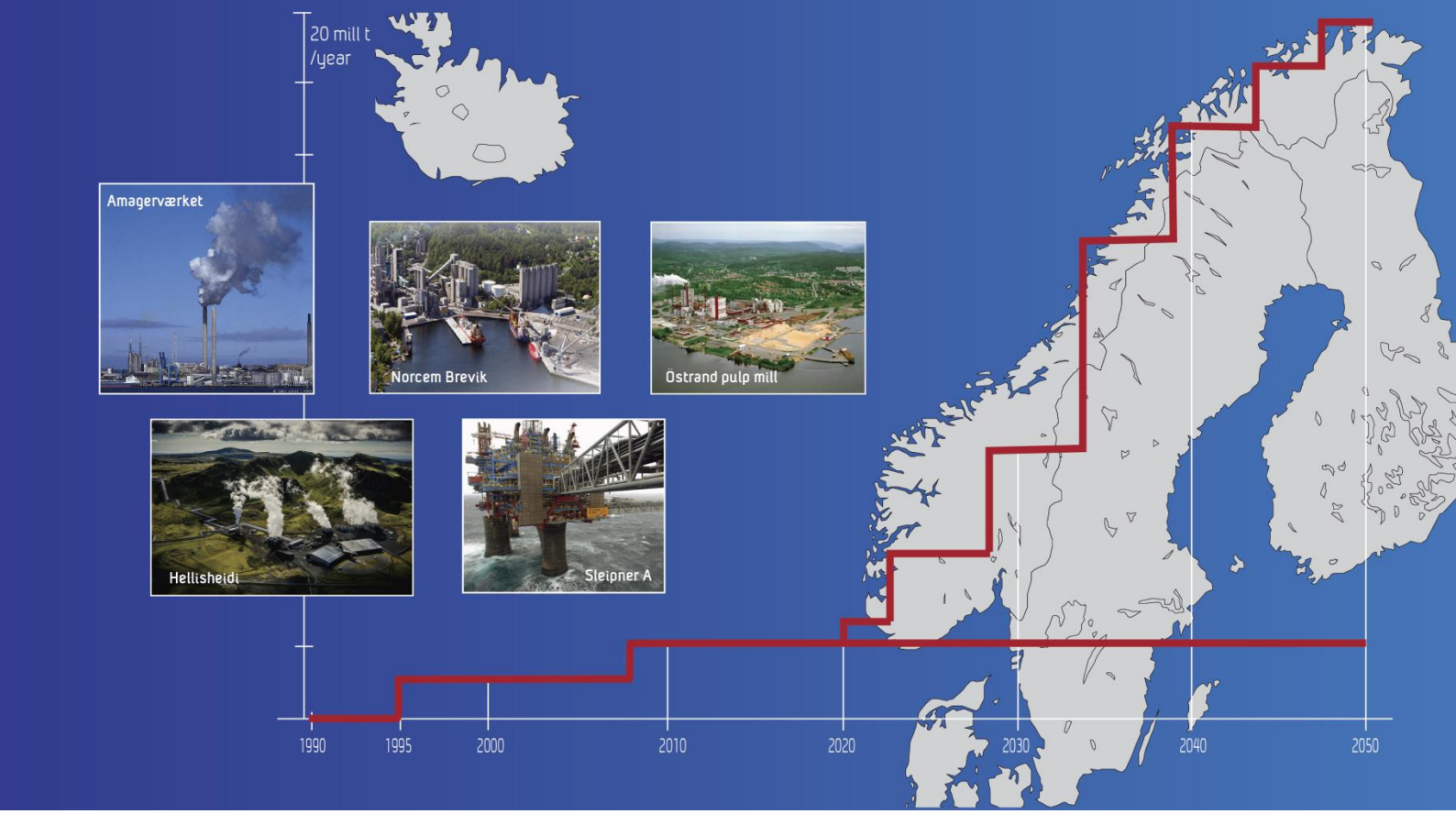

CCS-cluster in the Skagerrak-region – a politically feasible solution?

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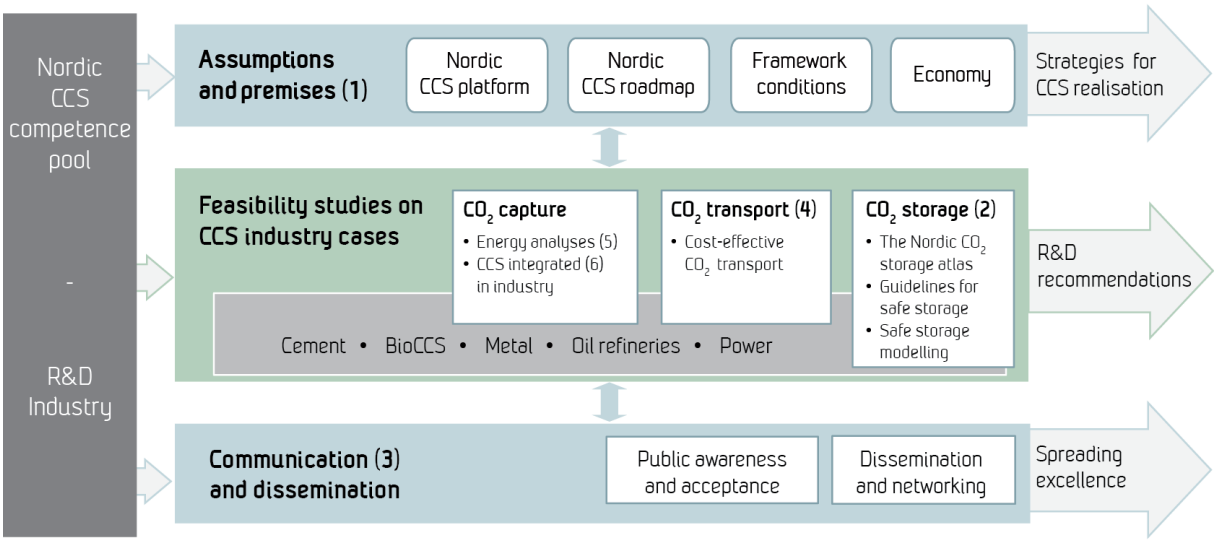

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Summary

In this study, we have analysed the political feasibility of a joint carbon capture, transport and storage solution in the Skagerrak region. This has been done by conducting interviews with Swedish, Danish and Norwegian authorities at different governance levels, industry in the respective countries as well as complementary document and literature analyses.

The results from this study illustrate a number of barriers for a potential CCS-cluster, in that there are currently no specific policies for cooperation between the three countries and thus no concrete policies for a realization of a joint activity in the Skagerrak region. Moreover, the highly different national CCS policies in the three countries may create substantial challenges. The study also identifies some features of the national policies that nevertheless may facilitate for a realization of a Skagerrak CCS cluster, which could form a starting point for political discussions between the three countries policymakers.

Keywords CCS, policy, acceptance, Skagerrak

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About NORDICCS

Nordic CCS Competence Centre, NORDICCS, is a networking platform for increased CCS deployment in the Nordic countries. NORDICCS has 10 research partners and six industry partners, is led by SINTEF Energy Research, and is supported by Nordic Innovation through the Top-level Research Initiative.

The views presented in this report solely represent those of the authors and do not necessarily reflect those of other members in the NORDICCS consortia, NORDEN, The Top Level Research Initiative or Nordic Innovation.

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1. Introduction

Increasing the possibilities to implement CCS in Europe boils down to a number of different topics and concerns within different stakeholder groups. While the technical applicability is important, there are also several non-technical barriers and opportunities. This includes general awareness of CCS, acceptance thereof among different stakeholders, costs and investment willingness, and general policies and policy instruments that assign responsibilities as well as providing financing and incentivisation.

Different studies (NORDICCS Roadmap 2013, Tel-Tek 2012, Skagestad et al. 2013) have pointed to different advantages of Nordic collaboration. A CO2 cluster in the Skagerrak-region – consisting of several CO2 point sources as well as a joint transport and storage solution – has been highlighted as particularly interesting in this regard. In the research project NORDICCS[1], cost estimates has shown that the Skagerrak cluster is among the most economically viable cases due to significant economies of scale (NORDICCS Roadmap 2013, Skagestad et al. 2013). Also, the potentially large scale of this CO2 cluster could make it a candidate for enhanced oil recovery (EOR)[2] projects in nearby oil fields, thus reducing costs further (NORDICCS Roadmap 2013).

The political framework needed to establish a possible CCS solution in the Skagerrak region has to some extent been studied before. It has been suggested that there should be particularly good prospects for CCS in the Skagerrak region, since the Nordic governments have ambitious long-term emission reduction targets (Tel-Tek 2012). In-depth studies of political preconditions for joint development in this region has, however, not been conducted. On this background, we will examine; *which main political obstacles and opportunities – on a national and local level - will influence on the possibilities to establsih a CCS cluster in the Skagerrak region?*

Relevant questions to be answered will be;

- What constitutes the Danish, Swedish and Norwegian main CCS relevant policies and how do they differ between the countries?
- Are there any policies specifically targeting Nordic CCS collaboration?
- What role and trade-offs (social, economic and environmental concerns) may the local authorities need to consider when being faced with CCS implementation?
- How are the political framework perceived by the industry and how can it be improved?

To do this, we will examine the countries' political position towards CCS in general and an integrated Skagerrak CCS solution in particular, including the implementation of CCS policies and interpretation and implementation of other framework conditions. The relevant industries' views, i.e. large stationary point sources and potential project owners, form an

[1] For further details – see http://www.sintef.no/Projectweb/NORDICCS/
[2] This means that the CO2 is injected into an oil reservoir to increase the oil extraction at the same as storing the CO2.

important contribution to illuminate multi-level governance challenges and project feasibility.

2. Method

A qualitative case study design has been applied in the data gathering and analysis. The basis for the analysis is political documents and interviews (Table 1). The interviews were conducted with key national and local authorities as well as industry representatives in the period of March 2014-June 2014. The respondents were purposively selected to gain insight into the different priorities that are made on the different governance levels.

Table 1 – General affiliation of respondents. The table lists the country, organization and respondent number of the informants

Country	Organisation	Informant number
Norway		
	Ministry of Petroleum and Energy	1
	Ministry of Climate and Environment	2
	Norwegian Environment Agency	3
	Porsgrunn Municipality	5
	Yara	6
	Norcem	7
Denmark		
	Danish Energy Agency	8
	Aalborg Portland	9
Sweden		
	Ministry of Environment	10
	Ministry of Enterprise	11
	Swedish Energy Agency	12
	Swedish Environmental Protection Agency	13
	Swedish Geological Survey	14
	Swedish Geological Survey	15
	Stenungsund Municipality	16
	Lysekil Municipality	17
	Borealis	18
	Preem	19

Note: In all countries several ministries and directorates have been contacted. Some have pointed to CCS being the responsibility of other authorities, hence the different number of authorities between the countries. Some also did not answer our request (Gassnova in Norway). Moreover, no one could answer questions about CCS in Aalborg municipality, as they are not currently working with CCS. For Nordjyllandsværket in Denmark, Vattenfall wasn't able to find anybody who could participate, due to several re-organizations and down scaling of CCS activities.

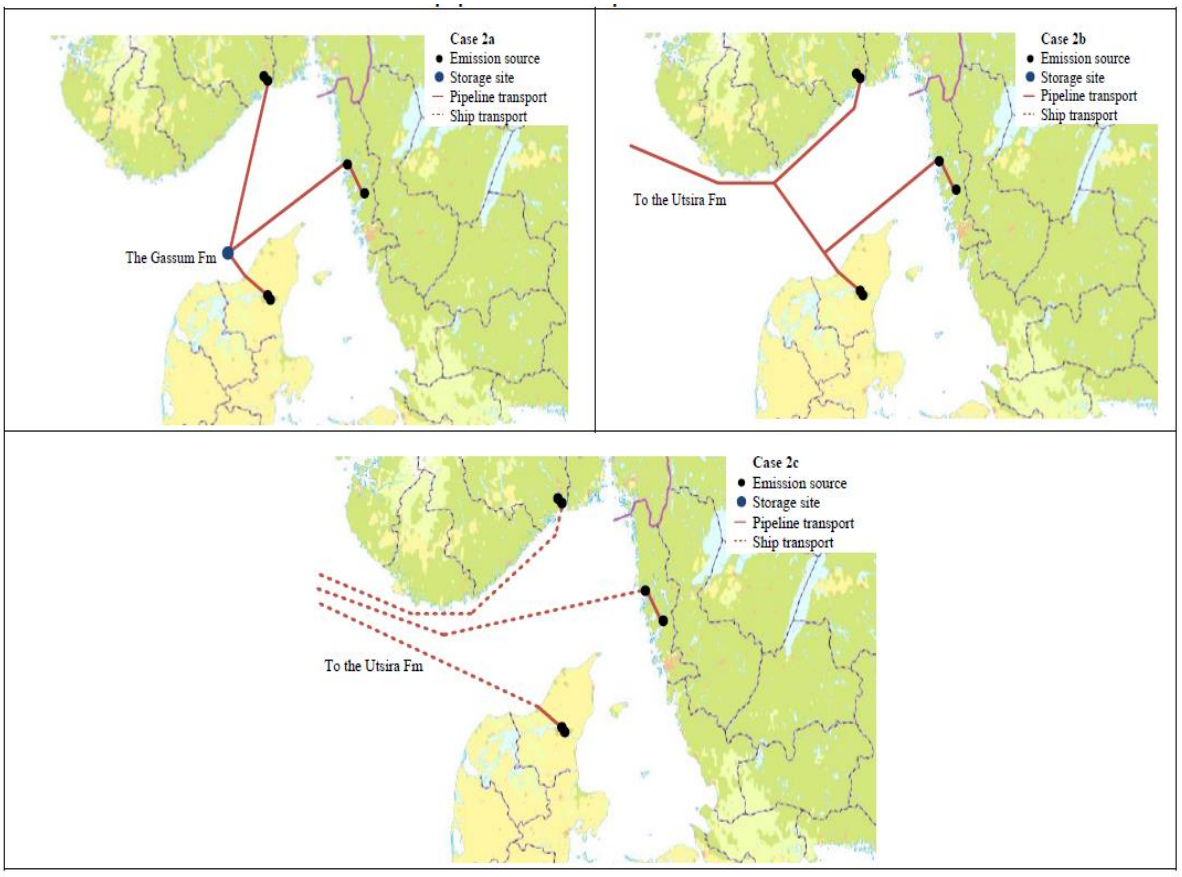
The interviews followed a semi-structured interview guide that was sent the interviewees beforehand. The interviews lasted between 20 and 90 minutes. Interviews with Norwegian respondents were conducted in Norwegian, Swedish respondents were interviewed in Swedish and the Danish respondents were interviewed in Norwegian or English. Most interviews were recorded

on tape and the informants have been given the possibility to comment on the interview extracts. The interviews were complemented by a literature review and a review of key documents related to energy and environmental policy in Norway, Denmark and Sweden.

3. The Skagerrak-cluster

The Skagerrak-cluster is one of several cases that have been treated in the NORDICCS project, Work package 3 - Feasibility studies of industry cases. The aim of work package is to coordinate integrated CCS cases in the Nordic countries and assess their feasibility. The Skagerrak CCS cluster would be located between the southern part of Norway, Southwestern Sweden and Northern Denmark. This includes six CO2 point sources located in relatively close proximity to each other and also to a potential storage site in the Gassum formation. Storage at the Utsira formation on the Norwegian west coast is also a possibility. Both CO2 transportation by ship and pipeline have been investigated (Skagestad et al. 2013).

Figure 1 – Potential infrastructures of a Skagerrak cluster



Source: Skagestad and Mathisen (2014)

The idea of a Skagerrak CCS cluster have been described before (Tel-Tek 2012), albeit with somewhat different constellations of CO2 emission sources than what is investigated through the NORDICCS project. The emissions from sources in this study vary on a yearly

basis, but together emit the substantial amount of approximately 7.6 million tons CO2 per annum (table 2). As such, capturing and storing CO2 from these sources could substantially reduce GHG emissions and contribute to the fulfillment of the respective countries emission reduction targets.

Table 2 – CO2 point sources in the Skagerrak-cluster, geographical location and annual CO2 emissions

Source	Country	Municipality	Type of company	CO2 emission (kt/y)
Norcem Brevik	Norway	Porsgrunn	Cement	927
Yara Porsgrunn	Norway	Porsgrunn	Chemicals	815
Preem Petroleum	Sweden	Lysekil	Refining	1 670
Borealis Cracker	Sweden	Stenungsund	Chemicals	690
Aalborg Portland	Denmark	Aalborg	Power	1 150
Nordjyllandsværket	Denmark	Aalborg	Power	2 380

Source: Skagestad et al. (2013)

4. National CCS-relevant policies

Overall, there is a strong international interest for CCS, which has been expressed in energy outlooks by the IEA (2012a, 2012b) and goals for CCS demonstration by, among others the G8 (G8 Energy Ministers 2008) and EU (European Council 2008). International policy initiatives that influence CCS include the international climate negotiations under the UN Framework Convention on Climate Change (UNFCCC) and EU policies establishing the EU Emissions Trading Scheme (EU ETS) and the" CCS Directive" (Directive 2009/31/EC) establishing rules for storage site selection.

While EU policies on energy, climate and CCS naturally matters, the domestic climate and environmental policy agenda are also critical for national CCS developments. Traditionally, Norway has been most proactive of the Nordic countries with regard to CCS and has since the 1990's focused on facilitating for CCS deployment by a variety of policy measures. In Denmark on the other hand, low carbon technology policy has been directed more towards wind power, whereas biomass energy has been a focus in Sweden. To many observers this has appeared as a sensible arrangement as it plays to each country's comparative advantages (Tjernshaugen and Langhelle 2009, p. 120). For a CCS cluster in the Skagerrak region, however, too different political priorities could impede the development of a common solution. In the following, we will therefore look into the respective countries' CCS policies and assess whether these policies together facilitate for a joint Nordic CCS solution.

4.1 Norway

Norway has been regarded as a frontrunner internationally on CCS (van Alphen 2011) and the political climate for CCS has been favorable (Stigson et al 2012), not least due to the possibility of maintaining petroleum production and high climate ambitions at the same time. The political signals and regulatory environment combined with relevant expertise and project opportunities in the oil and gas industry resulted in Statoil's CCS project at Sleipner and later at Snøhvit (Tjernshaugen and Langhelle 2009). However, despite having a CCS friendly policy environment, one of the cornerstones of the Norwegian CCS policy in recent times – the plans for a full scale CCS project at Mongstad – were abandoned in 2013, mainly due to high costs.[3]

Norwegian policymakers have agreed on the importance of realizing CCS both in Norway and internationally, as expressed in several policy documents, not least the Agreement on Norway's climate policy from 2008 (Norwegian Parliament 2008), which was later followed up in 2012 (Norwegian Ministry of the Environment 2012). The importance of both international and national efforts to reduce greenhouse gas emissions has been important for the Norwegian CCS strategy (Climate Agreement 2008, 2012, White Paper 9 2010-2011).

Most parties in the Parliament have favored CCS (Ministry of Petroleum and Energy 2014). The only party not embracing CCS is the Environmental Green Party, as it does not see CCS as a part of a lasting solution to the climate crisis and thinks society's resources mainly should be used to establish the infrastructure for production and deployment of renewable energy. However, the party acknowledges that CCS can be useful in a transition period and supports continued commitment to the test centre at Mongstad (TCM), as it can contribute to technology development for use in other parts of the world. Gas fired power plants in Norway are however seen as unnecessary. CCS applied to industrial process emissions in Norway are not mentioned (Stortinget 2013).

The political commitment is also highlighted by the informants and the political signals are perceived to have been consistent (informants 6,7). Although some respondents points to CCS possibly being negatively influenced by the focus on high costs associated with the Mongstad project (informant 2), the general view is that that CCS still has legitimacy among stakeholders and the public and that CCS will continue to be a government priority (informants 2,7). Moreover, when compared with public opposition towards onshore storage in Europe, the possibilities of storing CO2 offshore is seen as an important factor for acceptance for CCS among stakeholders and the general public (informants 1,2).

In late 2014, a new CCS strategy (Ministry of Petroleum and Energy 2014) was proposed by the Government. The government states that a comprehensive commitment to CCS is necessary to reduce greenhouse gas emissions and that technology development and cost reductions are necessary to realize CCS**.** The new CCS strategy also states that the Government aims to realize at least one full-scale demonstration facility by 2020. It is not

[3] The center-left Government decided, right before it resigned in September 2013, to end the plan for the full-scale capture plant at Mongstad. However, the existing test center at Mongstad (TCM) was decided to continue

specified if this will done in Norway or abroad. Some have claimed that the measures in the strategy is not enough to achieve a full scale project in Norway which would be an important contribution to achieve national emission targets (ENDS 2015, Teknisk ukeblad 2014). [4]

With regard to framework conditions, the Norwegian state – through the Ministry of Petroleum and Energy and the state enterprise Gassnova – have been found to have contributed with unusually generous funding for research, development and demonstration (Tjernshaugen and Langhelle 2009, p. 99). The CO2 tax, introduced in the early 1990s, has been instrumental in leading to the establishment of CCS projects at Sleipner and Snøhvit. Yara's CCU-project[5], on the other hand, has been realized without any political measures (informant 6).

Other than this, however, the framework conditions employed in the Norwegian CCS context have not led to the wanted commercialization of CCS. Both NORCEM and Yara has a positive interest in CCS and see CCS as a possibility to be environmentally responsible. However, the importance of state funding is seen as essential for CCS realization. Moreover, the importance of the carbon price including ETS in the EU and not least countries beyond Europe is highlighted, as their business otherwise could be at risk and overall emissions possibly increase, unless competitors are subject to the same rules (informant 6,7). Moreover, it is underlined that the government must take responsibility for transport and storage solutions (informant 7). A government facilitated but industry-led value chain study, looking at capture, transport (including both pipelines and ship), a hub for intermediate storage and storage (including reuse of CO2 for enhanced oil recovery and other industrial purposes) is also requested (informant 7).

Another driver for their interest in CO2 capture is the interest in exploring other sales opportunities for CO2. However, neither Yara or Norcem have had any contact with potential buyers and point to the importance of clarifying whether the CO2 can be used for different purposes (informant 6,7). Moreover, it is underlined that there must be actors that have interest in buying the CO2 (informant 7) and cover all costs associated with the capture, liquefaction, storage and transportation (informant 6).

In sum, the Norwegian CCS policy is quite well developed, although the future for realization of full scale CCS projects located in Norway now is uncertain. With regard to a joint CCS realization in Skagerrak, there are currently no concrete policy signals. From the interviews it became clear that Norwegian authorities are not engaging in any concrete discussions about a Skagerrak cluster, although it is underlined that all initiatives that could reduce costs – such as a Skagerrak cluster - could be interesting (informant 1,3).

[4] The interviews were conducted in the spring/summer of 2014. Hence, the new CCS strategy was not covered in the questions to the informants

[5] Yara capture around 200.000 tons of CO2 from Yara's ammonia production and transports it to Europe for use in beverages

4.2 Sweden

The general debate around CCS in Sweden is best described as having been almost non-existent. However, the technology has been debated, for example in relation to the Swedish state-owned power utility Vattenfall engagement with CCS technology development in Germany. The situation has changed somewhat the last couple of years, where the CO2 emission intensive industries, such as the steel company SSAB and cement producer Cementa, have sought to push CCS onto the political and public agenda.[6]

The presence of CCS is likewise low on the national policy agenda. However, in an 2012 report (Swedish Environmental Protection Agency 2012) which serves a basis for a roadmap for Sweden to become carbon neutral in 2050, CCS is given quite a lot of attention. It is argued that the vision of net zero emissions through domestic action, is only possible to reach if CCS is applied. When assessing the potential within different sectors, it is said that large emission reductions within the basic industry, such as the steel, cement and chemical industries, is dependent on new technology and CCS. Especially within the iron- and steel sector, breakthrough and rapid deployment of CCS is argued important. In addition, bioCCS is mentioned as a possible application. In December 2012, a summary of the detailed appendices to the first interim report confirmed this picture: seriously reducing industry emissions requires new technologies such as CCS. In the Swedish scenarios for industry, however, a very late introduction, in 2040, of new technologies such as CCS is assumed. BioCCS is also assumed to be realized in a far future.

This picture is confirmed by the Swedish informants (10-16) who described that they do not experience any societal debate about CCS. Some experienced a growing debate a few years ago, in relation to the development of the EU CCS Directive, however, the attention to CCS has decreased in recent years. The low level of debate about CCS is seen as unfortunate (informants 18,19) and a need to increase the dialogue about CCS, and hence awareness thereof, is requested (informant 19). The low level of debate is seen partly a result of CCS not being clearly positioned on anyone's agenda, resulting in a weak push for the technology. A possible increase in the interest for CCS is related to the technology being applied to biogenic emissions (informants 12,13).

Likewise, political decisions on CCS are seen as few and indecisive (informants 15,19). Policy instruments to support CCS developments are seen as lacking and short-sighted, to the extent they exist (respondent 19). Increased R&D to reduce technology costs, potentially a certificates system for CO2 reductions through CCS, and cost and risk sharing in terms of logistics and infrastructure are suggested as important policy initiatives (informant 19). A policy aspect that was brought up (informant 11), was that the EU ETS does not provide incentives for CCS applied to biogenic emissions (i.e. bio-CCS), which is of relevance given that the total amount of biogenic CO2 emissions from large stationary point sources (i.e. with emissions > 100,000 tonnes) in Sweden is larger than the total amount of fossil CO2 emissions from large stationary point sources (informant 12).

[6] For example, through sessions during Almedalen, being the largest political arena in Sweden which is open to the public. For more info, see http://www.almedalsveckan.info/13069

Finally, with regard to a joint Skagerrak-cluster, clusters are seen as preferable to benefit from scales (informants 11,15). However, there does currently not exist any concrete policy signals in policy documents and there has been no concrete discussion between the Swedish authorities and their Danish and Norwegian counterparts about his subject.

4.3 Denmark

There are currently no CCS projects implemented in Denmark, despite some attempts by companies such as Vattenfall and Maersk. In 2011, the Danish government stopped the CCS project at Nordjyllandsværket as a consequence of lack of knowledge about onshore CO2 storage and local concerns concerning onshore storage (Ministry of Climate, Energy and Building 2011, Stigson 2012). Maersk have also considered the possibilities for enhanced oil recovery (EOR) on the Danish continental shelf (DEA) and are currently considering this option (Maersk Oil 2015).

Today, CCS is generally not a political priority, as can be seen in key government documents. In Denmark's 'Energy strategy 2050' (Danish Government 2011) the main focus is measures to become independent from coal, oil and gas by 2050. The government, however, do not exclude "some use of coal with CCS, if this turns out to be an efficient, feasible and environmentally appropriate solution in a green transition. BioCCS is also mentioned as possibly relevant. Hence, Denmark's energy strategy does acknowledge CCS as an option but in a cautious way. In the Energy and Policy Report 2012 (Danish Government 2012), a report from the Ministry of Climate, Energy and Building to the Danish Parliament, both short-term (2020) and long-term (2050) goals are discussed but the ministry does not mention any role for CCS. Other signs that CCS is not a prioritized issue in Danish climate and energy policy, is that CCS was absent in the Danish climate policy plan from 2013 (Danish Government 2013a). It was also not part of the government's growth plan for energy and climate (Danish government 2013b) which were launched in late 2013.

Hence, CCS is not a particularly visible in key political documents. The amend bill written by the Energy Committee in the Danish Parliament in conjunction with the implementation of the CCS Directive into Danish law sheds some light on the Danish political parties view on CCS. Here, it stated that the government wants to await experiences from other planned CCS projects in Europe before discussing CO2 storage and then a principal decision will have to be made as a result of a discussion in the Parliament. Decisions regarding concrete proposals for call for applications and issuance of licenses to use the underground for storage of CO2 will be handled by Energy Policy Committee. This approach also applies to enhanced oil recovery (EOR). However, it is stated that the government would work to ensure that injection and storage of CO2 will be realized at oil fields in the North Sea, provided that this could be done in a safe and environmentally sound manner. An important reason is that this could increase state revenue (Folketinget 2010-2011).

Moreover, the amend bill contains several parties views on CCS in general important for explaining the political attitude towards CCS. CCS is viewed by the parties Socialdemokratiet,

SF og Radikale Venstre as an expensive and unnecessary technology to reduce Danish GHG emissions. Moreover, it is considered an unclear signal to the world and to energy companies if the government supports CCS from fossil fuels and that energy efficiency and renewable energy should the political priorities. Hence, the parties are clearly negative to CCS based on CO2 from fossil fuels. EOR is however, viewed positively, as long as it can be realized on a commercial basis. Also, the three parties do not dismiss the possibility of CCS from biomass or biogas based energy in the future. Hence, the Danish general political reluctance towards CCS, except for EOR, is here quite clearly expressed although one party, Dansk Folkeparti, stated that the CO2 used for EOR could be attained from Danish combined heat and power plants. Further illustrating the Danish interest in EOR is the study initiated by the Danish Energy Agency, which assessed the socio-economic sustainability of a CCS/EOR system based on CO2 capture from Danish sources (including Nordjyllandsværket) and injected into selected Danish North Sea oil fields (Rambøll 2012).

The "wait and see"- approach is also describing the government's position on CCS today. CCS is today generally not a widely debated topic and is not a political priority in Denmark (informant 8). Generally, the debate about CCS in Denmark is seen as being negative towards the technology (informant 9) and the impression from the industry is that that politicians do not want CCS, for example as part of the national energy plan (informant 9). CCS is generally perceived as costly and other policy measures such as renewable energy production and energy efficiency measures are more favored measures to reduce greenhouse gas emissions (informant 8). Moreover, a strongly contributing factor to a negative attitude towards CCS is the protests towards Vattenfall’s plans for a demonstration project at Nordjyllandsværket (informant 8,9).

As a reflection of the political situation, incentives and regulations are geared towards production of renewable energy and energy efficiency and there are no specific incentives or regulations that have or are seen to have immediate effect on CCS realisation in Denmark (informant 8). The government supported the efforts of Maersk to use CO2 for EOR in the Danish part of the North Sea in the Dutch ROAD project, however, there was no financial support involved (informant 8). Moreover, since 2010 there has been decreasing research activity and reduced funding to CCS.

Similar to the Swedish and Norwegian situation with regard to a joint Skagerrak-cluster, there are currently no concrete policy signals that can be identified from the policy documents or from the interviews. In the past, the DEA attended the Carbon Sequestration Leadership Forum, but has now withdrawn due to the lack of mandate to pursue CCS. Hence, discussions with Norwegian and Swedish authorities have also become irrelevant (informant 8). Despite this, the possibility of using Norwegian and Swedish CO2 for EOR on the Danish continental shelf (either independent of, or in conjunction with Danish CO2) is not dismissed, if this can be done on a commercial basis (informant 8).

5 Local CCS policies

As mentioned earlier, local acceptance of CCS projects can be a major barrier for CCS implementation and it is therefore important to shed light on local actors' perception of CCS. Municipalities are important actors in this regard, both individually as potentially influencing implementation of a CCS project, as well as a manager and mediator of the multitude of interests related to a given CCS project in the local community. The importance of the municipality's position towards a project has been demonstrated before, in Barendrecht in the Netherlands the municipality opposed the project due to fears of, among other things, negative effects on public health and risk of decrease in real estate values (Brunsting et al 2011). Therefore, it will be important to gain insight into the municipalities' awareness about CCS, experiences with the technology, perceptions about risks and benefits and how the municipality would look at a potential CCS project in its own "backyard".

5.1 Norway

Norcem and Yara are located in Porsgrunn municipality in the county of Telemark. Porsgrunn is located near the coast in Southeastern Norway and has approximately 30.000 inhabitants. Porsgrunn has a long history of industrial activities and the industry constitute the backbone of the community with the processing industry being the biggest industry.

Porsgrunn municipality has no formal role with regard to CCS but facilitates to the extent possible for CCS activities. This is done through communication with a variety of actors, such as the industry, research institutions and national authorities. A particular concern for the municipality is to communicate with the local public to make sure that concerns are addressed.

In general, Porsgrunn municipality view CCS very favorably and has trouble identifying any clear downsides. CCS is instead seen as a way of promoting and profiling the local community and the region as an environmental leader. As a large share of the inhabitants work in the industry, CCS is seen as important to maintain the industry in the region, to maintain jobs and to prevent depopulation. The additional jobs related to the CCS activities are also seen positively. Developing new industrial activity as a spinoff of the CCS activity is also seen as a potential benefit. In this context, further research and development of reuse of CO2 for industrial use is seen as an interesting option.

Moreover, the impression is that the area is seen as well suited for CCS activities as the inhabitants are used to the industry and due to compatibility with the industrial infrastructure. No major protests have been identified, neither from the Norcem demo project, nor Yara’s extensive experience with the technology, and the impression is rather that the local public is positive towards the two companies' proactive approach for handling CO2 emissions. Specifically with regard to transport, the inhabitants are generally used to ship transport of products considered more dangerous than CO2 (ammonia, gas) and there has not been any big protests against the shipping of CO2 by Yara (informant 5). This picture is confirmed by Yara, even to the extent that CO2 transport by trucks is seen as profiling the company in a positive way (informant 6). Storage of CO2 hasn't been discussed much, but

this is predicted to be relatively unproblematic, as the storage either would take place offshore or in reuse processes (informant 5).

In sum, Porsgrunn municipality display very positive attitudes towards existing and potential CCS activities. CCS activities are seen as compatible with the history of the community and fits well with the current identity and plans for community development. Hence, rather than a technology with negative consequences, CCS is seen as an opportunity for the local community.

5.2 Sweden

Positioned on the west coast of Sweden, the municipalities Stenungsund and Lysekil maintain a tradition of strong industrialization, where the industries are important employers for the approx. 24.000 inhabitants in the region.

The municipalities of Lysekil and Stenungsund do not have a formal role with regard to CCS and the municipalities do not work very actively with this issue at the moment. The national agenda is not seen as providing any signals about CCS and the view is that CCS in general should be treated as a national issue (informant 17). The current dialogue with large local industrial emitters is described as well-functioning, but CCS is not a topic that is being discussed at the moment (16,17). Discussions with industries are more related to job opportunities and other environmental concerns (informant 16). Similarly, the informants expressed that CCS has not been discussed locally in general, neither with industrial stakeholders, the public nor in the local media. The officials themselves also stated that their knowledge about CCS was limited (informant 16,17) and that the municipality likely would have a small role in relation to a potential CCS project (informant 17). Nevertheless, informant 17 mentioned the municipalitys' responsibility to contribute to a dialogue about CCS, which could possible increase R&D efforts.

5.3 Denmark

Portland Aalborg and Nordjyllandsværket are located within Aalborg municipality. The Aalborg area is situated in the North East of Denmark in the North Jutland region. It is Denmarks third largest city with around 130.000 inhabitants and is North Jutlands major industrial and commercial centre.

The area has in the past, experienced controversies related to a planned CCS project. In 2008, Vattenfall planned to build a CO2 capture facility and store the CO2 in a nearby geological formation in Vested, just outside the Aalborg area. When Vattenfall in 2009 was to conduct the seismic investigations, however, local estate owners denied Vattenfall access to their land. The local inhabitants saw the project as risky and unknown and that there were uncertainties related to health, the environment and farming as well as the potential negative effect on the value of property (Stigson 2012). Vattenfalls application was eventually rejected by the Ministry of Climate, Energy and Building in 2011. The Government

stated it wanted to await international experiences with the use of CCS technology before it would decide on whether storage of CO2 onshore could be permitted (Ministry of Climate, Energy and Building 2011).

Currently, no one in Aalborg municipality works with CCS and could answer questions about the municipalitys' view on the technology. How the municipality would look at a new CCS project therefore remains to be seen.

5. Discussion – implications for an integrated Skagerrak-solution

Currently, there is no specific CCS policy in place tailored for a development towards a common Skagerrak CCS cluster. Neither key Swedish, Danish and Norwegian policy documents, nor the results from the interviews, identified any significant cooperation between Sweden, Denmark and Norway regarding joint CCS development in Skagerrak or comparable regions/clusters in the three countries.

The lack of transnational cooperation may be understood in light of the respective countries national CCS policies. Traditionally, Norway has been most proactive of the Nordic countries and has been regarded as a frontrunner on CCS (van Alphen 2011). In Norway, CCS is a visible ingredient in the Norwegian key policy documents and several incentives and regulations to stimulate CCS development have been implemented and are present today. In Sweden and Denmark, CCS policies have mainly consisted of transposing the CCS directive into Swedish and Danish law and have been less oriented towards developing capture and transport policies.

These general trends were also evident in the interviews. The Swedish respondents overall identify a lack of attention and debate around CCS and sees this as unfortunate and reducing interest among industries that could potentially apply the technology. The political acceptance for CCS in Denmark is seen as virtually non-existent and CCS is not a political priority or a widely debated topic. The public opposition towards Vattenfall's CCS project, the perception of CCS as a costly technology and the focus on climate policy measures to develop renewable energy and increase energy efficiency measures are reasons why CCS currently not is a political priority. In contrast, political acceptance for CCS is perceived to still be present in Norway. Although some informants point to CCS possibly being negatively influenced by the focus on high costs associated with the Mongstad project, the general view is that that CCS still has legitimacy among stakeholders and the public and that CCS will continue to be a government priority. Moreover, the low level of controversy associated with offshore storage at Sleipner and Snøhvit is seen as an important factor for acceptance of previous and future CCS development in Norway and the Nordic region.

Moreover, with regard to framework conditions, a substantial increase in the ETS price is seen as necessary to invest in CCS and to speed up CCS development. Moreover, governmental support for all parts of the chain was seen as vital. There are also regulatory challenges that specifically concern a Skagerrak cluster that must be resolved, as export of captured CO2 from Sweden and Denmark to Norway for offshore storage remains prohibited

under the London protocol and captured CO2 to be transported by ship as a part of a CCS operation is currently not allowed under the EU ETS (Tel-Tek 2012). Although underlining that such regulatory barriers must be resolved in time for actual CCS deployment, these issues were not seen as insurmountable (informant 1,2,3).

Hence, although the prospects for CCS in the Skagerrak region have been highlighted favorable due to Nordic governments' ambitious long-term emission reduction targets (Tel-Tek 2012, p. 97), the challenges identified above suggest that establishing a CCS cluster in the Skagerrak region could be challenging. However, there are some factors identified in this study that may function as potential drivers.

Norcem's demo project has received substantial governmental funding and stands out as perhaps as the most concrete and realistic CCS project today. Norcem has taken a proactive stance on CCS and is interested in solutions – including transnational solutions - where actors within capture, transport, hub and storage/reuse options are involved and cooperates. Thus, as the key emission source in a potential Skagerrak-cluster, Norcem work on CCS could kick-start an integrated cluster solution. A full scale project will, although the costs are uncertain, likely be considerably cheaper than at Mongstad and thus may be more in line with the recent political signals, not least the new CCS strategy launched in late 2014, where bringing down costs are necessary to realize CCS (Ministry of Petroleum and Energy 2014). However, a Norcem full scale plant will obviously be dependent on how the Norwegian CCS policy further develops. With an increased Norwegian CCS focus on international efforts and technology R&D development in recent years (Roettereng 2014), and the recent CCS strategy in mind, some have expressed concerns about whether the Norwegian government now is more interested in supporting CCS projects abroad rather than Norwegian projects.

Moreover, although CCS currently in general is a non-issue in Demark as renewable energy and energy efficiency are favored climate measures, the government has expressed a clear interest in enhanced oil recovery (EOR). As a challenge for profitability is large enough volumes of CO2, CO2 from emission sources in Norway, Sweden and Denmark could potentially help alleviate this challenge. The possibility of finding ways to use CO2 – both for EOR and other commercial purposes – have also been highlighted by several companies as something that could spur interest in CCS (6,7,9,19).

Furthermore, at the community level, the already existing industrial activities in the three countries potential localities (see figure 1) could be an advantage for a Skagerrak-cluster as previous research has found that a history of industrial activities in the local community have predisposed local acceptance (Hammond and Shackley 2010). This can be seen quite clearly in Porsgrunn, where CCS activities are seen as compatible with the history of the community, local identity and future plans. The region is highly industrialized and the local inhabitants are therefore used to industrial activities. Moreover, the local inhabitants have experience from Yara’s carbon capture and transport activities and Norcem’s demo plant and the municipality has not experienced any major public protests from these activities. Moreover,

development of industry based on reuse of CO2 is seen as an interesting option for local authorities as it fits well with a desire to create local business development and to the possibility to stand out as an innovative and high tech region (informants 5). The EU has also suggested that CO2 utilization paths could help addressing public acceptance issues of CCS due to possibilities for CO2 to be viewed as a valuable resource (European Union 2013, see also Hammond and Shackley 2010) and anecdotal evidence has also shows that this has been the case in local communities in Europe (Oltra et al. 2010).

Porsgrunn's support for CCS should also be seen in relation to the possibility for offshore storage of CO2. Storage of CO2 has been the most contentious part of the CCS infrastructure, and onshore storage has been clearly more contentious than offshore (Hammond and Shackley 2010). This can also be seen in the Nordic region, where the Sleipner and Snøhvit projects did not experience much controversy. The possibilities for offshore storage have also been highlighted as a clear advantage by some of the informants and in the Porsgrunn-case, storage of CO2 hasn't been high on the agenda and is predicted to be relatively unproblematic, as the storage either would take place offshore or for CO2 reuse. On the other hand, the North Jutland area in Denmark experienced public opposition towards onshore storage in 2008. Hence, the possibilities for offshore storage could be a factor that contributes to a low conflict level in the Nordic region.[7] Finally, it is also important to note that support for CCS in local communities – such as in Porsgrunn - is something that Norwegian authorities (informant 2) express is an important factor that is emphasized when policies are created.

There is, however, no guarantee that projects will be accepted in the Skagerrak-region, although offshore storage and/or reuse of CO2 could be an advantage, and the emission sources in all three countries are located in areas with existing industry. Other factors, such as onshore pipelines, could potentially result in public resistance. Close dialogue with the local community about all parts of the infrastructure will be important, both to ensure a process that is perceived as fair, but also to retrieve information about specific local conditions.

Finally, an important finding is that several industrial companies were positive towards CCS as a technology. All companies have had, on some level, activities in CCS and several also had suggestions for how national framework conditions could be improved – such as increased R&D, cost and risk sharing in terms of logistics and infrastructure and a certificate system - to facilitate for CCS deployment. Hence, on this background, and also acknowledging that several of the informants pointed to the potential benefits from cluster solutions such as in Skagerrak, there should be a basis for national policymakers discuss the opportunities of a joint Skagerrak CCS-cluster. This should include relevant authorities in all three countries and

[7] It is, however, important to note that although offshore storage seems preferred to onshore storage, and the low conflict level experienced at Sleipner could be a result of its offshore location, there is currently little empirical evidence to back this up (Hammond and Shackley 2010) and there is no guarantee that conflicts not will arise offshore (Mabon et al. 2013)

where policies pertaining to all parts of the infrastructure – capture, transport, potential hub solutions and storage/reuse are discussed.

6. Further research

The present study has attempted to understand the current political feasibility of a joint carbon capture, transport and storage solution in the Skagerrak region. To better understand this case, further contributions are needed.

One contribution would be to study national policymakers views before and after discussing a concrete case, such as Skagerrak (or other clusters that entail transnational cooperation). The identified barriers and possible drivers in this study could provide a starting point for the discussions. Such a study could among other things capture how Swedish policymakers would look at the possibilities of providing Danish or Norwegian oil fields with Swedish CO2 to be used for enhanced oil recovery (EOR) and how costs and risks in terms of logistics and infrastructure could be shared.

Moreover, as this study included industry from the capture part of the infrastructure, the views and interest of potential transport companies (e.g. shipping companies), hub operators, storage operators and potential users of CO2 (e.g. oil companies, the polymer industry, the food industry) in the Skagerrak region could shed further light on the possibilities for a joint CCS cluster. Of particular importance would be how the different companies envisage how the national authorities could facilitate transnational solutions.

Finally, as the views of local inhabitants, local organizations etc. may be different than the views of municipalities, a study of different local actors' perceptions of CCS would complement the findings in this study. This would be relevant both with regard to communities where CCS projects are considered, but also with regard to existing projects, such as in Porsgrunn. Such a study could, in addition to provide knowledge about general risks and benefits from being affected by a CCS project, also shed light on how the local actors view on how they would like to be engaged in CCS-related matters or how they perceive previous or existing CCS engagement (i.e. Porsgrunn). Moreover, this could provide knowledge about whether the local community's view on CCS would be affected by new technology developments – e.g. if the CO2 originates from biomass or if the CO2 is reused for commercial purposes and is included in local business development.

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