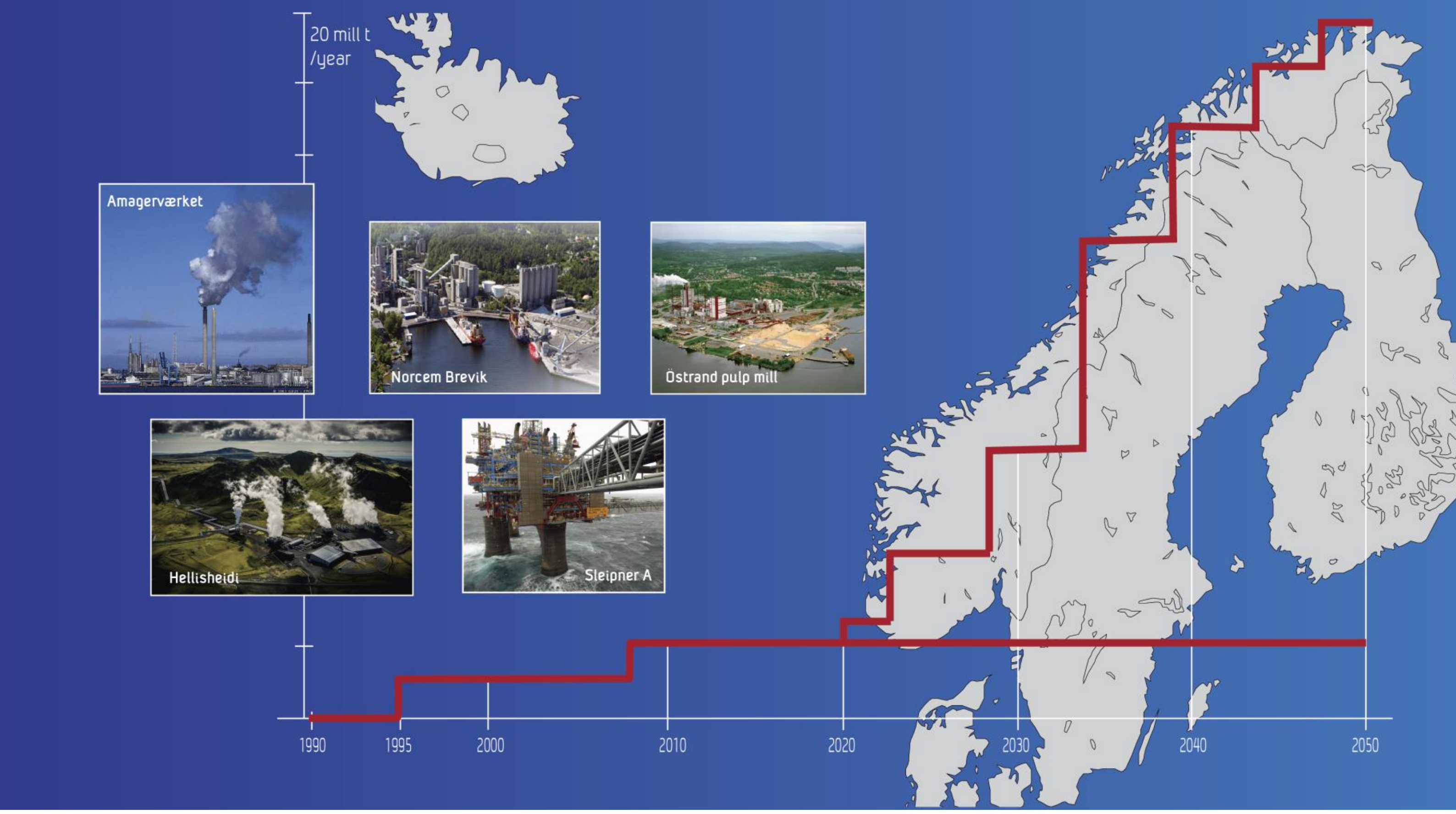

Public perceptions of CCS:
State of the art and the NORDICCS context

Peter Stigson, Jens Jacob Kielland Haug

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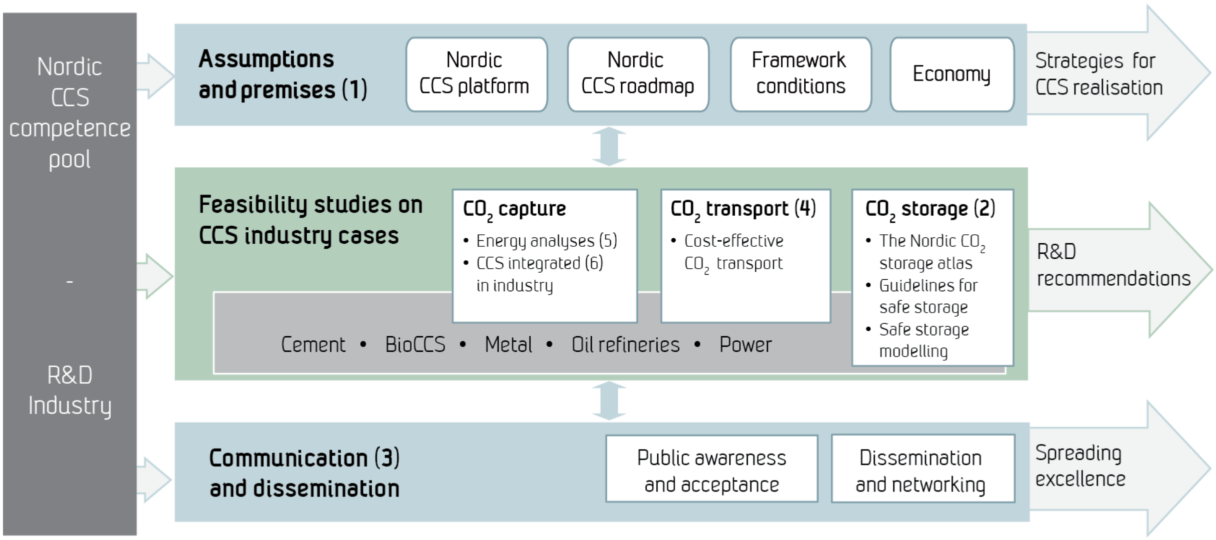

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Summary

This report provides a literature study on perceptions and acceptance of CCS, and a discussion on the implications thereof for the NORDICCS case studies. The purpose is to facilitate a discussion on social acceptance in the Nordic region as an important framework condition in the regional development of CCS. The first aim is to provide the reader with an understanding of the concepts of perceptions and acceptance, such as how CCS is understood, how perceptions are formed, and how this is influenced by different contexts. The second aim is to provide insights into these contexts in relation to the NORDICCS case studies, as to provide a first overview of contexts in relation to Nordic CCS developments. This also contributes to setting an agenda for continued research on CCS acceptance and communication in the Nordic region. The contextual analysis furthermore provides input for prioritisation in a social site characterisation or early efforts on creating communication agendas in CCS projects, especially if sharing similar contexts as the NORDICCS case studies.

Keywords Acceptance, Perception, Communication, Stakeholders, Capture, Transport, Storage

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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.

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Summary

This report provides a literature study on perceptions and acceptance of CCS, and a discussion on the implications thereof for the NORDICCS case studies. The purpose is to facilitate a discussion on social acceptance in the Nordic region as an important framework condition in the regional development of CCS. The first aim is to provide the reader with an understanding of the concepts of perceptions and acceptance, such as how CCS is understood, how perceptions are formed, and how this is influenced by different contexts. The second aim is to provide insights into these contexts in relation to the NORDICCS case studies, as to provide a first overview of contexts in relation to Nordic CCS developments. This also contributes to setting an agenda for continued research on CCS acceptance and communication in the Nordic region. The contextual analysis furthermore provides input for prioritisation in a social site characterisation or early efforts on creating communication agendas in CCS projects, especially if sharing similar contexts as the NORDICCS case studies.

The literature study on social perceptions and acceptance in Europe show that research on these issues has increased in recent years and has evolved to a central topic on social science research on CCS. This research, for example, focuses on how perceptions of CCS among the local and general public is formed and how this is influenced by communication actions. The conclusions are not consistent in that the relationships sometimes appear to be contradictory. It has been shown that, what can be described as high quality communication, does not assure acceptance. While the quality of communication can influence the outcome, no simple causal relationship exists. Sometimes more information increase acceptance, sometimes it lowers acceptance. Hence, there appears to be no “silver bullet" with regard to CCS communication and public acceptance.

The literature study furthermore finds that lessons are difficult to transfer between past and new projects, and highlights differing contexts that the projects are embedded in as a reason for such difficulties. The study thus presents literature that point, explicitly or implicitly, to such contexts. These contexts are then used to discuss how they would possibly affect the opposition or support of a number of CCS case studies that are presented within WP3 of NORDICCS. This also contributes to a description of how similarities between projects may facilitate learning.

As the first Nordic overview of contexts and potential perceptions of a broad range of possible CCS projects, the report identifies that there are generally few reasons to assume that the design and location of the projects would evoke opposition. More detailed analyses would, however, be needed to make more robust assumptions, as the case studies are hypothetical and the opposition of a project may be provoked by single individuals. Moreover, the analysis has focused on the main emission source in each CCS cluster due to the large number of localities in the different cases. The results furthermore inform continued work to formulate hypotheses that could be tested in surveys or interviews with the different stakeholder groups, hence furthering the level of understanding of contextual influence on perceptions and acceptance.

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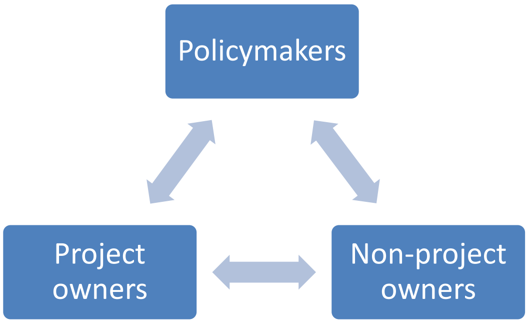
Contents

1 Introduction

The acceptance[1] of carbon capture and storage (CCS) projects is one of the key aspects that are discussed as determinants for successful demonstration and deployment. Experiences from several countries in the EU, such as Germany and Netherlands, have pointed to public opposition (e.g. Ashworth et al., 2013; Bäckstrand et al., 2011; Hammond and Shackley, 2010; Kojo and Nurmi, *forthcoming*; van Alphen, 2007) and causing projects to be restructured, halted or stopped (Stigson et al., 2012). For this reason, the NORDICCS project includes research on how perceptions of CCS are formed, which acceptance there is under different circumstances and how this may influence CCS communication agendas.

The analysis takes stock of past acceptance research, acknowledging the need for social acceptance, not only public acceptance, rather including three key stakeholder groups and their acceptance of technologies, of facilities and by markets (Figure 1; cf. Wüstenhagen et al., 2007). This includes the socio-political acceptance and perceptions of political and state actors, as *policymakers* that set rules for technology support and conditions as well as permission and supervision of potential projects. It furthermore includes community acceptance by *non-project owners*, such as the public, other businesses (e.g. shipping and fishing industries) and municipalities that are confronted with project plans. Lastly, it also include market acceptance by *project owners*, such as large stationary sources of fossil, biogenic and process emissions of CO_2, and their willingness to invest in the technology.

Figure 1 – Stakeholder groups included in the analysis



All Nordic countries include targets for CCS deployment in their climate policy agendas, although with quite different emphasis and detail (Buhr et al., *forthcoming*). Moreover, the nature of emissions and possibilities for storage differs significantly between the countries and regions. While, as general examples, Norway has large emissions from fossil fuel activities (see reports from the NORDICCS Centre of Excellence on CCS, NORDICCS, WP4) and ample storage possibilities (see reports from NORDICCS WP6), Finland and Sweden has large shares of biogenic emissions, but less readily available storage sites. Iceland, on their side, has special geological conditions that influence both the energy system and emissions of CO_2 as well as storage conditions. Denmark has a large number of coal fired power plants, but has faced oppositions towards storage plans.

[1] The analysis defines acceptance as a lack of opposition towards CCS as a whole, or a specific project. In other words, it does not denote an active support.

Hence, the contexts for new and additional deployment of CCS differ to a great extent between the Nordic countries. As a result, this report sets out to describe the scholarly literature on perceptions, acceptance and communication about CCS. The purpose, in light of the NORDICCS project, is to promote and facilitate a discussion on social conditions in the development of CCS in the Nordic region. The aim is to provide the reader with a theoretical understanding of these concepts as well as experience based lessons from early CCS projects. The aim is furthermore to provide a first overview of contexts in relation to Nordic CCS developments and contributing to setting an agenda for continued CCS acceptance and communication research in the Nordic region.

To this end, our research questions are:

- How does literature describe the formation of perceptions, acceptance and opposition of CCS globally and how can these communication efforts be applied to the Nordic context?
- What are the key contexts that may affect perceptions and acceptance, and consequently required communication, in the NORDICCS case studies?

These questions are answered by means of a literature study and comparisons to NORDICCS research outlining CCS case studies. The results may be useful for policymakers and project owners, in evaluating the need and how to communicate both about CCS in general as well as regarding specific projects.

2 Social science insights on CCS communication

2.1 Perceptions, acceptance and communication

According to Markusson et al. (2012), social science on CCS has focussed on two main areas – publications regarding economic evaluations and publications on public understanding and acceptance of CCS (Markusson et al., 2012, p. 905). Although social science studies of CCS have been found to be relatively few within the CCS as a whole (Teir et al., 2010), an increased focus on public acceptance have emerged in recent years.

The increased focus on public acceptance can be dated to around the mid-late 2000s (Bäckstrand et al., 2011, p. 277; Hammond and Shackley, 2012; Johnsson et al., 2010), when a number of planned small- to large-scale CCS projects began to encounter opposition from local communities and were either cancelled, or went ahead in a reduced or restructured form, due to low acceptance (Hammond and Shackley, 2012, p.4). Nowadays, public acceptance is commonly recognized as an important factor influencing the realization of CCS (e.g. Bäckstrand et al., 2011; van Alphen, 2007). According to Bäckstrand et al. (2011), a driving force behind the evolving research field has been these concerns, and that public acceptance and awareness as a consequence frequently being perceived as one of the key barriers to CCS deployment by various CCS stakeholders, such as the industry, government and NGOs (Bäckstrand et al., 2011, see also Teir et al., 2010). Scholars have therefore pointed to the need for proactive communication to raise public awareness, as knowledge is a prerequisite for making informed decisions about individual projects (Hammond and Shackley, 2010, p. 5) whereas it has also been argued that increased awareness would ultimately ease implementation of projects (Ashworth, 2010).

Generally, public awareness has been found to be relatively low (De Best-Waldhoberet al., 2011; Oltra et al., 2010; Teir et al., 2010) and unstable (De Best-Waldhober et al., 2008). Provision of information on CCS can lead to both increased (Tokushige et al., 2007) and decreased (De Best-Waldhober et al., 2009) level of support. There is consequently 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 (Hammond and Shackley, 2010). This echoes findings from the siting of renewable energy, where opposition by local communities have frequently emerged despite general public support for renewable energy (Walker, 1995; Wüstenhagen et al., 2007).

Moreover, it can be difficult to scientifically deduct reasons why people oppose and block projects (Hammond and Shackley, 2010, p. 26; Oltra et al., 2012). This is also supported by findings by Brunsting et al. (2011a), who 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 (Brunsting et al., 2011a, p. 1652). This is found to be partly due to the wide range of contexts, or variabilities, 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 (*ibid*).

Furthermore, high quality communication is not a guarantee for realization of projects or vice versa. Brunsting et al. (2011b) found that the quality of communication can influence the outcome, but that it does not exist a simple causal relationship between the two factors (Brunsting et al., 2011b). The authors assessed that only half of the eight reviewed European project communication and consultation efforts to be adequate. Six projects, however, would, or had, at the time proceeded (Brunsting et al., 2011b, p. 6245). Similarly, an important insight from other previous studies (Pragnell, 2013, p. 53, Hammond and Shackley, 2010, p. 4) has been that there is no "magic bullet" with regard to CCS communication.

Finally, Wolsink (2013) have found that the largest barriers for the deployment of renewables has been a lack of socio-political acceptance (Wolsink, 2013, p.12), and political support for CCS still remain a key obstacle in several European countries. It is therefore interesting to note that Shackley et al. (2009) 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 (Shackley et al., 2009, p. 344 and 350).

2.2 Contexts and conditions influencing perceptions and acceptance

Nevertheless, despite a wide range of potential conditions influencing the perceptions and acceptance of a CCS project, different studies have identified main patterns or contexts that are similar across cases (Hammond and Shackley, 2010, p. 26, see also Oltra et al., 2012; Brunsting et al., 2011b). The importance of the context and social fit of the project in the community, in which the project is located, has been highlighted as an important indicator of potential acceptance or opposition for CCS projects (Brunsting et al., 2011a; Hammond and Shackley, 2010; Oltra et al., 2012; Pragnell, 2013, p. 53) and have also been found important for renewable energy technologies (see e.g. Cohen et al., 2014; Devine Wright, 2012). In the following, we review some contextual features that have been highlighted and of particular relevance for the Nordic situation. Knowledge about these contextual factors is important for project developers and authorities in planning CCS projects and when conducting public engagement i.e. in general or in relation to specific project stages (capture, transport or storage, or indeed as a whole system).

Building on, *inter alia*, Brunsting et al. (2011b), Hammond and Shackley (2010), Oltra et al. (2012) and Stigson et al. (2015), Table 1 summarises a number of contexts that are identified as important to include in an analysis of the NORDICCS case study projects (Chapter 3). While the table suggests the potential effects of certain contexts, these effects cannot be taken for certain, and should be seen as recommendations in characterising the social conditions in which a project is embedded. There are, of course, difficult to say if and how these contexts will play out in each case. There are furthermore other factors that may also influence the acceptance or opposition of a project, such as the perspective that media chooses to communicate. Another factor is activities in environmental regulated and protected areas or areas with social values, such as cultural or recreational values. As similar factors are difficult to analyse before being faced with real project plans, they are excluded here.

Table 1 – Summary of contexts included in the analysis

CONTEXT	POTENTIAL EFFECTS
Emitting source	- Industrial process emissions may cause *less* opposition
Emission type	- Industrial process emission and biogenic emissions may cause *less* opposition - Emissions from fossil fuels for power and heat production may cause opposition
Means of transport	- Previous experiences of pipelines may cause *less* opposition - Increased shipping in busy waters may cause opposition
Storage location	- Offshore storage may cause *less* opposition than onshore - Onshore storage areas with low population density may cause less opposition
Spatial discounting	- A longer distance between CCS activities and communities may result in *less* opposition
Trust	- A higher level of trust in the project owners may cause *less* opposition
Economic and other benefits	- Stimulating the economy through, and creating jobs in, a CCS project may cause *less* opposition - Creating the possibility to sustain carbon intensive industries that are important employers may cause *less* opposition - Activities perceived to have negative effects on existing local business activities – e.g. tourism – may cause opposition
Experiences with industrial activities	- Novel technologies and activities may cause opposition in communities with no previous industrial activities - Previous industrial activities may result in *less* opposition
Local identify	- Activities perceived to have a negative effect on the local identity may cause opposition

Climate is excluded as a context, perhaps counterintuitively, as literature does not provide any clear indications on whether the arguments on CCS abating CO_2 emissions, or potentially prolonging the use of fossil fuels, will play out as the predominant perception (e.g. Stigson et al., 2015).

2.2.1 Emission sources, transport and storage

Capture, transport and storage of CCS are typically seen as the three key infrastructural stages, of which storage is the stage that has been the focal point of most opposition (also see Section 2.2.3). Examples of this include experiences from Germany, Netherlands and Denmark. The perceptions of storage has however been found to depend on the emission source, where for example Wallquist et al. (2012) have identified a potentially lower opposition towards transport and storage of biogenic emissions. Norway has, as another example, experienced stakeholder concerns also about capture processes. In relation to the Mongstad Test Centre, the use of amines was associated with potential environmental and health effects of possible leakages (Ministry of Petroleum and Energy, 2010). Another interpretation regarding perceptions of the different infrastructural stages is provided by Wallquist et al. (2012), who in a Swiss case study identified the largest concerns to be directed towards transport. Hammond and Shackley (2010) found that there have not been any reports of concerns over CO_2 transport. However, by comparing CO_2 transport to transport of natural gas, they point to the possibilities of CO_2 transport – whether transported by pipeline or ship - becoming controversial. In particular, pipelines could prove controversial as their lengthy nature provides more sites and opportunities for opposition. This was the case in the UK, where a proposed onshore natural gas pipeline route was highly contested due to the proximity to housing and the perceived safety risks (Hammond and Shackley 2010, p. 32).

As capture, transport and storage of CCS are typically seen as the three key infrastructural stages, the project owners in all of these three stages may be evaluated. Stigson et al. (2015) has indicated that it is likely that the emitter, or the one that is perceived as having the largest economic gain in a CCS project, that will be in the focal point. Hence, opposition along the infrastructure may play out differently towards stakeholders engaged in the related activities.

Trust is typically seen as one of the key determinants for a well-functioning dialogue and acceptance (e.g. Brunsting et al., 2012; Prangnell, 2013). This may affect projects depending on the trust in the emitting industry or industrial sector of that industry. This is typically very case-specific, as individual industries may enjoy a higher social trust that others in the same sector, and is therefore not further analysed in this report.

2.2.2 Economic and other benefits of CCS

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 (see Hammond and Shackley, 2010; Pragnell, 2013; Oltra et al., 2012). Furthermore, tangible benefits have been regarded as essential for the acceptance of local stakeholders by CCS communication managers (Pragnell, 2013, p. 4). Such tangible benefits are often interpreted as 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 (Brunsting et al., 2012; Pragnell, 2013;

Stephens, 2009). Hence, a national agenda on CCS may have tangible effects also on the local level. According to Gjefsen (2013), the economic factor has been a key element in explaining the higher level of 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 have removed some of the economic incentives that contributed to local support in the US (Gjefsen, 2013, p.11).

According to Oltra et al. (2014), tangible benefits have been an important factor for community acceptance also in some of the European CCS projects. In Ketzin, Poland, 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 (Hammond and Shackley, 2010, p. 27). Similarly, in the Weyburn-Midale project, local attitudes were generally positive towards onshore Enhanced Oil Recovery (EOR)[2] and a key reason for this was attributed to the economic benefits of the activity (Pragnell, 2013, p. 14). 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 favourably. Moreover, the possible economic benefit for Scotland in storing imported CO_2 in the North Sea was seen as factor influencing local acceptance (Brunsting et al., 2012, p. 51).

Finally, 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 (Brunsting et al., 2012, p. 50; Pragnell, 2013, p. 4 and 28). 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 have been found to play a significantly lesser role at the local level (Brunsting et al., 2012, p. 50; Pragnell, 2013, p. 4). One example of how developers have strategically framed their communication, taking this knowledge into account, can be found in the Longannet case in Scotland. Here, the developer went from an initial focus on the projects relevance for reducing CO_2 emissions to highlight the economic (and other) benefits in the formal consultations with the locals (Pragnell 2013, p. 39). Thus, it seems that communicating the possibility for the local public to contribute to mitigate climate change has a greater possibility to succeed when framed as a "positive side effect" rather than being the main argument. Again, this points to the need for a communication agenda on both national and local levels, acknowledging the potential effects and design thereof on different levels.

2.2.3 Spatial discounting

According to Hammond and Shackley (2010), onshore storage of CO_2 is the most contentious aspect of CCS deployment where the local public, local public groups, and local politicians have been the most important stakeholders opposing CCS projects (Hammond and Shackley 2010, p. 26). For the local public, onshore storage have 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 and there have not been any reports of concern over CO_2 transport (*ibid*, p. 32). However, the difficulties to draw robust conclusions is emphasised by the results in Norway with concerns towards Test Centre Mongstad, and Wallquist et al. (2012) who identify largest concerns towards transport.

[2] I.e. where the extraction of oil is increased through different means, such as injecting CO_2.

Moreover, the location of CO_2 storage in an area with low population density have been found to be a key factor for project acceptance regarding onshore storage in several cases (Hammond and Shackley 2010, p. 27, Oltra et al., 2012, p. 241). In Bahrendrecht, a main concern was the monitoring of the CO_2 storage and not enough knowledge about morbidity issues, such as illness and psychosomatic effects on public health (Brunsting et al., 2011a; Brunsting et al., 2011c). However, there are also projects in more sparsely populated areas that have been subject to strong opposition (Dütschke, 2010; Pragnell, 2013). In the Jänschwalde case, the local inhabitants in Beeskow feared CO_2 would escape from under their homes, contaminate drinking the water and negatively affect tourism (Pragnell, 2013, p. 33).

Spatial discounting and population density could furthermore be a factor for explaining why offshore storage projects have encountered significantly less opposition. It has been noted that projects involving offshore storage have not faced public opposition at all (Hammond and Shackley, 2010, p. 20; Tel-Tek, 2011, p. 95). Although there are few concrete examples of offshore storage projects to draw experiences from, the Maasvlakte-project in the Netherlands, located just 50 km from Bahrendrecht, the offshore storage option was found as a factor strongly contributing to the low opposition (Pragnell, 2013, p. 12). 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 (Brunsting et al., 2012). Mabon et al. (2013), nevertheless challenges the argument often put forward, that offshore storage will be "out of sight and out of mind". Interviews with stakeholders and publics in three areas of Scotland where offshore storage developments were relevant, suggested that no clear opposition could be detected. However, it was pointed out that conflicts could occur if future projects are not governed carefully and concerns over issues such as long term migration, effects on the marine environment of an uncontrolled leak, possibilities of induced seismicity and risks to existing activities, such as fishing, potentially result in conflicts. Also, even though storage may occur offshore, Stigson et al. (2015) have discussed cases similar to CO_2 storage, where the sometimes inherent onshore activities, such as booster stations or other parts of the infrastructure, may become the focal point of 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 (Teir et al., 2010). The Sleipner project in the North Sea was, for example, realized without much public controversy and it has been suggested that this could be a result of its offshore location (Hammond and Shackley, 2010, p.20). Similarly, the Snøhvit project was realized without great controversy in Finnmark in the North of Norway (Heiskanen, 2006), and similarly to Sleipner, the offshore location has been pointed out as a possible explanation (Oltra et al., 2010). Although there were critical voices and a national debate about investing money in CCS, and environmental NGOs protested against further utilization of the Barents area and CO_2 emissions from the planned gas-fired power plants, it was concluded that safety issues had not been a major point in the debate, as all plans were for offshore storage (Heiskanen, 2006). Based on this, offshore storage could therefore be preferred to onshore storage, however as pointed out by Hammond and Shackley (2010), there is actually currently little concrete empirical evidence to back this up. Especially if accounting for the full transport infrastructure required, including capture and transport (Stigson et al., 2015). Finally, it has been suggested that acceptance for CCS could increase through engaging CO_2 utilisation, due to possibilities for CO_2 to be viewed as a valuable resource (European Union 2013, see also Hammond and Shackley, 2010). Anecdotal evidence also shows that this has been the case in local communities (Oltra et al., 2010).

2.2.4 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 (Oltra et al., 2014, p. 241; Hammond and Shackley, 2010, p. 27). According to Hammond and Shackley (2010), local acceptance have been higher in areas with a history of extractive and fossil fuels industry, whereas the opposite have been the case when the fossil fuel industry was new and lacked a good long-term relationship with local stakeholders (Hammond and Shackley, 2010, p.27). An example is Ketzin in Poland, where a key reason for the relatively high acceptance of the CO_2Sink-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 (Dütscke, 2010). 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 (Oltra et al., 2014, p. 239). Similarly, in Lacq in France, the social fit with the site was favourable. The region has the most underground gas fields in France and thus, 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 (Hammond and Shackley, 2010).

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, mainly a rural area with high recreational values and a limited industrial history, CO_2 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 welcomed addition, as the project attracted domestic and foreign visitors (Dütschke, 2010, p. 6).

Finally, it may be important to see contextual factors separately, such as tangible benefits and local history and identity, but also as interdependent and potentially mutually reinforcing. As pointed out by Pragnell (2013), local reactions to the Weyburn-Midale project were overwhelmingly positive. Pragnell also notes that the local community and stakeholders familiarity with oil and gas technology, and the direct economic benefits attained by the project was a key factor for local acceptance (*ibid*). In Ketzin, the CCS fitted neatly into the long tradition and familiarity with the technology, current development and future plans of establishing low carbon technologies. In addition, as mentioned above, the economic benefits that CCS storage would mean came timely, as gas storage was coming to an end. Similarly, the local inhabitants in Beeskow feared CO_2 escaping from under their homes, contaminating drinking the water and negatively affecting tourism (Pragnell, 2013, p. 33) illustrates that managing risks, while providing tangible benefits that fits into the community's history and identity can be important. Thus, assessing these contextual factors at an early planning stage in continuous dialogue with the community therefore seems vital to correctly addressing specific communication needs in different communities.

3 NORDICCS project case-studies

The NORDICCS project provides an opportunity to discuss how different contexts of potential Nordic CCS cases could influence communication needs. The work package on cases studies (NORDICCS WP3), which aims to analyse the feasibility of six CCS cluster cases in the Nordic countries (i.e. based on more than one source of CO_2), will be used as a basis to assess how different contexts should be taken into account. This will provide synergies within the project's research agenda and an additional point of analysis in terms of the feasibility analyses of these projects. Table 2 lists the respective cases that form the basis for the analysis.

Table 2 – NORDICCS case study projects (Skagestad and Mathisen, 2014))

	COUNTRY	MAIN SOURCE	CLUSTER	TRANSPORTATION AND STORAGE
1	**Iceland**	Hellisheiði Thermal Energy Plant near Reykjavik (Electricity and heat)	Aluminium and ferrosilicon plants in Iceland	- Onshore pipeline to storage in basaltic rocks in Iceland - Offshore pipeline to storage in Utsira Formation (Fm) - Ship transportation to storage in Utsira Fm
2	**Skagerrak**	Norcem in Brevik (Cement)	6 large sources around Skagerrak	- Ship/pipeline transportation to Gullfaks - Ship and pipeline combined to storage in Gassum Fm - Ship and pipeline combined to storage in Utsira Fm
3	**Bay of Bothnia**	Generic steel factory near Swedish-Finnish border (Steel)	Sources in the Gulf of Bothnia	- Onshore pipeline to storage in Norwegian sea - Offshore pipeline/ship transportation to storage in Baltic sea - Ship transportation to storage in Utsira Fm
4	**Northeast Sweden**	SCA Östrand (Pulp and paper)	Sources in east coast Sweden and west coast of Finland	- Onshore pipeline to storage in North sea - Offshore pipeline/ship transportation to storage in Baltic sea - Ship transportation to storage in Utsira Fm
5	**Copenhagen**	Amagerværket (Heat and power plant)	Large emitters in Fyn and Sealand	- pipeline transportation to storage south in Denmark - Ship and pipeline combined to storage in Gassum Fm
6	**Lysekil**	Preem Lysekil (Refinery)	Large emitters around the main source	- Ship and pipeline combined to storage in Gassum Fm - Ship and pipeline combined to storage in Utsira Fm

3.1 Short descriptions of case studies

The descriptions of the case studies focus on the main characteristics and may, as a consequence, unintentionally omit contexts that are important, or perceived as such by any person or stakeholder. Examples of this can be sensitive biotopes. In other words, the descriptions are not meant to be comprehensive, rather based on how they are described in WP3 of the NORDICCS project. They nevertheless serve to provide insights into how different contexts may play out for different case studies.

Our analyses are mainly based on the key emission source (Table 2). The reason is that describing all contexts for all affected areas would be too extensive for this study. Moreover, the literature does not discern how other activities in the CCS cluster, such as other emission sources, may affect the perception of individual components in the infrastructure (e.g. other emission sources). In other words, our analysis does not include an analysis of how the inclusion of capture at a fossil based power plant in Denmark may affect the perceptions of project on cement based capture in Norway.

3.1.1 Reykjavik – Iceland

The Reykjavik case is based on capture of CO_2 from the Hellisheiði geothermal power plant, which is located approx. 20 km inland from Reykjavik and some distance from other settlements, as well as emissions from aluminium and metals plants. Hence, the source of CO_2 is volcanic, not based on combustion of fossil fuels for the production of electricity and heat. Transport is suggested through mostly sparsely populated areas and with low visual impact. Storage is suggested onshore in the absolute proximity of the plant. While large scale storage of CO_2 is new to Iceland, there is a long history of using underground heat for electricity production and heating purposes. Also, the University of Iceland has together with partners also been successful in testing new technologies to store CO_2 in basaltic rocks, which have not met with any opposition, but rather support.

3.1.2 Skagerrak – Norway, Sweden and Denmark

The sources in this cluster include cement production, refineries, and power and heat production in Sweden (Västra Götaland), Norway (Telemark) and Denmark (North Jutland). The main source is Norcem (cement production) in Porsgrunn municipality in Norway. Porsgrunn is located by the coast in South-eastern Norway and has approximately 30.000 inhabitants. Porsgrunn has a long history of industrial activities. Today, the processing industry is the biggest industry and Yara, one of the world's largest fertilizer companies, are located within the municipality. Yara is also the other emission source included in the Skagerrak case. They have captured and transported around 200.000 CO_2 yearly from their ammonia production to European soft drinks and beer producers for over 30 years without major public opposition. Norcem is currently running the first European CCS test center for cement production, where four post combustion technologies are tested. Transport is predominately planned through offshore pipelines or ship transport to offshore storage outside Norway, albeit some onshore pipelines are also included in the cluster.

3.1.3 Bay of Bothnia – Finland and Sweden

The key emission source in the cluster, based around the Bay of Bothnia, is a generic steel plant located near the Swedish-Finnish border, presumed to have a history of such activities. The emissions from the steel plant are mainly process emissions from chemical reactions, using coal and coke, which also contributes to necessary heat production. Other emission sources in the cluster include pulp and paper industries, power and heat production as well as additional steel production in Finland and Sweden. The transportation from the plant and cluster is almost exclusively planned as offshore pipelines or by ship transport to storage locations in the Baltic Sea, North Sea or Barents Sea.

3.1.4 Northeast Sweden – Sweden and Finland

This case study is based on a Swedish cluster of pulp and paper industries and Finnish power and heat producers. The key emission source is SCA's pulp and paper plant Östrands massabruk, located along the coast in the village borders of Timrå (approx. 10.000 inhabitants), which has a long industrial history. The emissions from the pulp and paper plants are predominately biogenic, resulting from the combustion of biofuels (incl. biogenic by-products from the production) to support chemical processes and provide heat. The suggested transport solution includes a relatively large share of onshore pipeline transport, as compared to the other case studies, and pipeline or shipping for offshore transport. The storage site is in the Baltic Sea, where storage of CO2 is a novel activity.

3.1.5 Copenhagen – Denmark

As the only study focussing on a single emission source, the case includes Amagerværket power and heat plant, which is centrally located in Copenhagen, along the shoreline. The plant produces approx. 12 % of Zealand's electricity demand and 30 % of Copenhagen's district heating demand (HOFOR, 2015). The fuels are mostly of fossil origin, however including a large share of biofuels, which are planned to be the dominant fuel in a near future. The plant has been operational since the 1970's. Potential storage sites are either offshore (relatively close to land in the Danish part of the West Baltic Sea) or partly onshore (West Zealand). The former includes either onshore pipelines or ship transport and the latter onshore pipeline transport. Both pipeline connections are passing through Copenhagen.

3.1.6 Lysekil – Sweden

This case exclusively includes Swedish sources from chemical (mainly petrochemical) and pulp and paper industries, with the main source being the Preem refinery Preemraff. This refinery is Scandinavia's largest and located in near proximity to Lysekil on the Swedish west coast (north of Gothenburg), which is a municipality with a strong presence of chemical industries since the 1970's. The transport in this case study transit to offshore directly at the point source and onshore transport is therefore negligible. The designated storage site is the Gassum formation, within close proximity to the Danish north coast of Jutland, by means of either pipeline or ship.

3.2 Contexts and conditions in the case studies

This section focus on an initial comparative analysis of the case studies in relation to literature on conditions and potentially having a relatively larger influence on public perceptions and acceptance. As summarised in Table 3, it is possible to discern situations (i.e. boxes in the figure) where there is less reasons to assume that opposition may be provoked (*green*), compared to situations where there are reasons to assume an increased likelihood that opposition may be provoked (*red*). There are also situations where it is difficult to make assumptions in these regards, either due to a lack of literature on the subject or requiring more in-depth research. Hence, situations where there is either a lack of data, or contexts where there are indications of both low and higher likelihood of opposition, are labelled *yellow*. Some factors are not evaluated due to constraints in this initial analysis, but included here as a reminder of their potential influence.

The reader should be reminded that this analysis show indications of how factors that may influence how a project is perceived, but that it does not signify how this may play out in reality when different stakeholders are confronted with plans for a factual project.

Table 3 – Evaluation of context for NORDICCS case-studies

Context	Iceland	Skagerrak	Bay of Bothnia	Northeast Sweden	Copenhagen	Lysekil
Emitting source	Geothermal*	Industry	Industry	Bio	Coal Biofuels	Industry
Emission type	Volcanic*	Process	Process	Biogenic	Fossil Biogenic	Process Fossil
Means of transport	Short Medium	Short	Short	Long	Short Long	Short
Storage location	Offshore Onshore	Offshore	Offshore	Offshore Onshore	Offshore	Offshore
Spatial discounting	Capture Trans/Stor	Capture Trans/Stor	Capture Trans/Stor	Capture Trans/Stor	Capture/Trans Stor	Capture Trans/Stor
Trust	*Not eval'd*	*Not eval'd*	*Not eval'd*	*Not eval'd*	*Not eval'd*	*Not eval'd*
Economic and other benefits	*Not eval'd*	*Not eval'd*	*Not eval'd*	*Not eval'd*	*Not eval'd*	*Not eval'd*
CCS experiences	*Not eval'd*	*Not eval'd*	*Not eval'd*	*Not eval'd*	*Not eval'd*	*Not eval'd*
Local identity	*Not eval'd*	*Not eval'd*	*Not eval'd*	*Not eval'd*	*Not eval'd*	*Not eval'd*

*Notes: * = Literature does not cover perceptions of capturing CO2 from geothermal heat and power plants, and emissions of volcanic origin.*

3.2.1 Emitting source and emission type

The contexts that relate to the emitting industries include whether emissions are originating from combustion of either fossil fuels or biofuels, from chemical reactions in industrial processes, or being of volcanic origin. Looking at these factors, the case studies typically do not cause any specific reasons for concerns. There is little information in literature on how emissions from refineries may be perceived, seeing that it may be identified as process emissions, however possibly also associated with fossil fuels, despite potentially including biogenic raw materials. The situation in relation to the Hellisheiði geothermal power plant is also uncertain, as literature does not cover perceptions of capturing CO_2 with volcanic origin, i.e. from geothermal sources. Perceptions could arguably be based on volcanic activity being something inherent to the region and thus cause less opposition. Hence, the Lysekil and Icelandic cases are labelled yellow. The emissions from Amagerværket are labelled in two fields, due to the combustion of both fossil and biogenic emissions.

3.2.2 *Means of transport*

The situation with few specific reasons to caution against the case studies is similar for transport. One exemption is however the Northeast Sweden and Copenhagen cases, including relatively long transport on land. As mentioned, the analysis does not include whether the transport solution passes through, or nearby, environmentally or culturally sensitive areas. The Copenhagen case deserves a special recognition also as it includes transport through Copenhagen, which may be contentious due to the urban context (also see spatial discounting). The shipping transport in this case is also labelled yellow, due to the transition to ship, and associated gas handling, in a city central location. Furthermore, the Icelandic case includes an alternative with medium long onshore transport, which consequently is labelled yellow. The colour coding otherwise focus on whether transport is onshore or offshore, as indicated in the context's definition, as well as how long onshore pipeline transport would be. This includes that onshore transport is more likely to provoke opposition than offshore transport, which is assumed by transferring lessons from natural gas transport analogues.

3.2.3 *Storage location*

The analysis of storage locations is predominately based on whether the case studies' storage is onshore or offshore. The former has proven likely to provoke opposition, based on lessons of opposition towards onshore storage projects in the EU, which has resulted in projects being cancelled (e.g. Barendrecht). However, while some projects have faced initial opposition, it has been reduced through communication efforts, e.g. Lacq (Hammond and Shackley, 2010). For offshore storage, the storage of CO_2 at Sleipner and Snøhvit has been pointed out as a possible explanation for the low conflict level in these projects (Hammond and Shackley, 2010; Oltra et al., 2010). It should also be acknowledged that smaller pilot storage projects onshore have been implemented at Iceland with support, rather than protests. For these reasons, most cases are coloured green, while the Northeast Sweden case is labelled yellow due to storage in the Baltic Sea rather than North Sea. The Icelandic case should typically have been red, but taking experiences into account, it is opted as yellow.

3.2.4 *Spatial discounting*

The extent to which the proximity between CCS activities and other interests (e.g. recreational areas) and settlements, could be more or less likely to cause to opposition, should be evaluated for capture, transport and storage individually, seeing their spatial distribution. This also means that different stakeholder groups should be accounted for each infrastructural stage. The most significant case in regards to capture in this sense is Amagerværket, which is centrally located in Copenhagen. The Skagerrak, Bay of Bothnia and Lysekil cases are located close to a city, however in smaller cities where the industrial presence may provide a relatively large number of job opportunities. Hence, the Copenhagen case is coloured red, while several cases are coloured yellow. Here, transport is also coloured red due to onshore pipelines transiting through Copenhagen. Looking at transport and storage from a discounting perspective complements the previous contexts on transport and storage through adding a spatial dimension. For example, the Copenhagen case is labelled green in terms of storage location as it is offshore, while it is yellow here seeing that these sites are nevertheless in close proximity to land. All cases are labelled as yellow in terms of transport and storage, seeing that the cases include different storage sites, where some could be considered as more prone to cause opposition.

3.2.5 Other factors not evaluated

An analysis of trust in the individual key sources in each case study falls outside the scope of this report. The same applies for a socio-economic analysis and evaluation of potential job opportunities within the construction and operation of different part of the CCS system. The report does not either analyse what experiences there are of CCS, meaning to which extent that CCS has been applied or, for example, to which extent that storage sites has been prospected and pilot or demonstration operations has been realised. This consequently also excludes how such experiences of CCS may affect perceptions of a new project. The reasons are that such an analysis would have to distinguish between small R&D or pilot projects, which may not have been brought to a general attention, and larger projects. It should be noted that a higher level of CCS experiences would not necessarily be seen as supportive of less likely opposition, if such experiences include accidents or other events that may have lowered the trust in the potential project owners. Lastly, the analysis excludes cultural aspects, such as cultural values of resources that CCS projects may compete with, such as recreational values and fishing rights. This is left out due to the large number of such contexts and the very case specific nature thereof.

4 Discussion

4.1 General findings

The literature study provides a picture of potential perceptions towards different technical, design and operational elements of a CCS system, which is much more diverse than what is captured in the common perception of storage as the key obstacles acceptance. While the overall influence of contexts is a finding in itself, being a research focus that is gaining momentum in CCS acceptance studies, an account for specific contexts provide insights important to learning between projects and as a basis for ex-post and ex-ante analysis of project perceptions and acceptance (also see section 4.2).

Specifying which part of the CCS infrastructure, which stakeholder, or which context that will result in opposition or support is not feasible as a general finding. This is due to the same situation making contexts important, namely the plurality of social, ecological and economic situation in which a project may be embedded. Importantly, this is not insignificantly a result of the infrastructural nature and hence complexity of CCS, seeing how literature differently highlights varying aspects and technology components as causing opposition. Hence, the findings of the literature study and case study analysis should neither be taken for evidence that opposition, or even protests, will occur or not, nor that certain conditions will create support. As an example described in Stigson et al. (2015), protests towards an electricity transfer project in the Baltic Sea (SwePol Link) spurred from coordination by a single person, who took leave of absence to push the concerns onto the public agenda.

The findings should however be seen as input to a discussion about priorities for CCS development strategies, seeing that such strategies, as is demonstrated by the case studies, can include several options with different social, technical and other contexts. Prioritisation may, for example, be preferable if aiming to demonstrate CCS in a region with no, or negative, previous experience of the technology. Strategies where priorities may preferable can be siting of technologies, choice of technologies, preferred project stakeholders, and naturally, communication and social interaction.

This boils down to one of the most common recommendations for communication, namely to engage in an early dialogue, seeing that such efforts can and should include analyses of the contexts affecting the social acceptance of a project, meaning a range of potential concerns of different stakeholder groups. This should be carried out as part of the feasibility study in order to account for how social characteristics may influence the project design. Such actions are parallel to methodologies of social site characterisation, of which there are several descriptions, all however more or less pointing to the same actions. Namely to (Stigson et al., 2015):

- Context analyses
  - Identify socio-economic contexts
  - Identify political contexts
  - Identify cultural contexts
  - Stakeholder analysis
- Stakeholders analyses
  - Map stakeholder interests
  - Map stakeholder concerns and perceptions
- Project-related analyses
  - Identify how above influence project plans

4.2 Influence of contexts

Experiences of protests from CCS projects in different regions have put perceptions and acceptance of CCS on the technologies' agenda. This is reflected in the literature study and the increasing body of literature on perceptions, acceptance and communication of capture, transport and storage, however with a focus on onshore storage. While there are differences in terms of how well scholars have covered each of these three technology stages, there is less need for additional theoretical contributions to the research field.

As the literature study points out, there is however a need for evaluations of real projects of increasing sizes and complementary natures, seeing that this provide a validation of theoretical contributions, as well as valuable insights into defining key determinants for perceptions and acceptance in different settings. This conclusion is drawn partly due to existing analyses of factual projects showing large differences in how support and resistance towards projects have played out in reality. Research increasingly point to this being a result of differences in contexts as well as other more undefined circumstances. The effects of this can be exemplified in different ways, such as that a low level of opposition for CO_2 storage in the North Sea, does not necessarily imply a low level of opposition towards CO_2 storage in the Baltic Sea (Stigson et al., 2015). To this end, the literature study is complemented by a first analysis of how the contexts, which NORDICCS case studies are embedded in. This analysis does not mean to imply that these are the only important contexts and that these contextual factors would eventually play out as most influential in terms of forming stakeholder perceptions. The results are however valuable for moving research on social conditions of CCS in the Nordic region from the theoretical towards the plausible and regionally significant.

The analytical results, as summarised in Table 3, show that the contexts may play out quite differently in terms of influencing case studies (along the rows), as well as how the case studies are influenced by the contexts (along the columns). *Looking at the contexts*, spatial discounting is emphasised, mostly based on the different options included in the case studies. However, the spatial discounting also relate to the other contexts of onshore transport lengths and storage sites. While not included in this report, the spatial discounting may also be linked to the economic benefits of a project, where effects of less opposition due to economic benefits could be argued also being discounted in a spatial perspective. While robust analyses of factual experiences of how type of emission may influence perceptions are missing, there is ample anecdotal evidence that this may be an important factor, which in the case studies could be important in two cases (i.e. Copenhagen and Lysekil). *Looking at the case studies*, two projects display characteristics that do not immediately link to contexts that could be argued as potentially causing opposition. Hence, such projects could be seen as strategic priorities in demonstrating CCS in the Nordic region. However, such a priority should be preceded by more in-depth analyses and naturally also taking economic and other factors into consideration. Conversely, there is one project, Copenhagen, which has characteristics that would arguably make it less suitable for technology demonstration, seeing that it is based on combustion of fossil fuels, has a central location and two proposed transport options being onshore and through urban areas.

Excluding climate change and CO_2 emission mitigation as a context deserves an additional explanation, especially to reflect on the above. The context is excluded as literature fails to provide consistent suggestions on whether climate arguments may be used in support or opposition of CCS. Relevant project experiences include that less carbon intensive energy systems are seen as favourable and gaining support also from environmental NGOs, despite being fossil (Stigson et al., 2015). However, experiences also point to CCS potentially being seen as prolonging the reliance on fossil fuels (*ibid*). This reiterates the situation where perceptions may differ depending on the emissions origin being from combustion or processes as well as by which fuels. There could potentially also exist situations where biogenic emissions are used for EOR, which arguably could provoke perceptions that reduce or annul the potential lower opposition towards a system solely based on biogenic emissions.

4.3 Stakeholders

In addition to the discussion about contexts, there are reasons to reiterate that social acceptance include not only the general public (where the local level is emphasised in this report), but also policymakers' opinions and supporting or conflicting business' interests. Protests from the public have worked as show-stoppers in numerous occasions for a variety of engineering projects, both in its own capacity as well as through influence on policymakers, for example in permission processes. The cause and effect of opinions about CCS is however an intricate web, which is difficult to analyse on a generic level due to its complexity, plurality and context dependence.

Several stakeholder groups are concerned about acceptance for CCS and how it may reflect on organisations taking action on CCS. This is natural given how acceptance has played out as a decisive factor for several European CCS projects. However, as several high-level policy documents lay out plans for demonstrating and deploying CCS as a key mitigation technology, there is a need to discuss the feasibility of such plans and how they may be accomplished. Such plans should take stakeholder opinions into account in order to fully evaluate the feasibility of overarching plans and specific projects. Such discussions and associated communication may play an important role in informing different stakeholder groups, which is valuable seeing that it is preferable to evaluate perceptions and potential acceptance of CCS, based on stakeholders having as educated opinions as possible. The reason being that people often form pseudo-opinions when confronted with information about a new concept, and increasingly so the less informed respondent (Hammond and Shackley, 2010; Malone et al., 2010). This provides a poor foundation for decision-makers in basing strategic decisions, seeing that such pseudo-opinions often change when people are faced with a real project (*ibid*).

A central task in relation to acceptance of CCS is consequently to provide information as to allow for increasingly informed stakeholders. This is not a matter of creating acceptance and proving CCS, rather a matter of transparent and unbiased information on basis of which stakeholders form their own understandings. Downplaying risks itself holds great risks, should events occur that has been argued as unlikely due to safe operations, seeing how this would undermine confidence in the sender of such information.

4.4 Future research

With that in mind, the case study analysis point to a few gaps in literature, as identified in this report, which would be beneficial to cover either theoretically or based on experience. This includes that literature does not provide any specific insights as to whether CO_2 transport in the offshore context by ship or pipeline would be more or less likely to cause opposition, where both alternatives are included in most case studies. It also includes whether CO_2 emissions from refineries are likely to be perceived as fossil or process emissions, seeing that this may affect acceptance. Another gap is emissions from volcanic origin, although this is a very regional issue. Lastly, although research exists, additional insights would be valuable into how perceptions of capture, transport and storage as individual components. This includes how perceptions of one item in the infrastructure could affect the perceptions of the whole system.

5 Final words and recommendations

This report provide a theoretical background to the research field, insights from studies of real projects as well as an analyses of how the NORDICCS case-studies' contexts relate to previous lessons and the potential perceptions thereof. This is however not an in-depth study and conclusions cannot be seen as definite. However, the results point to a number of contexts that should be prioritised in additional research and project activities in relation to further investigation or realisation of such case studies. As such, it provides recommendations for researchers, potential project owners and policymakers.

Hence, while acknowledging the limitations in the study, it could be argued that a strategy to demonstrate and develop CCS in the Nordic region could face less opposition if being based on capture of industrial process or biogenic emissions from a source that has significant benefits to the regional society and do not interfere with the existing activities and identity of the community, address risks such as CO_2 leakage, use offshore transport to offshore storage, where storage has been present and proven, or reuse of CO_2. Based on analysis in this report, the conditions in the Nordic region could prove as important advantages for CCS implementation.

Based on the analysis, the following are the key recommendations:

- CCS projects should engage in early activities to identify contexts in order to identify how lessons can be transferred from other project experiences. Such efforts can use initial contributions in this report as a basis. Early dialogue with the local community should then be conducted to further gain insight into actual local perceptions.
- A joint Nordic study of perceptions should be carried out, which is designed to provide in-depth insights into how different contexts, and differences thereof may influence the role and development of CCS.
- This should complement and contribute to climate roadmaps, adding to robustness in analyses of the role of CCS in mitigation efforts.

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