to technical reasons [30] raises the question of what is considered to be 'reasonable to overcome' [31]. For new activities such as pipeline transport of industrial CO_2, this may be difficult to judge and underlines the importance of flexible but clear European standards.
- Lack of capacity. A facility operator is only obliged to provide access to the extent of available capacity. Since access may be denied if capacity has run out, the way in which the capacity is allocated is therefore important. The regulated tariffs will be crucial to determine whether or not there will be a real risk of undercapacity. For the foreseeable future, however, this is not an issue given the lack of CO_2 for EOR. If an operator refuses third parties access on the grounds of lack of capacity or a lack of connection, it is up to each MS to take the measures necessary to ensure that the operator makes any necessary enhancements provided a prospective customer is willing to pay for them.
- Need of owner/operators/existing users - whether it is necessary to respect a storage or transport operator's [32] duly substantiated and reasonable needs. This is strongly depended on allocation of capacity (see previous point). If the owner has the operative responsibility and allocates capacity to themselves or to connected companies in preference to other potential users, it could be considered as discrimination.
- Climate obligations - whether access would affect the national CO_2 reduction obligations. The Storage Directive Art. 21 states that it is

[29] The Storage Directive does not state who is a user or potential user

[30] E.g. pressure, temperature, H_2O content or other CO_2 stream compositions which are not compatible with the transport network or the specification for storage

[31] It is however more likely that if it requires large investments to remediate, it would not be reasonable

[32] or the interests of 1)other users of the CO_2 storage or transport network and/or 2)relevant processing or handling facilities who may be affected

up to the MS to decide the proportion of CO_2 reductions that they intend to meet through CCS. If a MS has already met its reduction obligations through CCS, the Directive suggests that third parties will not have any right to access under fair and open conditions. It may however be challenging for MSs to assess when this target is achieved as facilities covered by the EU ETS system are not subject to a 'cap' in emissions [33]. Therefore MSs are limited to verify that actual emissions match surrendered EUAs and other emission allowances. Hence it is difficult to give this criterion any significance .

Conditions for access should be set as to encourage widespread CCS deployment, e.g. by weighing the need to provide incentives for first movers who build infrastructure with the need to reduce transport and storage prices.

5.1.2 Terms and conditions of access

The Storage Directive does not provide further regulation as to how the right of access should be carried out. MS are therefore free to create a suitable regime.

In the EU legislation applicable within the gas sector, three different regimes of TPA are applicable, depending on the part of the gas chain: a) a regime for downstream pipelines, b) a regime for upstream petroleum pipelines and c) a regime for the subsoil gas storage facilities. Depending on the stage of the gas chain [34], the access regime is either a regulated access or a negotiated access [35].

In implementing the requirement on TPA in the Storage Directive, MS could use a similar approach to the one provided in the EU gas legislation and decide to use existing legislation governing the upstream petroleum sector or the legislation governing the downstream gas sector. In Roggenkamp and Woerdman [2009] it has been argued that CO_2 pipelines should be considered as 'reverse' upstream pipelines and should be regulated in a similar way to upstream petroleum pipelines. In other words, the regulatory regimes applying for TPA to existing pipelines can also apply to CO_2 pipelines. This parallel could apply even more broadly to the regulatory and safety regime already applicable in MS.

Although we have experience with

[33] their only obligation being to surrender allowances

[34] Regulated access is mandatory in the downstream pipeline sector while for gas storage and upstream pipelines, MS can decide to apply and combine different regimes

[35] Under a system of negotiated TPA the parties concerned negotiate the price and conditions for transporting the commodity, whereas under a regime of regulated TPA the governments or regulator sets in advance the transportation conditions and tariffs or the methodology to calculate them. One of the main differences between both regimes is the moment at which the competent authorities become involved

TPA rules in the gas sector, it is however more challenging to provide a rational regulation for a new CCS infrastructure than for a well-established infrastructure. The original TPA scheme for the gas (and electricity) market has indeed developed along with the development of this market and its infrastructure. The need for a flexible scheme which can easily be changed or developed seems particularly important for CCS as the CCS technology is still in the beginning of its development and it is difficult to predict what the CCS value chain will look like. This need for certain flexibility is, however, in conflict with the investors' need to have certainty about the way TPA will be organized and on which grounds access and/or refusal of access will be granted.

5.1.3 System operation

A network of interconnected pipelines is expected to be established under successive pipeline licenses. The CO_2 producers will then connect to the downstream pipeline network. To achieve an efficient resource management, a coordinated operation and development of the whole network is required (System Operation).

The system operator would manage the capacity allocation (capacity physically available at any time, capacity rights under existing contracts) and the coordination of CO_2 flows (including quality specifications) in a similar manner to what is done for other infrastructures such as airfields and ports. The CO_2 producers would have to follow the instructions given by the system operators in order to avoid operational disturbance or deterioration of the pipeline/storage site due, for example, to corrosion.

To avoid situation of ownership structures resulting in competition distortion, it should be considered to organize the transport system operator as a company with no commercial interests in the CO_2 market and that all aspects of the system operation are conducted in a neutral manner (as is the case for the electricity and gas markets).

5.2 Stimulate TPA through pipeline construction permits

Most infrastructure systems have been planned and/or funded by governments. There is an obvious need for governments to similarly sketch out priority corridors for CO_2 pipelines, as part of national or regional CCS infrastructure master plans. A system similar to the rolling 10 year investments plans coordinated by the new EU Agency for Co-operation of Energy Regulators (ACER) could be envisaged. In this way, competent authorities could ensure the chance that construction takes account of future use.

6 In Conclusion

Europe is the world region with the most comprehensive pricing of

CO_2 emissions. Yet it has very little EOR. ETS is leading the way, but provides insufficient investment security. Other incentives are thus needed. If general CCS incentives are not politically feasible, specific incentives aimed at CO_2 for EOR could be considered.

There is a range of alternative ways to stimulate investments in CCS - without putting the burden on public budgets. Among these are the Netherlands' CCS Task Force recommendation of a 'bonus-malus' scheme and the Forward capacity market dedicated to low carbon electricity generation.

A range of tax incentives for CO_2-EOR could be considered: Tax exemption, measures on depreciation time, tax credit and modification of the basis on which the tax is assessed ('carrots'). Any tax incentives should be designed on the basis of giving petroleum companies a tax reduction corresponding to their associated actual costs of capturing, transporting and storing each ton of CO_2 minus the benefits of EOR.

In addition Member States should consider to e.g. require CO_2 for EOR and to stimulate Third Party Access (TPA) through injunction and prohibition when assessing the oil or gas field operator's Plan for Development and Operation (PDO) ('sticks').

Ideally, specific incentives for CO_2-EOR would comprise elements from both 'carrots' and 'sticks'. Carrots without sticks in a high-margin industry may need to be very expensive to have a significant impact, while sticks without carrots may simply direct investments in petroleum industry to other regions of the world.

Additional revenues to the State arising from the increase of oil produced through CO_2 for EOR could be earmarked to be used for future investments in CCS (for example infrastructure).

At present it is difficult to assess what the CCS value chain will look like and how it will be organized. If the CCS value chain is vertically integrated it could simplify the nature and number of contractual engagements and simplify issues on transfer of liabilities. Alternatively, in order to avoid a situation of ownership structures resulting in competition distortion, it could be considered to organize the value chain [36] through a company with no commercial interests in the CO_2 market.

In the early phase of CCS, where the infrastructure is not yet established, rules on TPA should offer sufficient flexibility to adapt to the development of the infrastructure and of the market, and at the same time offer sufficient certainty to investors about the way TPA will be organized and on which grounds access and/or refusal of access will be granted. Since access may be denied if capacity has run out, the way in which the capacity is allocated is therefore important. If an operator refuses third parties access on the grounds of lack of capacity or a lack of connection, it is up to each

[36] transport system

MS to take the measures necessary to ensure that the operator makes any necessary enhancements provided a prospective customer is willing to pay for them.

Other issues that have been of concern to CCS industry, such as long term liability under the Storage Directive, should be of lower concern for CO_2-EOR projects than for other CCS projects.

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