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CCS in the Skagerrak/Kattegat-region

– Assessment of an intraregional CCS infrastructure and legal framework

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Abstract

This paper provides some initial results from the project "CCS in the Skagerrak/Kattegat-region" which is an intraregional CCS project partly funded by the EU. The project assesses the prospects for Carbon Capture and Storage (CCS) from industry and power plants located in the Skagerrak region which comprises northern Denmark, south-east coast of Norway and the west coast of Sweden. The project is a joint cooperation between universities, research institutes and industries in the region. The methodology used in one of the project work packages is presented together with some initial results on legal aspects. CCS in the Skagerrak region may potentially account for a third of combined emission reduction commitments by 2020 in the three countries involved in the project. Yet, much of the emissions in the region occur from industry (in addition to power plants) and it is still not clear how these industries will be treated under the ETS. Based on current knowledge, a good storage option would be in the Hanstholm aquifer on Denmark's northwest coast. The phasing-in of capture plants over time is central to the development of a cost efficient CCS infrastructure. However, many of the sources in the region are located at a port facilitating use of boat transport through the build-up period. The initial legal analysis show that significant regulatory uncertainties exist in the region with regard to CCS and it is not obvious that the implementation of the EU CCS directive into national law by June 2011 will alleviate these uncertainties. Finally, the project may provide a significant test case for what type of political and regulatory cooperation that will be required if CCS is to be deployed in a transboundary context under conditions of sufficient public acceptance and well-designed regulation.

Keywords: Intra-regional; Transboundary CCS; Legal assessment

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1. Background

The European Commission is targeting a 20 to 30% reduction in GHG emissions by 2020 and is advocating an 80 to 95% reduction for industrial countries by 2050, in both cases relative to 1990 [1]. Since CO_2-emissions correspond to around 83% of all GHG emissions while the transport sector accounts for around 23% of all CO_2-emissions (without LULUCF in 2007), there is little room for CO_2-emissions from any stationary sources if EU:s long-term reduction proposals shall be met [2]. Therefore, up to 2020 there is more or less only three options available which significantly can reduce emissions; increase the use of renewables, efficiency improvements on all levels in all sectors and switch of fuel from coal to gas. After 2020, nuclear energy and CCS may also play a role to reduce CO_2-emissions and post 2020 it is likely that all emission reduction options will have to be utilized in order to reach long-term reduction goals.

The three countries situated around the Skagerrak area (Denmark, Norway, Sweden) emitted 150 Mt carbon dioxide in 2007 (roughly a third each) of which the transport sector is responsible for exact one third, i.e. 50 Mt [3]. Within a circle centered in Skagerrak and with a radius of around 100 km, there are 14 large emitters with combined emissions of around 13 Mt and a capture potential of around 10 Mt (see Figure 1). In other words, after 2020 CCS in the Skagerrak region may alone account for one third of total emission reductions required in the three countries, assuming an overall reduction target of 20%. Also, several other large scale emission sources are found 100 to 200 km further south of the region such as the coal-fired power plants situated in Copenhagen and Sködstrup (Studstrupverket CHP) and the refineries in Kalundborg and Fredericia. It is generally believed that CCS will start in the power sector (coal power plants) and consequently that most CCS systems also will start up and evolve from coal power stations, i.e. in this case from the coal power plants in the region. However, for two of the countries (Norway and Sweden) there are no coal plants.

One task in the project (Work Package 3) is to assess the build-up of a complete CCS infrastructure from a system perspective, covering economical, technical, practical and legal aspects. So far the work has identified relevant CO_2 sources in the region and made a first assessment of the process of establishing the legal framework for implementing CCS.

Along with site specific evaluation of capture, pathways for implementation of CCS in the region is developed, i.e. the phasing-in of capture plants over time which will also define CO_2-flow and transport requirements over time. The phasing in of capture plants over time is in other words central for the development of the transportation system. A large bulk CO_2 pipeline transportation system may consist of collecting pipelines from each individual source, bulk pipelines carrying the CO_2 from several sources and injection pipelines depending on the injection rate in a specific reservoir. In the Skagerrak region where most of the sources are located along the coast (see Figure 1), boat transport may be a least cost solution during the ramp-up period offering flexibility and enabling the CO_2-volume to build up to a plateau volume, so that when a pipeline transportation system is developed, it will be a large bulk system that is cost efficient with minimal impact on the surroundings.

The task reported in this paper also includes investigation of the role of climate policies and their potential effect on the development of CCS, including the European Emission Trading Scheme (ETS) and the potential impact of banking, carbon leakage, carbon negative and emission performance standards. At the time of writing this paper, it is for instance not clear how the various industry sectors will be treated under the ETS[2]. Finally, the legal preconditions for deployment and operation of CCS according to the pathways that are developed are being analyzed. The analysis comprises international and EU perspectives but is based on the specific characteristics of the Skagerrak/Kattegat-region. Sections 2 and 3 describe the ongoing work with respect to capture and the legal assessment respectively.

2. Initial work on CCS infrastructure

The study comprises assessment of CCS in 2 cement plants, 3 refineries, 2 chemical plants and 2 power plants in the region (see Table 1). CCS in the power sector is modeled by Chalmers Electricity Investment model (ELIN,

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[2] In fact, the ETS itself may change, for instance if the EU chooses to raise the 2020 reduction target to 30%. In the longer term, the ETS will probably also depend on global efforts to reduce emissions.

described elsewhere [4]) which provides a CO_2-emission price that may be used as a benchmark for application of CCS in the industry. As opposed to power plants, CO_2-emissions from industrial sources often come from several different sources within each facility which of course will complicate and drive up the cost for capture. Table 1 shows the industries and power plants that are investigated along with approximate annual CO_2-emissions and the number of relevant sources at each facility.

Table 1: Relevant industries, annual CO_2-emissions and relevant CO_2-sources/facility in the Skagerrak region

Industry	Country	Installation name	CO_2 emissions, kt	# of relevant CO_2 sources
Cement	Denmark	Aalborg Portland A/S	2,500	1
Cement	Norway	Norcem AS, Brevik	850	2
Refinery	Sweden	Preemraff Lysekil	1,630	4
Refinery	Sweden	Preemraff Göteborg	475	2
Refinery	Norway	Esso Slangentangen	380	9[1]
Chemicals	Norway	Yara Porsgrunn	700	3
Chemicals	Sweden	Borealis Cracker	650	5
Power station	Denmark	Nordjyllandsverket	2,200	1
Power station	Sweden	Ryaverket	400	1

1: Refers to all CO_2-sources at the refinery.

The power plant Nordjyllandsverket in Denmark is targeted by the owner (Vattenfall) to be one of the first full-scale CCS plants around 2020. Vattenfall is aiming to be CO_2-neutral in the Nordic countries by 2030 and companywide by 2050 [5]. At this stage, the analysis is restricted to existing plants and it was therefore decided to restrict the capture assessment to post combustion technology only. The project assesses the heat supply required during the capture process for the industries in the region. The capture technologies evaluated are CO_2 absorption using Mono-Ethanolamine (MEA) and the Chilled Ammonia Process (CAP). The temperature in the desorber of these capture processes is an important parameter that influences the process design (hence capital costs). Four alternatives for heat supply are evaluated and compared:

- Use of excess heat from the process (above 120°C)
- Use of excess heat from the process but heat pumped above 120°C
- Use of a Natural Gas Combined Cycle (NGCC)
- Use of a Biofuel Boiler

In total, 16 different cases are identified and evaluated for the Skagerrak industries, applying energy market scenarios given in [6]. The analysis gives a price for heat supply (both operational costs and capital costs) per ton net CO_2 avoided.

Figure 1 shows the area considered and its surroundings. CO_2-sources are shown as circles while CO_2-sinks are shown as squares. Figures in red denote estimated storage capacity while figures in black denote approximate emissions.

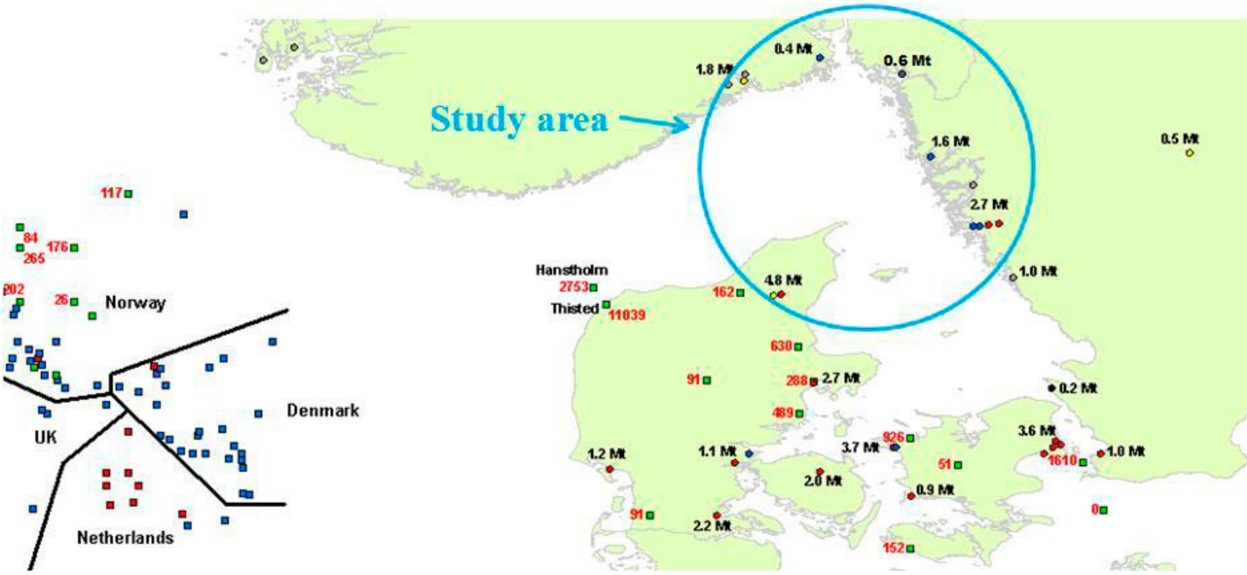

Figure 1: The region studied in the Skagerrak project together with relevant sources and identified sinks (other sources and sinks in the region also shown). CO_2-sources are shown as circles while CO_2-sinks are shown as squares. Red circles refer to power plants, yellow to cement plants, blue to refineries and grey circles to chemical, fertilizer and pulp and paper plants. Blue squares refer to oil fields, red squares to gas fields while green squares refer to aquifers (which obviously cover a large area while the square only indicates the center of the aquifer). Figures in red denote known estimated storage capacity while figures in black denote approximate emissions.

Work is being carried out in another work package to identify possible structures in the region suitable for storage. Current knowledge indicate that the closest storage option exist in Danish aquifers in the northwestern parts of Jutland, or more precisely in the Thisted and Hanstholm aquifers with a combined estimated storage capacity of almost 14 Gt (see Figure 1) [7]. However, since there are doubts with regard to Thisted's storage ability (may have low permeability [8]) and since it may be difficult to obtain public acceptance for onshore storage, the Hanstholm aquifer which is located offshore appears to be the best alternative for storage of CO_2 in the region. This may however change if suitable structures are identified in the Skagerrak region.

3. CCS from a legal perspective

3.1 Legal premises

The judicial part of the project has the aim to identify and explore legal obstacles and opportunities in the various phases of CCS operations. The pathways for CCS developed within the project will serve as focal points and reality checks for the legal analyses and provide added value compared to a more generic approach. The ultimate question is how CCS regulation may be designed in the region so as to be protective of humans and the environment while supporting an efficient deployment of CCS and navigating the complications of a plurality of interacting legal systems. Here some significant facts and relevant findings so far are presented.

CCS as a regulatory object is a novelty to most legal systems and its large-scale application for climate change mitigation lacks obvious precedents. The pathway or pathways in this project are being built around a presumption of regional cooperation which would likely include transboundary transport of captured CO_2 for maximum efficiency. This adds to the complexity but hopefully also to the relevance of the analysis. Unlike for any domestic CCS scheme this makes the allocation of rights and responsibilities between private and public (government) agents in two or more countries a vital factor and also necessitates a searching analysis of the potential repercussions of diverging or incompatible rules in the States concerned.

3.2 Diversity and harmonization

Significant among the legal preconditions for CCS in the Skagerrak/Kattegatt-region is that Denmark and in particular Norway have substantial experience of regulating ocean based oil and gas production whereas such experience and the attendant legal structures are relatively absent in Sweden. Norway is also among the few countries that have actual experience of operating CCS projects of scale. Like most States that have commenced with CCS operations of any significance Norway has used existing legislation pertaining to the oil and gas industries, noticeably the Petroleum Act but also the more generally applicable Pollution Act [9]. In Denmark the existing Underground Act, after some adaptation, is likely to play a significant role in CCS regulation, in particular for the storage step [10]. There is also a marked difference in public attention and display of political interest in CCS in the three countries with Norway being the champion of CCS whereas official actors in Sweden in particular have so far shown limited interest in the technology.

All this makes for rather different vantage points when it comes to establishing sufficient legal structures for the eventual industry-scale deployment of CCS in the region. However, these differences will be attenuated by the implementation, no later than June 25, 2011, of the EU CCS Directive (Directive 2009/31/EC) which entails partial harmonization of CCS regulation in all EU Member States (hereafter MS) as well as EEA States such as Norway. The Directive is the linchpin of the EU's legal approach to CCS and focuses predominantly on the storage phase, setting standards inter alia for the selection of storage sites and the granting of storage permits. It also entails amendments to several other EU legal acts, including those relating to environmental impact assessment, handling and transport of waste and environmental liability. Some of these amendments are intended to enable and/or regulate transport of captured CO_2. Apart from requirements for environmental impact assessment capture operations are so far subject to limited direct regulation. However, the Directive establishing the EU ETS (directive 2003/87/EC) has also been amended to allow for CO_2 captured as part of a CCS process to be counted as not emitted. The amendment also makes emissions of CO_2 from the CCS chain, including storage facilities, liable to be covered by emission rights under the ETS. The CCS Directive must not, for several reasons, be seen as doing away with all potentially disruptive variants between domestic legal systems.

Firstly, as is always the case with legal acts adopted under the EU environmental competence it only requires a minimum harmonization and allows for each MS to adopt its own more far-reaching requirements with respect to protection of human health and the environment (art. 193 of the Treaty on the functioning of the European Union). The other legal acts that have been amended to accommodate and promote the safe application of CCS, such as the Waste and Environmental Liability Directives, also enable individual MS to go further if they so choose. If past experience is any guide, however, most MS are unlikely to peruse a more demanding regulatory level than that prescribed by the pertinent EU legislation [11]. Secondly, the choice of a directive as a means of EU legislation means that each MS will adopt or amend its own laws and regulations in order to adhere to the standard set by the Directive. This invariably leads to significant variations in both form and substance due to different legal traditions and pre-existing legislative and administrative structures even in the absence of any intention to adopt specifically far reaching rules in any MS. Thirdly, some potentially very significant areas of law are not subject even to minimum harmonization. This goes inter alia for liability for harm to human beings or property, as well as for the damage caused by other CCS activities than CO_2 storage, such as transport or injection, and for issues of access to land for transport infrastructure or storage sites. Hence, these issues are left to the individual MS to deal with. This is likely to result in significant differences in how they are regulated, mainly due to different traditions in the fields of land law and tort law. Since the Scandinavian countries studied belong to the same overall tradition e.g. in the field of tort law they are less likely to have fundamentally conflicting principles or perceptions than European countries rooted in more diverse traditions. However, they are by no means immune from costly or disruptive inconsistencies in the regulation of similar issues. In countries that take a low general interest in CCS there is likely to be little if any adaptation of existing laws outside of what is required by the EU. This will likely give rise to further costs and uncertainties further down the road towards eventual deployment of CCS.

Another cause of regulatory uncertainty is the fact that significant EU legislation pertaining to protection of workers and/or the general public in relation to the handling of explosive gases do not apply to CO_2 since it is not explosive. This raises the question of what standards should be applied regarding the security risks associated e.g. with transport of pressurized CO_2 in pipelines. Some existing EU or national standards on handling of pressurized gases are relevant for CO_2 but their application is unlikely to provide sufficient security if transports of CO_2 under high pressure in populated areas become part of CCS operations.

Formally, every MS has the right to completely rule out storage of captured CO_2 within its territory or under its jurisdiction at sea (Directive 2009/31/EC, art. 4). There are no signs however, that such a stance will be taken by any of the States in the Skagerrak/Kattegat-region. As soon as a MS establishes a system for authorizing CO_2 storage, that system must be open to any actor, irrespective of nationality, on a non-discriminatory basis (Directive 2009/31/EC, arts 5 and 6). Exclusively allowing for "domestic CO_2" to be transported or stored within a MS's CCS infrastructure or storage sites would thus not be acceptable.

3.3 Incentivizing CCS

As to the economic preconditions it is clear that CCS will not be deployed in the region – and probably nowhere else either – without either prescribing the technology for certain installations; establishing CO_2 emission standards which de facto require CCS to be employed when, for example, lignite or coal are used as fuel; or, more likely by putting a price on carbon emissions and thereby making CCS economically attractive for large CO_2 emitters. Although the EU is mulling legal requirements of some kind, the current avenue is to promote CCS by means of including it in the EU ETS. This gives rise to significant uncertainty regarding the eventual pace of CCS deployment within the region and the prospect of significant CO_2 emitters being able to coordinate their eventual CCS initiatives so as to minimize costs and disturbances from e.g. transport infrastructure. This problem is accentuated in a region were cooperation among multiple actors, public as well as private, is a likely prerequisite for deployment of CCS on a scale that makes it economically feasible. However, the legal frameworks adopted so far have little to offer in this regard beyond a general obligation incumbent on MS and EU institutions to cooperate diligently in the implementation of EU law.

The choice of the EU ETS as the main incentive also has repercussions for the prospect of deploying CCS in combination with the combustion of biofuels (bio-energy with carbon storage, BECS) thereby drawing CO_2 from the atmosphere. This could be a particularly attractive way of using CCS for countries like Norway or Sweden with large biomass resources and modest or low use of fossil fuels in the stationary energy sector. However, the EU ETS does not currently cover the combustion of biomass why no economic incentive exists for such operations (Directive 2003/87/EC, Annex IV).

3.4 Opaque requirements

The nebulous nature of the specific requirements on site selection for storage operations may also open up for varying interpretations. A geological formation may only be selected as a storage site "if under the proposed conditions of use there is no significant risk of leakage and if no significant environmental or health risks exist" (Directive 2009/31/EC, art. 4). Hence, some level of risk for leakage is to be accepted. That is probably inevitable if CO_2 storage operations are to be carried out since no design or operation scheme can offer complete absence of risk. The bewildering part is the definition of a "significant risk" which is "a combination of a probability of occurrence of damage and a magnitude of damage that cannot be disregarded without calling into question the purpose of the Directive for the storage site concerned" (Directive 2009/31/EC, art. 3). Indeed, the purpose of the directive is not crystal clear but, as has been seen above, it "establishes a legal framework for the environmentally safe geological storage of CO_2 to contribute to the fight against climate change." The purpose of "environmentally safe geological storage of CO_2 " is in turn defined as "permanent containment of CO_2 in such a way as to prevent and, where this is not possible, eliminate as far as possible negative effects and any risk to the environment and human health" (Directive 2009/31/EC). Hence, the purpose of the Directive may be assumed to be at least that. Accordingly, a "significant risk" should be at least a combination of a probability of occurrence of damage and a magnitude of damage that cannot be disregarded without calling into question the ability of permanent containment of CO_2 (at a specific site) to prevent and, where this is not possible, eliminate as far as possible negative effects and any risk to the environment and human health. Reasonably, it is a tall order to establish for example when a risk calls into question the ability to eliminate as far as possible negative effects and any risk which may not be prevented. One can hope that the non-binding supervisory procedure under which the EU Commission will have a say will eventually help alleviate the confusion.

3.5 Third-party access

Although regulatory flexibility and learning by doing have advantages with respect to new technologies legal foreseeability has suffered from the CCS Directive's minimalistic and open ended rules on third-party access (TPA) to transport infrastructure and storage facilities. Two major models for dealing with third-party access may be discerned in other fields of EU law [12]. However, it is hard to predict whether individual MS will opt for either of these or rather settle for just meeting the minimal requirements of the Directive, something which will indeed leave considerable uncertainty as to how competing interests in infrastructure and storage capacity will be handled. Particularly in a region where CCS activities are likely to span international borders the effective early establishment and preferably harmonization of TPA rules could be decisive for decisions to invest in CCS projects.

3.6 Standards and decision-making

The fact that the EU's regulatory approach to CCS takes the form of minimum harmonization, that it leaves out significant legal aspects of CCS activities and that it contains open-ended or opaque requirements all make for significant regulatory leeway for national authorities in EU MS. Moreover, the novelty and complexity of the technology and the varying extent to which such States have experience with (reasonably) similar activities make for many national regulatory peculiarities. However, technical standards and guidelines developed by industry or industry in association with engaged governments and intergovernmental agencies can provide significant guidance and exert a harmonizing effect. Perhaps unfortunately, the much awaited DNV Recommended Practices have so far shun away from substantial recommendations regarding regulation, monitoring, reporting and other issues outside the strictly technical field which are decisive for the outcomes of national decision-making and oversight procedures [13]. It is also remarkable how few States have actually been involved in the development of those guidelines despite the apparent weight ascribed to them also by regulators. Although understandable, it may be problematic from a legitimacy and acceptance perspective that predominantly those with an economic self-interest in the technology are active in the development of crucial standards.

A related fact that may strongly influence the quality and outcome of decision-making regarding CCS operations is the political commitment exhibited and the technical and legal competence held by relevant political bodies and government agencies in different States. A low level of competence may not only lead to substandard decisions but also to diminished legitimacy and acceptance of CCS. Legitimacy and acceptance require that decision-makers individually or in cooperation can be seen to arrive at reasonably well-informed and well calculated decisions on the various pros and cons of individual CCS operations. This should call for intensified cooperation among decision-makers and regulators. It is also important that industry interests are not seen as permeating all the significant forums and bodies where CCS policy is decided nationally and internationally. In the end, that should also benefit commercial actors with a stake in CCS since public trust and competent and foreseeable regulation are linchpins in any reasonably solid and long term business calculus. The argument is further corroborated by the necessity, in many cases, of coordinating the plans and interests of many stakeholders – producers and transporters of CO_2 as well as storage site operators, insurers, various consultants etc. – who will all be in need of reasonable certainty as to the rules of the game applicable not only to themselves but also to their business partners and potential competitors in different jurisdictions. The Skagerrak/Kattegat-region may provide a significant test case for what kind of political and regulatory cooperation will be needed if CCS is to be deployed in a transboundary context under conditions of sufficient public acceptance and well-designed regulation.

4. Conclusions

The Skagerrak project is the first intraregional CCS project being funded by EU regional funds and covers three regions in two EU MS plus Norway. CCS in the Skagerrak region may potentially account for a third of combined emission reduction commitments by 2020 in Denmark, Norway and Sweden, i.e. up to 10 Mt and possibly even more if the region is expanded further southwards to comprise Copenhagen. The CO_2 could be stored either in aquifers on Denmark's northwest coast, in the Norwegian part of the North Sea or in the Skagerrak region itself if suitable reservoirs are identified. The paper reports on initial work carried out within one of four work packages in the project with the initial work focused on legal aspects for CCS in the region. Regarding these aspects, the project may provide a significant test case for what type of political and regulatory cooperation that will be needed if CCS is to be deployed in a transboundary context under conditions of sufficient public acceptance and well-designed regulation. There is a risk that implementation of the CCS directive into domestic legal systems will fail to significantly alleviate the prevailing regulatory uncertainty. Certain regulations aiming to protect the general public may not apply to CO_2 thus likely triggering calls for distinct national responses, unclear regulations with regard to TPA may serve as a disincentive for potential investors and operators of CCS infrastructure and certain terms in the CCS directive, such as "significant risk" with regard to leakage from a storage site may actually add to the uncertainty rather than bring much needed clarity.

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