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Local acceptance and communication as crucial elements for realizing CCS in the Nordic region

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Abstract

The purpose of this paper was to assess the Nordic situation with regard to carbon capture and storage (CCS) deployment at the local level. This was done by identifying important factors found in the literature on community acceptance and communication and relating this to possible CCS deployment in the Skagerrak region. The analysis was complemented with findings from interviews made with municipalities in the three countries (Denmark, Sweden and Norway). The results show that the possibilities to store CO2 offshore may be a clear advantage for the Nordic region and that Porsgrunn municipality in Norway display very positive attitudes towards existing and potential CCS activities, which stands in contrast to the many public acceptance challenges experienced in Europe. Moreover, the municipalities display very different awareness about CCS, which is seen in relation to CCS experiences and national policies.

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Keywords: Local acceptance; communication; Nordic region; Skagerrak

1. Introduction

To date, European Carbon, Capture and Storage (CCS) projects have not been realized to the extent envisioned. Low public awareness and acceptance have been identified as one of the most important barriers for CCS deployment [1,2]. The increased focus on public acceptance can be dated to around the mid-late 2000s [1,3], when a number of planned small- to large-scale CCS projects began to encounter opposition from local communities in several European countries and were either cancelled, or went ahead in a reduced or restructured form [4].

For the Nordic situation, the status of CCS implementation and experiences with the technology varies between the different countries. Norway currently has two large scale projects at Sleipner and Snøhvit, whereas no large scale CCS project has been realized in the other countries. However, all Nordic countries have formulated targets for CCS deployment in their climate policy agendas, although with quite different emphasis and detail [5].

Moreover, in recent years there has emerged an increased focus on joint collaboration between the Nordic countries to create synergies with regard to CCS implementation. The NORDICCS research project has identified several possible advantages.

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Among these are 1) the benefit from significant economies of scale due to developing large-scale projects utilising joint CO2 hubs and storage sites 2) the potential to store CO2 from both the Nordic region and other European countries due to the large storage capacity off the coasts of Norway and Denmark and 3) accelerating the development of carbon negative solutions (bioCCS) [6].

Still, to benefit from possible advantages and synergies, achieving public acceptance for the CCS projects will be needed. As there are only a few projects that have been realized or planned in the Nordic region, there are few experiences and research to draw lessons from. This stands in contrast to research on European experiences of CCS projects. Here, research have increased markedly in recent years and is, together with publications regarding economic evaluations, the most covered social science topics on CCS [7].

In this paper, we will explore the local dimension of CCS realization in the Nordic region by drawing on literature on public acceptance and communication and relate this literature to the Nordic context. Moreover, we will also shed light on the Nordic CCS situation by referring to findings from interviews with municipalities in one of the cases studied in the NORDICCS project – the Skagerrak cluster[*]- to gain further insight into public acceptance challenges and opportunities specific for the Nordic situation. Hence, the paper will;

- identify important factors found in the literature on community acceptance and communication relevant for the Nordic situation
- identify important factors for local community acceptance based on interviews made with representatives from municipalities in the Skagerrak cluster
- on this basis assess acceptance and communication challenges and opportunities for CCS implementation in the Nordic region

It is important to note that municipalities may have other interests and perceptions towards CCS than the local lay citizen, local interest groups or other local stakeholders. This study must therefore be seen as a modest attempt to gain insight into possible challenges and opportunities for CCS realization in the local communities and should be complemented by more research taking into account other perceptions and communication needs among other relevant stakeholders. However, the importance of the municipality's position towards CCS projects has been demonstrated before. In Barendrecht in the Netherlands, the municipal government opposed a proposed CCS project due to fears of negative effects on public health and risk of decrease in real estate values [8]. Local people supported by local politicians have also been found to be the most commited agents of opposition to projects [4], which illustrates the important role for municipalities. Therefore, it will be important to gain insight into 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".

The study is based on work conducted in the work package on communication in the NORDICCS research project. NORDICCS is a virtual CCS networking platform aiming for increased CCS deployment in the five Nordic countries.[†] The literature review is based on a report about public perceptions of CCS in the Nordic countries and the interviews was conducted with officials in municipalities in Sweden, Denmark and Norway in 2014 and is a part of a study on the political feasibility of a CCS-cluster in the Skagerrak region (see also section 3).

2. Theoretical and empirical insights from acceptance and communication studies on CCS

Societal acceptance is an important factor for implementation of energy technologies and in the last decades, research has investigated this issue with regard to a variety of energy technologies – eg. wind, nuclear, hydropower, electricity grids and CCS. Social acceptance of energy technologies should, according to Wolsink [6], be seen as multi-layered, consisting of three dimensions; *socio-political acceptance* (acceptance among regulators, policy actors, key stakeholders and the public) *market acceptance* (acceptance among consumers, producers, distributors, intra-firm, financial actors) and *community acceptance* (acceptance among end-users, residents, local authorities). Deployment of energy technologies is a result of acceptance among these actors and there is also an interdependent relationship between these layers and the accompanying actors.

According to Markusson et al. [7], social science on CCS has focused on two main areas – publications regarding economic evaluations and publications on public understanding and acceptance of CCS. Although social science studies of CCS have been found to be relatively few within the CCS domain as a whole [10], an increased focus on public acceptance has emerged in recent years.

Nowadays, public acceptance is commonly recognized as an important factor influencing the realization of CCS [1,2]. A driving force behind the evolving research field is that public acceptance and awareness frequently is perceived as one of the key barriers to deployment by various CCS stakeholders such as the industry, government and NGOs [1,10]. Scholars have therefore pointed to the need for proactive communication to raise public awareness, as knowledge is a prerequisite for making informed

[*] The Skagerrak cluster includes municipalities in three countries, Porsgrunn (Norway), Aalborg (Denmark) and Lysekil and Stenungsund (Sweden). See more info in section 3

[†] For more info, see http://www.sintef.no/projectweb/nordiccs/

decisions about individual projects [4], whereas it has also been argued that increased awareness would ultimately ease implementation of projects [11].

The focus on acceptance in the research literature should be seen in relation to other rationales for communication. Glucker et al. [12] distinguishes between three main categories of rationales for public participation; 1) Normative rationale (influencing decisions, enhancing democratic capacity, social learning, empowering and emancipating marginalised individuals and groups 2) substantive rationale (harnessing local information and knowledge, incorporating experimental and value-based knowledge, testing the robustness of information from other sources 3) instrumental rationale (generating legitimacy, resolving conflict, reflection). Hence, there are a variety of rationales for communicative efforts. It is important to note that recognition of different rationales for communication with the public is important as tensions and difficulties may arise if rationales are left implicit [13].

Nevertheless, public awareness has been found to be relatively low [14,15] and provision of information on CCS can lead to both increased [16] and decreased [17] level of support. There is a tendency towards treating opinions detected in surveys with caution, as there is a general agreement amongst experts that these opinions are a poor proxy for attitudes when faced with a concrete project [4]. This echoes findings from the siting of renewable energy, where opposition by local communities frequently has emerged despite general public support for renewable energy [18,19].

Moreover, Brunsting et al. [21], found that research with the aim of examining how communication actions have affected perceptions of CCS among the local and general public, not have led to consistent results and the relationships sometimes appear to be contradictory. This is found to be partly due to the wide range of contexts influencing the outcomes of communication processes and due to a large share of research not being primarily concerned with effects of specific features of communication. Furthermore, they found that high quality communication is no guarantee for realization of projects. Brunsting et al. [22] found that the quality of communication can influence the outcome, but that there does not exist a simple causal relationship between the two factors.

Furthermore, a lot of the conducted research on CCS acceptance has been focusing on the local community acceptance towards CCS. Shackley et al. [23] have found that communication efforts towards European stakeholders, including policymakers, have been weak and inadequate and that there has been little evidence of anything approaching real engagement with stakeholders. This is interesting, as scholars have pointed the importance of socio-political and market acceptance to implement new technology [9]. With regard to renewable energy, for example, the largest barrier was found to be present in the lack of socio-political acceptance and the idea that the main barriers to renewable innovation are found on the community level in local resistance has been claimed to be a myth reproduced over and over again [9].

Still, the community dimension is obviously of crucial relevance for CCS to be implemented. As mentioned earlier, protests stemming from the community dimension have stopped several CCS projects. Some important prerequisites for community acceptance are factors related to how the local community perceives the implementation of the technology with regard to distributional justice and fairness of process [9, 19]. 'Distributive justice' concerns fairness in distribution of costs and benefits (see for example [24]), whereas 'procedural justice' refers to general principles of citizen control, democracy and fairness in the process within which decisions are reached [25].

Although, as mentioned above, an important insight from previous studies has been that there is no "magic bullet" with regard to CCS communication, and it can be difficult to scientifically deduct reasons why people oppose and block projects [4, 20], different studies have identified several similarities across cases that have contributed to acceptance or opposition towards projects [4,20,22] which may be useful for CCS developers and authorities in guiding their communication efforts. In the following, therefore, we will render some of the main insights from previous studies and assess their relevance for the Nordic CCS situation. Although acknowledging that fairness of process can be crucial for acceptance [26], we will in this study mainly focus on factors related to the distributive justice dimension. The reason for this is that local risks and benefits are important factors for project acceptance [27] and that the Nordic region has some important geographical and spatial characterstics that is important to relate to another factor that has been found important for CCS acceptance - the material characteristics of the technology (e.g size distance to population, harmony with the environment) [20].

3. Background: The Nordic CCS situation

The status of CCS implementation and CCS policies differs widely between the Nordic countries. Although the plans for a full-scale operation in Mongstad[‡] stranded in 2014, Norway has been regarded as frontrunner internationally on CCS [28] and in the past implemented two large scale off-shore projects at Sleipner and Snøhvit. Also, Yara captures around 200.000 tons of CO2 yearly from their ammonia production and transports it to Europe where they sell it for use in soft drinks and beer. This has been a commercial business case for over 30 years. In addition to this, the test center at Mongstad is still in operation and Norcem is currently testing capture technologies at their sement plant in Brevik.

For the other two countries in the Skagerrak-cluster, Sweden and Denmark, no large scale CCS project has been realized, although Vattenfall some years ago planned to build a CO2 capture facility and store the CO2 in a nearby geological formation in

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

Vedsted, just outside the Aalborg area. This project, however, experienced public opposition towards the onshore storage solution and eventually failed [29].

Moreover, all Nordic countries include targets for CCS deployment in their climate policy agendas, although with quite different emphasis and detail. Policies for CCS have been an important part of Norways' climate policies for several years and are well documented in several policy documents. On the contrary, CCS is rarely included in key national climate, energy and environmental policy documents in Sweden and Denmark, and where mentioned, it is typically not given a high priority [5].

3.1 The Skagerrak CCS cluster

There is no specific CCS policy in place tailored for a development towards common Nordic CCS solutions, including a Skagerrak CCS cluster. Neither does there exist any significant political cooperation regarding joint CCS development in Skagerrak or comparable clusters [30]. Nevertheless, the NORDICCS research project has identified several possible advantages with joint CCS solutions between the Nordic countries. Among these are 1) the benefit from significant economies of scale due to developing large-scale projects utilising joint CO2 hubs and storage sites 2) the potential to store CO2 from both the Nordic region and other European countries due to the large storage capacity off the coasts of Norway and Denmark and 3) accelerating the development of carbon negative solutions (bioCCS) [6].

In this work, six CCS case clusters specific to the Nordic region have been identified and studied in more detail in terms of technical and economic aspects. One of these clusters are the so-called Skagerrak-cluster (see figure 1). Emission sources are located onshore in South East Norway (Porsgrunn municipality), South West Sweden (Stenungsund and Lysekil municipalities) and North Denmark (Aalborg municipality). The Gassum formation, located just off the coast of northern Denmark is one possible offshore storage site. Assessment of storage in the Utsira formation in the Norwegian part of the North Sea is also included. CO2 transportation using both ship and pipeline was studied [6].

The Skagerrak cluster has some important geographical features that are similar, and therefore of relevance to other proposed clusters; storage is offshore and emission sources are located relatively close to the sea. Ship transport and pipelines are also assessed as transport solutions in other clusters. Hence, the relevance of looking more closely at the Skagerrak cluster may provide valuable input for assessing acceptance and communication challenges for other clusters in the Nordic region.

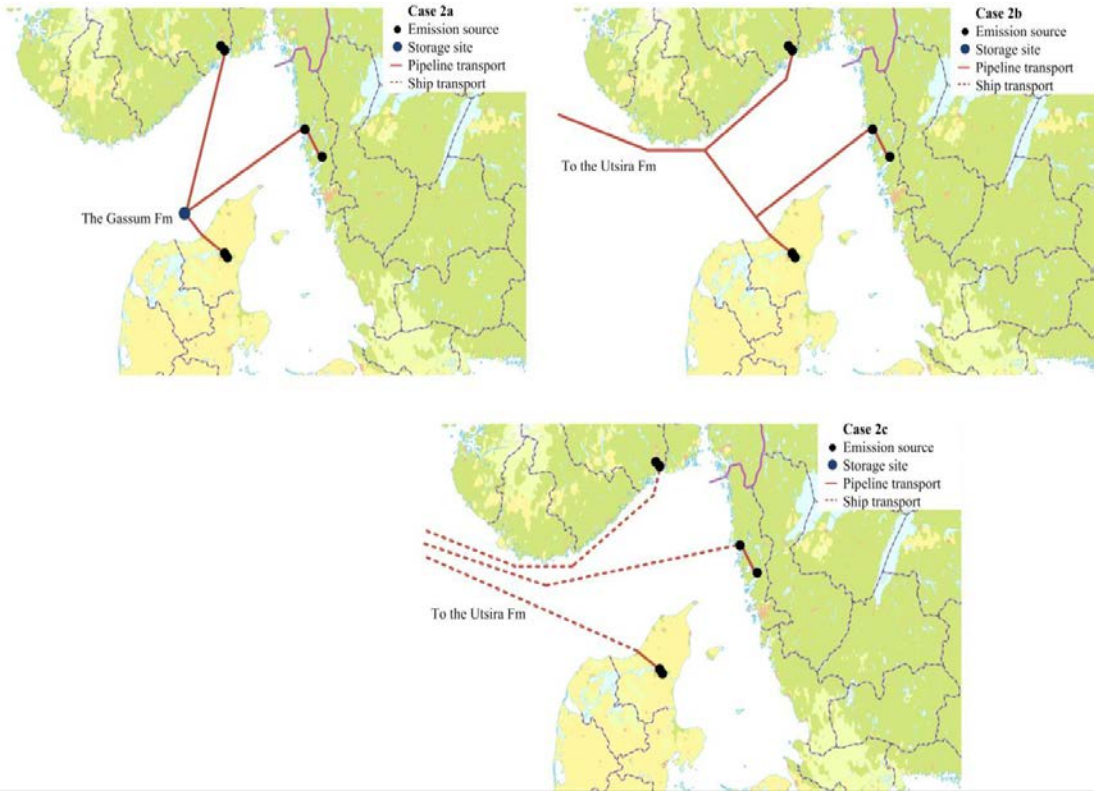

Figure 1: A map over the Skagerrak cluster with its emission sources and possible transport and storage options.
Source: Skagestad et al. 2014

The emission sources Norcem[§] and Yara[**] are located in Porsgrunn municipality. Porsgrunn is located near the coast 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.
The emission sources Preem[††] and Borealis[‡‡] are positioned on the west coast of Sweden in the municipalities Stenungsund and Lysekil. The area maintains a tradition of strong industrialization, where the industries are important employers for the approximately 24.000 inhabitants in the region.

The emission sources 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. Aalborg is the third largest city in Denmark with around 130.000 inhabitants and is the major industrial and commercial center in North Jutland.

4. The potential for CCS implementation in local communities in the Skagerrak cluster

As mentioned in section 2, there is no "one size fits all" with regard to CCS acceptance and communication. However, different studies have identified several similarities across cases that have contributed to acceptance or opposition for CCS projects. In the following, some factors relevant for the Nordic situation will be rendered together with findings from interviews with municipalities within the Skagerrak cluster.

Firstly, onshore storage of CO2 has been identified to be the most contentious aspect of CCS deployment. Onshore storage has been perceived as something new, unknown and potentially risky. In contrast, the capture element has so far been perceived as an extension of the existing technology [4, 32] and there have been few reports of concern over CO2 transport [4], although concerns have been identified [33]. As illustrated in section 3, storage is planned offshore, whereas the emission sources are located onshore in South East Norway, South West Sweden and North Denmark in relatively short distance to the sea. For the municipalities, therefore, it is the capture and transport onshore that the local community will be affected by.

4.1 The municipalities' general views on CCS

Generally, the awareness and perceptions about CCS varies to a great degree between the respective countries municipalities. On the one side, Porsgrunn municipality display very positive attitudes towards existing and potential CCS activities. Rather than a technology with negative consequences, CCS is seen as an opportunity for the local community. Tackling environmental challenges related to the areas industrial activities has been present among policymakers and the local public and the municipality's impression is that the continuous efforts made by the industry to solve environmental challenges, including CCS, are well received by the local public.

On the other side, although CCS is seen as an interesting option to reduce CO2 emissions, the Swedish municipalities' awareness about the technology is quite low and the officials themselves argued to have limited knowledge about CCS. Moreover, they expressed that CCS has not been discussed locally in general, neither with industrial stakeholders, the public nor in the local media. Furthermore, in Denmark, the North Jutland region some years ago experienced great controversy when a CCS project with CO2 storage onshore was planned outside the Aalborg area. The project was in the end rejected by the Danish authorities. How Aalborg municipality today would look at a new CCS project is uncertain. No one in Aalborg municipality currently works with CCS and as a consequence, the municipality was not able to assess how it would look at a potential CCS project.

As we go more into detail with regard to insights from the literature and the municipalities' views, it is important to have in mind the respective municipalities' different awareness and perceptions towards CCS. The review of the municipalities' views will therefore mostly be based on Porsgrunn municipalitys' views. The different awareness and perceptions are most likely results of different socio-political factors and experiences with CCS which will be addressed in the concluding section.

4.2 Socioeconomic factors

For a technology that is relatively new and frequently related with some degree of risk, the potential benefits for the local community hosting the CCS infrastructure has been highlighted as a factor contributing to acceptance [4,27,20]. Such benefits are often attributed to economic benefits in terms of job opportunities and other incomes related to the CCS activity. The possibility of creating local and national economic value through CCS projects has been identified as a major factor contributing to local acceptance [27]. According to Gjefsen [34], the economic factor has been a key element in explaining the higher level of

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[§] http://www.norcem.no/no
[**] http://www.yara.no/
[††] https://www.preem.se/privat/
[‡‡] http://www.borealisgroup.com/
[§§] http://www.aalborgportland.dk/
[***] http://corporate.vattenfall.dk/om-os/vores-virksomhed/vattenfall-i-danmark/om-kraftvarme/nordjyllandsvarket/

conflict in Europe with regard to onshore storage compared to the US. In the US, subsurface rights have made private landowners economic stakeholders in CCS, whereas EU member states control over subsurface land has removed some of the economic incentives that contributed to local support in the US.

According to Oltra et al. [20], economic benefits have also been an important factor for community acceptance in some of the European CCS projects. In Ketzin, Germany, gas storage had been important for the local economy for a long time, but as this was coming to an end, CCS storage could contribute positively to changes in the local economy [4]. Similarly, in the Weyburn-Midale project in the US, local attitudes were generally positive towards onshore Enhanced Oil Recovery (EOR) and a key reason for this was attributed to the economic benefits of the activity [27]. In the case of the North Sea Moray Firth site in Scotland, the prospect of maintaining jobs in the offshore sector through the use of EOR in the North Sea was also viewed favorably. Moreover, the possible economic benefit for Scotland in storing imported CO2 in the North Sea was seen as a factor influencing local acceptance [35].

Furthermore, socioeconomic factors are generally found to be more important and a key to local acceptance than, for example, the opportunity to contribute to reduced greenhouse gas emissions [35, 27]. While the role of CCS as an important climate change mitigation measure may have a substantial influence on acceptance at the regional and national level, this factor has been found to play a significantly smaller role at the local level [35, 27].

For the Skagerrak case, the industries are important employers for a large share of the inhabitants in the local communities in the three countries. Porsgrunn municipality sees CCS as important to legitimize and maintain the industry in the region and hence 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 a particularly interesting option. Based on the studies above, the possibilities of importing CO2 from Europe and economic benefits from enhanced oil recovery (EOR) could also increase acceptance among local stakeholders.

4.3 Community history and identity

A factor that has been emphasized as affecting acceptance is the familiarity of the community with the industry relevant for CCS implementation [20,4]. According to Hammond and Shackley [4], local acceptance has been higher in areas with a history of extractive and fossil fuels industry, whereas the opposite has been the case when the fossil fuel industry was new and lacked a good long-term relationship with local stakeholders.

An example is Ketzin, where a key reason for the relatively high acceptance of the CO2Sink-project was related to the history of storing gas in the area, as local inhabitants were familiar with the technology. This, despite an accident in 1965, when leakages occurred during installation of the gas reservoir at the site now utilized for the storage [36]. Moreover, in Hontomin in Spain, the community had some familiarity with the fossil fuel industry, as small scale oil prospecting activities had been developed nearby in the last decades [20]. Similarly, in Lacq in France, people were used to industrial activities as the industry had been operating in the area for over 50 years. This increased local trust towards the industry and government and implied a fit with the local place identity [4].

Furthermore, the connection between the community history and how the CCS infrastructure fits into the plans of the community's development have been identified as a relevant factor. In Beeskow in Germany, mainly a rural area with high recreational values and a limited industrial history, CO2 storage was feared to have negative impacts on the attempt by the community to enhance tourism in the region. In Ketzin, a different approach was conducted towards tourism, as different renewable energy production facilities were already established (biomass plant and wind turbines) and planned (photovoltaic field). The CCS project was seen as a welcomed addition, as the project attracted domestic and foreign visitors [36].

In the Skagerrak-case, these factors are quite apparent with regard to Porsgrunn municipality. The inhabitants are used to the industrial activities which have been an integral part of the local community for several decades. The community has also over the years tackled and resolved different environmental challenges related to the areas industrial activities. Moreover, in addition to the local inhabitants being used to industrial activities, the community has concrete experiences from CCS activities. The impression is that the local public is positive towards the proactive approach for handling CO2 emissions, and no major protests have been identified neither from the NORCEMs carbon capture demo project, nor Yaras' capture and transport of CO2. The inhabitants are also used to ship transport of products considered more dangerous than CO2 (ammonia, gas). Moreover, CCS is seen as a way of promoting and profiling the local community and the region as an environmental and technological leader, maintaining and developing new industrial activities. Hence, the Porsgrunn area is seen as well suited for CCS as a consequence of the industrial history and a good fit with the local identity.

4.4 Proximity to projects

The location of CO2 storage in an area with low population density have been found to be a key factor for acceptance regarding onshore storage in several cases [4,20]. In Barendrecht, a main concern was the monitoring of the CO2 storage and not enough knowledge about morbidity issues, such as illness and psychosomatic effects on public health [21]. Projects in more

sparsely populated areas have also been subject to strong opposition [36,27], which indicates that proximity to projects is a factor contributing to local opposition.

Proximity to projects could furthermore be a factor for explaining why offshore storage projects have encountered significantly less opposition than onshore storage projects. It has been noted that projects involving offshore storage have not faced public opposition at all [4,37]. In the ROAD project in the Netherlands, the offshore storage option was found as a factor strongly contributing to the low opposition [27]. Moreover, a study on a possible CCS offshore site, the North Sea Moray Firth site in Scotland, did not reveal any major public opposition to offshore storage, although the uncertainty regarding the effect on marine life was mentioned [35].

Based on this, offshore storage could be a factor contributing to a low level of controversy, however, as pointed out by Hammond and Shackley [4], there is actually currently little concrete empirical evidence to back this up. Moreover, Mabon et al. [39], challenges the argument often put forward, that offshore storage will be "out of sight and out of mind" and underlines that conflicts may occur if future projects are not governed carefully. Moreover, concerns over issues such as effects on the marine environment of an uncontrolled leak, possibilities of induced seismicity and risks to existing activities, such as fishing, may result in conflicts.

As mentioned, there are few examples of concern over the capture element and CO2 transport [4]. For the latter, Hammond and Shackley [4] point to the possibilities of CO2 transport – whether transported by pipeline or ship - becoming controversial by comparing CO2 transport to experiences with transport of natural gas. In particular, it is claimed that onshore pipelines could prove controversial as their lengthy nature provides more sites and opportunities for opposition.

The Nordic region has been highlighted as a suitable region for CCS implementation, not least due to offshore storage in the North Sea, seen in the light of recent public controversies around onshore storage [10]. The Sleipner project in the North Sea was realized without much public controversy and it has been suggested that this could be a result of its offshore location [4]. Similarly, the offshore location has been pointed out as a possible explanation why the Snøhvit project in the North of Norway was realized without great controversy [38,15]. Clearly, the offshore option could be a major advantage for the Nordic region and Skagerrak, however, as mentioned above, there are no in-depth studies of what may have contributed to low levels of conflict and this should be subject to more research.

The offshore option also seems favorable for a Skagerrak cluster, not least when seen in relation to previous controversies. In 2008, Vattenfall planned to build a CO2 capture facility and store the CO2 onshore in a nearby geological formation in Vested, just outside Aalborg in the North Jutland region. However, local estate owners denied Vattenfall access to their land to conduct the seismic investigations. The local inhabitants saw the project as risky and unknown and uncertainties related to health, the environment and farming as well as potential negative effects on the value of property, gave rise to the opposition [29]. The Vattenfall's application was in the end rejected by the Ministry of Climate, Energy and Building in 2011. According to Porsgrunn municipality, storage of CO2 hasn't been discussed much in the past and is predicted to be relatively unproblematic, as the storage either would take place offshore, or in reuse processes in Norway or abroad. Hence, seen in light of the controversies associated with onshore storage and Porsgrunn municipality's experiences, the offshore storage/reuse option may be a factor substantially contributing to a low level of controversy.

In sum, the offshore option could be a major advantage for the Nordic region and Skagerrak, however, it is important to note that offshore storage also must achieve approval from sea use stakeholders and that there is no guarantee for acceptance if these actors are neglected.

Finally, with regard to capture and transport, Porsgrunn municipality has not experienced any major concerns with regard to Yaras and Norcems capture activities and Yaras transport of CO2 by ship. It is important to note that Norcem and Yara are situated close to the coast and that the onshore transport in Sweden and Denmark (see figure 1), which includes longer onshore pipeline transport, could be challenging if communication with local stakeholders is neglected.

5. Conclusion

Different studies [31,6,37] have pointed to advantages of Nordic collaboration, not least since collaboration can benefit from significant economies of scale. Still, to benefit from possible advantages and synergies, achieving public acceptance for CCS projects will be needed. As there are only a few projects that have been realized or planned in the Nordic region, there are few experiences and research to draw lessons from with regard to public acceptance and communication. Hence, to gain insight into possible acceptance and communication challenges and opportunities for Nordic CCS deployment, we first identified factors found in the literature on community acceptance and communication relevant for the Nordic situation. On this basis, we assessed acceptance and communication challenges for CCS implementation in the Skagerrak cluster, one of the clusters identified in the techno-economic analysis conducted in the NORDICCS project. The analysis was complemented with findings from interviews made with municipalities in the Skagerrak cluster.

First, an important finding is that the possibilities to store CO2 offshore may be a clear advantage for the Nordic region. Onshore storage have been controversial in several CCS projects, not least in the North Jutland region, where Vattenfall's CCS project experienced public opposition towards the onshore storage solution and eventually failed [29]. Storing CO2 offshore could therefore increase acceptance, but it is important to note that there has been conducted little research on if and why offshore storage is more acceptable than onshore storage. Moreover, offshore storage will include other stakeholders than for

onshore storage that should be subject to attention. As the use of the sea for different purposes increases, not least due to concern about public opposition [40], early communication with sea use stakeholders should be an integral part of communication efforts.

Moreover, the municipalities in the Skagerrak cluster display very different awareness and perceptions about CCS. On the one side, Porsgrunn municipality displays very positive attitudes towards existing and potential CCS activities, which includes both capture and transport. CCS activities are seen as compatible with the history of the community and fit well with the current identity and plans for community development, as well as providing economic benefits. Hence, rather than a technology with negative consequences, CCS is seen as an opportunity for the local community. Compared to controversies in other places in Europe, the attitudes towards CCS in Porsgrunn is therefore interesting. Moreover, Porsgrunn municipality's positive view on CCS to a great extent mirrors what has been deemed key to acceptance in the literature on CCS, i.e. managing risks, creating benefits and taking the local community's history, identity and future plans into consideration. Moreover, the Porsgrunn case also illustrates that providing economic benefits and compatibility with the communitys' history and identity may be seen as closely related and mutually reinforcing.

On the other side, the Swedish municipality's awareness about the technology is low and no one works with CCS in Aalborg municipality. How these municipalities would look at a CCS project in the local community is therefore more uncertain. Still, as mentioned above the offshore storage could be an advantage also from a Swedish and Danish point of view. Moreover, the experiences from Porsgrunn with regard to capture and transport could provide valuable input to future CCS activities. However, it is important to notice that, based on the existing literature, onshore pipelines that will be needed for transport of CO2 could be a challenge, and here lessons from Porsgrunn are not necessarily transferrable, as transport routes in Sweden and Denmark will be longer and thus potentially more challenging.

Finally, the different local awareness and perceptions towards CCS on the community level should be seen in relation to the respective countries national CCS policies. The status of CCS implementation and CCS policies differs widely between the three countries, with Norway as the only country with a well-developed policy for CCS. Hence, it is quite natural that both awareness and efforts for implementing CCS is low in the Swedish and Danish municipalities. Moreover, there are no specific policy signals for a Skagerrak-cluster across the different countries. As deployment of CCS ultimately will require an aggregation of acceptance in the socio-political, market and community dimensions, not only in one country, but in all three countries, political discussions between the three countries will be needed. A joint statement of intention and/or joint regional strategy for CCS infrastructure has been suggested before [37] and could also be considered to create a framework for cooperation and to provide predictability for involved parties.

In addition to political efforts and discussions, research on the conditions for CCS in the Nordic region could benefit from in-depth analysis of the socio-political dimension of CCS. This should also include how communication with policymakers about CCS may contribute or not to CCS deployment.

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