Understanding community acceptance and social impacts of CCUS Projects: a meta-narrative literature review.

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1 Executive Summary

Carbon Capture Utilisation and Storage (CCUS) projects contribute to a range of decarbonisation technologies underpinning the aims of the climate change mitigation targets contained within globally significant policies and agreements such as the Kyoto Protocol, the Paris agreement, the European Green Deal, and the Green New Deal in the United States (US). CCUS projects comprise a combination of industrial processes that collectively achieve CO_2 emissions reduction, namely: carbon capture, utilisation, transportation and storage. Individual projects may include the modelling, demonstration, testing, modification, promotion and dismantling of some or all these processes. Such projects are complex as they are conducted according to national and international policy and legislative guidelines involving interrelated technical, financial, political and social factors. This review presents our meta-narrative review of peer-reviewed publications considering community acceptance and social impacts of CCUS projects to inform the design and implementation of site-specific CCUS projects generally and the ConsenCUS project specifically.

We utilised a meta-narrative approach to our systematic review to make sense of the research literature. This iterative approach allowed for publications from a range of research traditions to be identified and analysed to identify the three main areas of contestation. We then explored how these were conceptualised, aspects of commonality and difference, and notable omissions. This facilitated a synthesis of the key dimensions of each contestation to inform our discussion regarding the ways in which to engage with communities during the design, development and implementation of CCUS projects.

We reviewed 53 peer-reviewed papers reporting empirical evidence from studies on community impacts and social acceptance of CCUS projects published between 2009 and 2021. Communities studied were predominantly situated within Euro-American cultural contexts with no studies of communities in China, Africa, India or the Middle East. The majority of the papers (42) reported qualitative research (79%) with residents of the local community. The vast majority of research participants were adults of working age, with only rare mentions of elderly or young adults, children or youth community members. We found no direct involvement of marginalized, under represented and minority groups, such as faith based, ethnic, homeless and economically disadvantaged community members. Whilst 23 of the 53 papers did not specify which aspects of CCUS processes were studied, 25 papers referred to storage, only two considered transportation and three referred to utilisation. The three main areas of contestation identified within the papers were acceptance, communities, and impacts. Key findings for each of these are summarised in Figure 1:

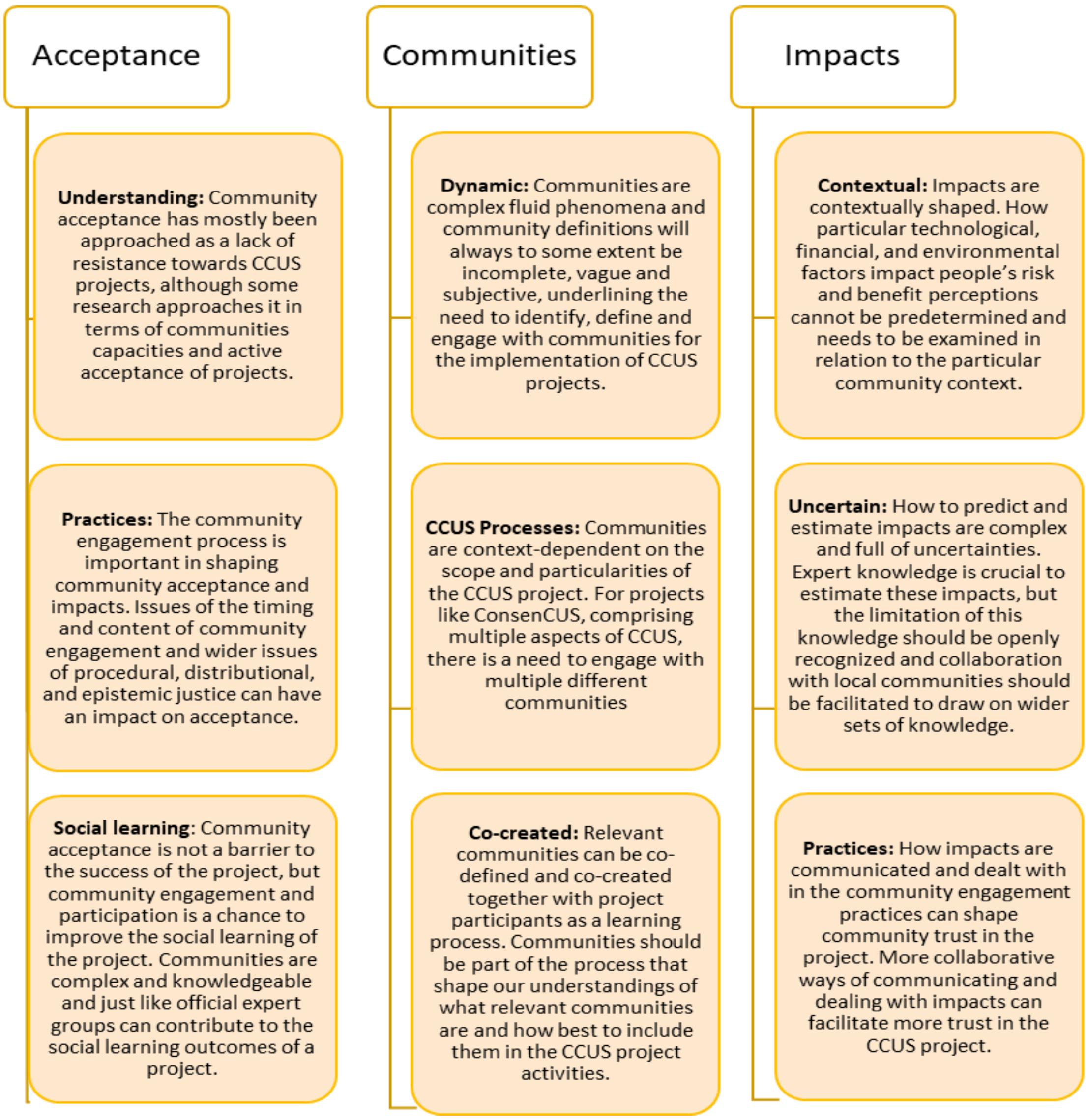

Figure 1 Summary of findings

Our findings show the relationship between community acceptance, impacts, and CCUS projects is complex, each involving unique combinations of many different factors and processes. It is therefore not possible to provide best practice guidelines that will ensure particular outcomes. There are however important methods of engaging communities that could potentially facilitate more comprehensive social learning outcomes. Our recommendations regarding the ways in which to engage with communities during the design, development and implementation of CCUS projects are based on three interrelated principles of providing transparency, acknowledging uncertainty and encouraging collaboration, summarised here in Figure 2. We suggest these project practices as possibilities to inform and inspire the design and implementation of site-specific CCUS projects generally and the ConsenCUS project specifically.

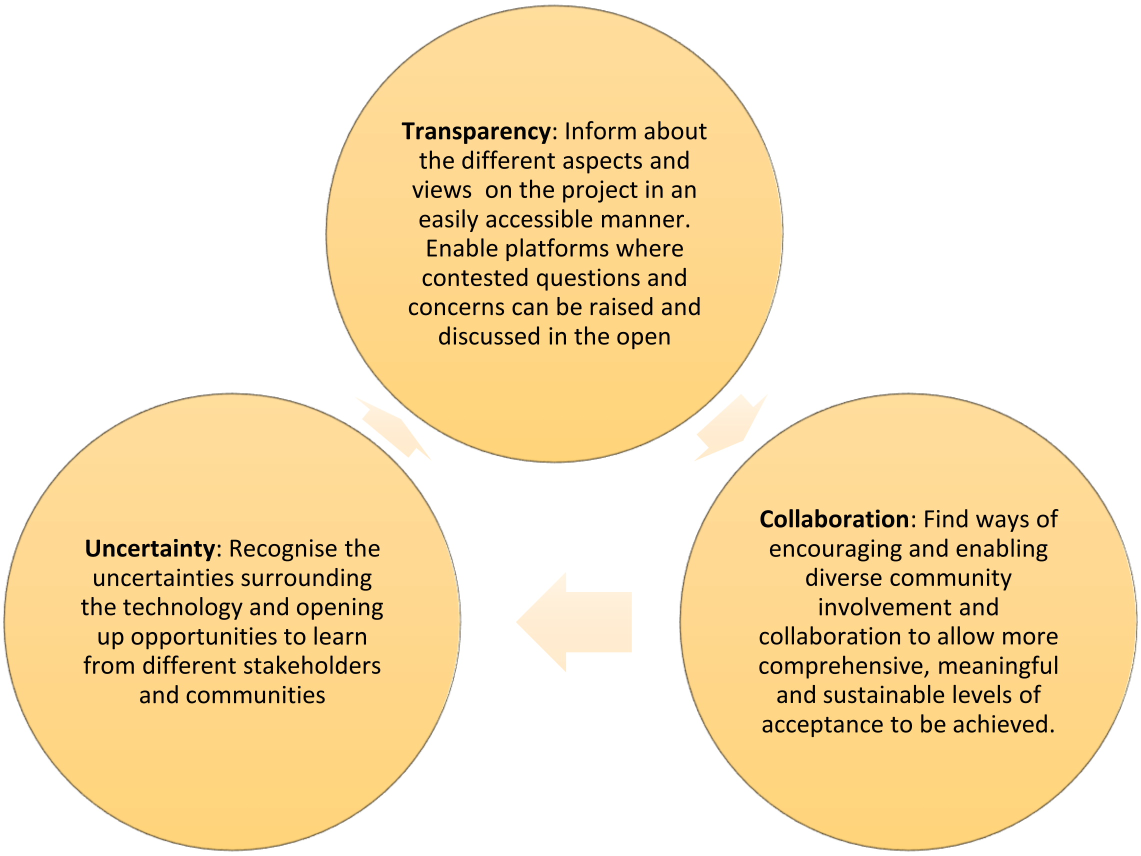

Figure 2 Recommended practices of community engagement

2 Introduction

We conducted a meta-narrative review of peer-reviewed publications considering community acceptance and social impacts of Carbon Capture Utilisation and Storage (CCUS)[1] projects. CCUS has been promoted as an essential technology that allows for the reduction in emissions from fossil fuel and manufacturing processes as well as enabling the removal of carbon dioxide (CO_2) already emitted into the atmosphere (Haszeldine et al. 2018). CCUS projects comprise a combination of industrial processes that collectively achieve CO_2 emissions reduction, namely: carbon capture, utilisation, transportation and storage. Individual projects may include the modelling, demonstration, testing, modification, promotion and dismantling of some or all these processes.

As with other new technologies, CCUS projects have received not just support, but also criticism and opposition in their development (Budinis et al. 2018;Stephens 2014). Whilst the success and failures of CCUS projects (usually known as demonstration or pilot sites) can be influenced by financial, technical, and political factors, one of the main aspects that shape the outcome of past projects has been how communities have responded to them (Reiner, 2016; Terwel et al., 2012; Terwel and Ter Mors, 2015). This recognition of the importance of social factors has led to an increasing focus on the relationship between the local site-specific context and community responses to CCUS projects (Witt, Ferguson, and Ashworth 2020) This has resulted in a range of publications in the last decade that have explored the issue.

To create a rigorous evidence basis for the planning and implementation of community engagement in the ConsenCUS project, we conducted a systematic review that would allow us to learn from previous experiences and research findings on community acceptance and CCUS projects.

[1] A number of different terms have been used for different aspects of carbon capture technologies such as Carbon Capture and Storage (CCS) and Carbon Capture Transport and Sequestration CCTS (Von Hirschhausen, Herold, and Oei 2012) and this diversity of terminology is also reflected in the reviewed literature. As it is not the purpose of this report to differentiate similarities and differences between different terminology, we will use CCUS as a catch-all term when referring to the range of technologies in the field.

2.1 Background - Climate change mitigation and CCUS

The overall increase in human activities and their dependence on fossil fuel consumption has resulted in unprecedented levels of environmental degradation (Abdelkareem et al. 2021; Elsaid et al. 2020). Since the industrial revolution, scientists have recorded a steep increase in human-induced carbon dioxide emissions (CO_2) in the earth-atmosphere-ocean system (Kellogg and Schware 2019), resulting in an overall global temperature rise of 1.2 Celsius (Busby 2018). This CO_2 increase has resulted in the rapid advancement of climate change and its associated environmental, social and economic impacts.

To address this issue a range of climate mitigation policies and strategies have been implemented. Although climate change is a global phenomenon and requires global mitigation efforts, it is often the case that nations around the globe do not have an aligned mitigation strategy, despite consensus on policies and agreements (Heitzig and Kornek 2018). Such policies and agreements include but are not limited to the Kyoto Protocol, the Paris agreement, the European Green Deal, and the Green New Deal in the U.S. One of the most recent climate change mitigation targets is to limit the rise of global temperatures to no more than 2 degrees Celsius, compared to pre-industrial levels. The Paris Agreement states aspirations to keep it below 1.5 degrees Celsius as anything above that might have negative implications for both natural and human systems (Allen et al. 2018). Along with those policies, there have been important developments in infrastructure and technological advancements including renewable energy technologies together with carbon capture, utilisation and storage technologies, with some being more successful than others (Åhman, Skjærseth, and Eikeland 2018).

Despite this plethora of initiatives, and the advancement of low carbon technologies, carbon emissions are still rising (Figueres et al. 2018; Peters et al. 2020; Stoddard et al. 2021). Current CO_2 levels are the highest they have been for at least the past 800,000 years (Cui, Schubert, and Jahren 2020; Lindsey 2020).

Nationally and globally promoted policies that seek to tackle climate change and bolster the reduction of global atmospheric CO_2 levels tend to focus on either carbon emission reduction, such as green energy and carbon dioxide removal (Carton *et al.*, 2020); fossil fuel supply reduction (Piggot *et al.*, 2020); or the use and relationship between each of these strategies (Campbell, Hart, Raimi, and Wolske, 2017; Stuart, Gunderson, and Petersen, 2020). Decarbonisation technologies and processes, both natural and mechanical, such as carbon capture, utilisation and storage (CCUS, also known as carbon sequestration) are increasingly being promoted as part of policy solutions to mitigate climate change (Geden, Peters, and Scott 2019;Kim et al. 2018; Lomax et al. 2015).

Amongst this portfolio of decarbonisation technologies CCUS began to receive attention in the late 1990s from political, industrial and research focused stakeholders and it was soon envisioned that the technology would play an important part in climate mitigation measures and policies (Metz et al. 2005; Von Hirschhausen, Herold, and Oei 2012). The promise of CCUS technologies was presented as enabling both the capture of CO_2 at the point of emission as well as the extraction of CO_2 already released into the atmosphere. Once captured, it was projected that some CO_2 could be reutilised to produce different materials and what was left could be safely stored in underground geological formations.

The realisation of these projections has however been slow to materialise. Although the component processes exist (Von Hirschhausen, Herold, and Oei 2012), CCUS as an integrated system is still a long way from significant contribution to national and global emissions mitigation targets. For example, whilst in 2019 34Mt of CO_2 per year were captured globally, that is still only around 1% of what is estimated to be needed by 2030 if the 2-degree target is to be met (Wang, Akimoto, and Nemet 2021). It has been reported that the lack of CCUS technologies could result in a 138% increase in the total climate change mitigation costs (Change 2014). Furthermore, 43% of all CCUS projects since 1995 have been cancelled or put on hold, and for larger projects that number increases to 78% (Wang, Akimoto, and Nemet 2021).

The consistent barriers to make a dent in total carbon emissions and the extensive challenges facing CCUS technologies indicate how climate change is a wicked problem that involves a range of interconnected social, technical, political and economic issues that make climate change mitigation difficult to address (Head 2008; Incropera 2016). Similarly, CCUS projects are complex, involving a wide range of interconnected technical, financial, political and social factors. One aspect of CCUS projects that has received particular attention is community acceptance of CCUS projects and technologies.

This focus on community acceptance was initially instigated by several CCUS projects that had to be abandoned due to community opposition (Brunsting, De Best-Waldhober, et al. 2011), but has since expanded to include a wider range of concerns such as issues about procedural, distributional and epistemic justice (Mabon and Shackley 2015) and social learning (Nils Markusson, Ishii, and Stephens 2011). Several reviews and empirical studies have been published on peoples' perceptions of carbon capture technologies (Reiner et al. 2006; Shackley et al. 2009; Tokushige, Akimoto, and Tomoda 2007; van Alphen et al. 2007). Whilst these provide partial insights into some of the aspects of community acceptance and CCUS, they often do not pay sufficient attention to the multidimensional social, political, technological and economic aspects of community acceptance of CCUS (L׳Orange Seigo, Dohle, and Siegrist

2014). They furthermore tend to overlook what role the local context and the particularities of the CCUS project play in shaping social acceptance.

Our initial scoping of the community acceptance literature identified a fragmented body of interdisciplinary work with limited coherence or cohesion around the contribution of social factors to the outcomes of CCUS projects. To address and understand this fragmentation, we drew inspiration from the growing literature on meta-narrative systematic approaches that "*treat conflicting findings as higher-order data"* (Greenhalgh et al. 2005, 420) in order to explore the underlying factors that result in different findings. Furthermore, instead of seeking to evaluate all research on community acceptance, we would focus on research that looks at community acceptance in relation to site-specific projects given the site-specific nature of the ConsenCUS project.

Our systematic review identified three key themes within the literature, namely: a) what is meant by communities, b) how is acceptance defined, and c) how are impacts perceived. These themes are explored here following a brief description of our review method. We then go on to consider the implications of our findings for the planning and implementation of the ConsenCUS multisite international CCUS demonstration project.

3 Methods

This report's findings are based on our meta-narrative review of empirical peer-reviewed literature on community impacts and social acceptance of CCUS demonstration sites. 53 research papers were reviewed covering 48 different CCUS sites in North America, South America, Europe, Australasia, and East Asia. Our review was informed by the literature on meta-narrative reviews (Greenhalgh et al. 2005; Greenhalgh and Wong 2013; Wong et al. 2013), although the findings of the review and practical concerns meant that we adjusted some aspect of the method. The meta-narrative review focusses on sense-making of the research literature rather than providing a catalogue of findings (Greenhalgh et al. 2009). It is particularly useful for examining diverse strands of research methods and conceptualisations in order to *"expose the tensions, map the diversity and communicate the complexity*" in the field (Greenhalgh et al. 2005, 427). To help guide the analysis meta-narrative reviews use six guiding principles of pragmatism, pluralism, historicity, contestation, reflexivity, and peer review (Wong et al. 2013) to make sense of the research literature. For more details please consult Appendix 1.

3.1 Scoping the literature:

We conducted an initial scoping review to familiarise ourselves with pertinent literature on CCUS. This allowed us to identify literature gaps and conceptualisations around the topic of CCUS technologies, community awareness and acceptance. Our different epistemological and expert backgrounds facilitated a diverse selection of publications. In contrast with other systematic reviews, the principle of reflexivity and pragmatism in meta-narrative reviews meant that an iterative search approach was followed. This allowed for publications from different research traditions to be included and different perspectives to be considered, and required the inclusion and search criteria to be adjusted through the search phase to reflect our engagement with the body of research. The search phase consisted of systematic searches using key phrases as well as forward and backwards referencing from key articles (see Figure 3)[2].

[2] For more details on the search process consult Appendix 2 and 3.

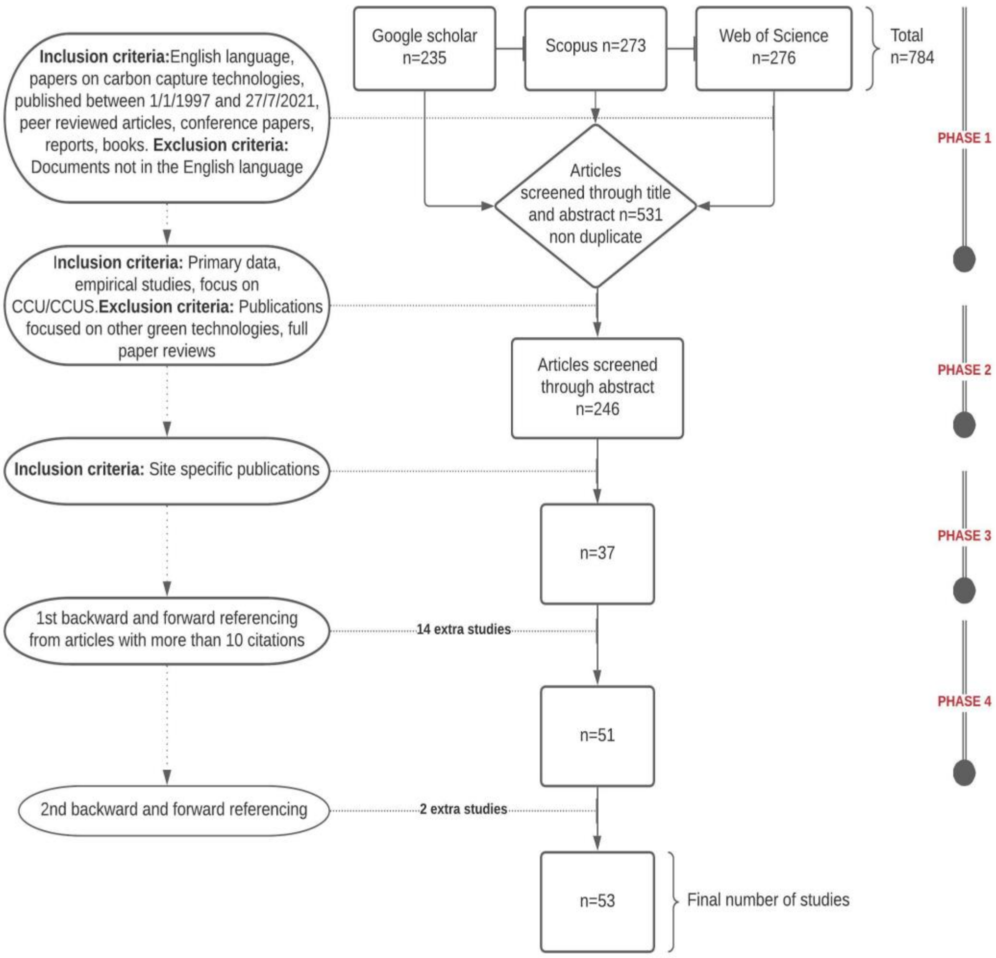

Figure 3. Identification of sources

3.2 Analysis:

In line with the meta-narrative principles, the analytical process was characterised by pragmatism, plurality, reflexivity, historicity, peer-review and contestation. The analysis consisted of a mapping, appraisal, and synthesis phase (Greenhalgh et al. 2005).

In the mapping phase, we thematically analysed all the papers that had been cited more than 10 times (n=27) in Google Scholar, in order to identify commonalities and differences in the types of research questions, methods and theoretical frameworks used. We drew out the key findings in order to map out similarities and differences and started to trace some of the limitations and gaps in the literature. During this phase of analysis we found that acceptance, community, and impacts were concepts that had shaped the key research questions, conceptualisations, and findings. We therefore decided that the review's sense-making focus should be on these three areas of contestation.

In the appraisal phase (Kim et al. 2020) the data was first extracted from the 53 papers in Nvivo ((version 20) 2020). Each paper was coded for findings and discussion related to acceptance, communities and impacts as well as for location, methods and project and policy recommendations. The quality of the papers was evaluated in line with the meta-narrative approach: we did not prioritise particular methodological approaches as being more valid than others as different research paradigms will have different standards for what makes high-quality research. Instead, we appraised the research based on the methodological and theoretical framework used. In the end, we did not exclude any papers based on a lack of quality, which may be a reflection of our limiting the review to peer-reviewed papers.

Finally, in the synthesis phase, we drew on the coded data to identify nine dimensions of community acceptance and CCUS demonstration sites. We grouped these dimensions under the areas of contestation they related to the most, recognising that all the dimensions and areas of contestation often overlapped and were interrelated. To identify and explore these dimensions we looked at how the research body had conceptualised them, what commonalities and differences existed between research approaches, and notable gaps in the research and evidence presented.

4 Results

We reviewed 53 peer-reviewed papers, as seen in Appendix 5, reporting empirical evidence from studies on community impacts and social acceptance of CCUS projects published between 2009 and 2021. We observed no discernable trend in publication rates by year (see Fig 6 & 7, Appendix 4). This may be due to several papers referring to more than one site, and some sites being more researched than others. Figure 4 shows the 53 reviewed papers and their associated CCUS study sites locations together with the number of different papers that have studied each individual CCUS site by country. This demonstrates the predominance of the study of Euro-American culturally situated communities. We could not locate any studies of communities in China, Africa, India or the Middle East.

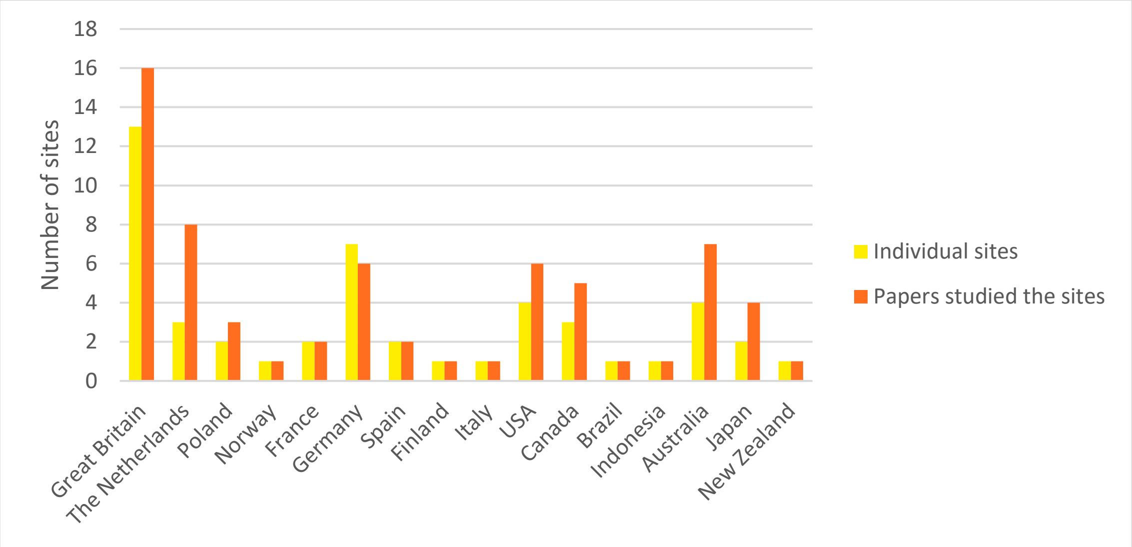

Figure 4 Number of CCUS sites per country

All of the papers reviewed included some primary data. A small number augmented primary data with the use of secondary data. The majority of the papers (42) reported qualitative research (79%), seven (13%) described their methods as qualitative and quantitative, two (4%) as mixed methods and two (4%) as quantitative. We found a general lack of specificity in the papers reviewed. For example, communities were described as local, but the exact locality was not designated. Many studies referred to research participants as community residents, but did not define the boundaries of the residential area studied. Similarly, 23 of the 53 papers did not specify which aspects of CCUS processes were studied. Interestingly, some CCUS processes were more researched than others. Whilst 25 papers referred to storage, only two considered transportation and three referred to utilisation.

In addition to this lack of specificity, we identified a lack of research participant diversity in the studies reviewed. Research examined the outcome of community engagement but there was only very limited evidence of community members having been involved in the research design or dissemination. Most of the research participants were adults of working age, with only rare mentions of elderly or young adults, children or youth community members. We found no direct involvement of marginalized, under represented and minority groups, such as faith based, ethnic, homeless and economically disadvantaged community members.

Accepting these limitations of specificity and community participation and sampling, we focused on acceptance, community, and impact as key areas of contestation conceptualised and approached in a variety of ways within the literature. Within each of these areas we identified a further nine dimensions illustrative of the underlying dynamics that had shaped understandings of acceptance, community, and impacts. These are summarised in Figure 5 and detailed in this section.

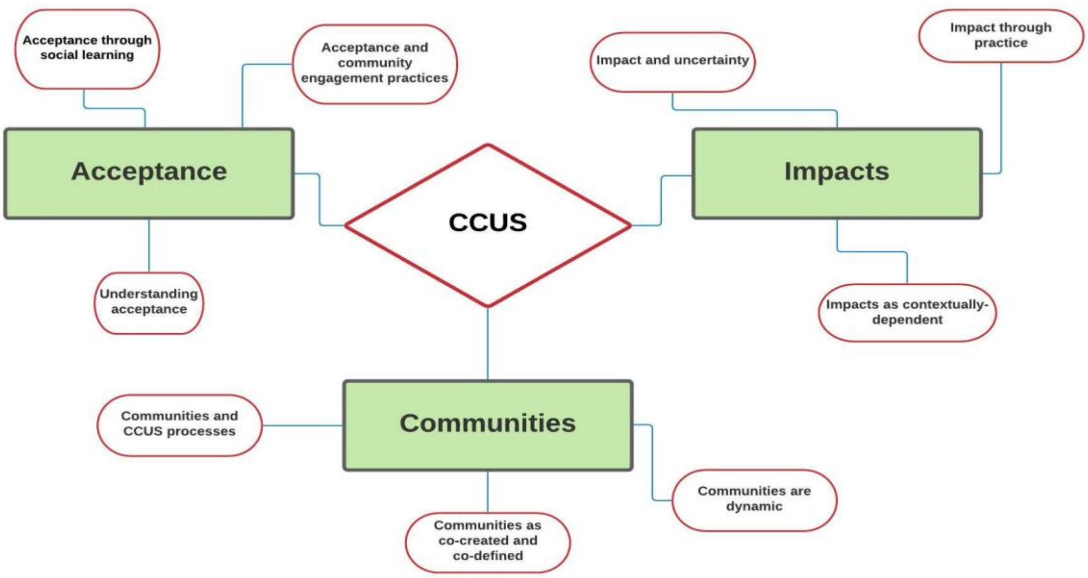

Figure 5. Review themes and sub-themes

4.1 Acceptance

Community and social acceptance of CCUS technologies are considered to be important for the successful implementation of CCUS projects, yet there is still a wide range of understandings about what is meant by acceptance. How '*successful acceptance'* is conceptualised informs project evaluation and shapes our understanding of social factors that might be influential in achieving this. Our review suggests three key dimensions of community and social acceptance:

Key findings

1. Community acceptance has mostly been approached as a lack of resistance towards CCUS projects, although some research approaches it in terms of communities capacities and active acceptance of projects.
2. The community engagement process is important in shaping community acceptance and impacts. Issues of the timing and content of community engagement and wider issues of procedural, distributional, and epistemic justice can have an impact on acceptance. However, to what extent community engagement practices can overcome wider social issues is debatable.
3. Community acceptance is not a barrier to the success of the project, but community engagement and participation is a chance to improve the social learning of the project. Communities are complex and knowledgeable and, just like official expert groups, can contribute to the social learning outcomes of a project.

4.1.1 Understanding acceptance

One of the most common understandings of acceptance in the reviewed papers was a lack of publicly visible resistance. For example, the absence of public protests was interpreted as an indication that a project is accepted "*or at least quietly tolerated"* (Dütschke 2011, 6235). When surveys found a willingness to sign petitions against a specific CCUS project this was seen as a sign that the community did not accept the deployment of CCUS (Terwel, Ter Mors, and Daamen 2012). Acceptance was sometimes understood as consensus amongst established groups, for example where the interests of relevant stakeholders within a particular policy framework had aligned and thereby eliminated any visible opposition (Markusson, Ishii, and Stephens 2011). A lack of visibility of all social groups, including marginalised and under-represented voices, may be assumed as acceptance.

This implicit assumption of acceptance is interesting. In several of the papers reviewed what is meant by "*observed acceptance and resistance*"(Ashworth, Bradbury, Wade, Feenstra, et al. 2012, 403) is not clearly detailed. Whilst local, social, and public acceptance may be mentioned several times (e.g. Oltra et al. 2012) it is not always clear why a lack of public resistance is considered to indicate social acceptance. This lack of clarity might be due to the policy-focused context these papers emerge from. Within the policy context of CCUS, and other renewable energy technologies, acceptance is often conceptualised as a top-down process whereby energy infrastructure projects are "*gifted"* to local communities whose only purpose is to passively accept and tolerate them (Batel, Devine-Wright, and Tangeland 2013). Seen from this perspective the purpose of community acceptability research is to devise engagement strategies and practices that can ensure passive community tolerance of the project. Although research findings using this perspective have provided some valuable lessons in terms of engagement strategies, our review uncovered some limitations to this approach.

Although most of the literature approached acceptance as a lack of resistance, there were a few cases that contested and highlighted some of the limitations of this approach. In one study of a project in Otway, Australia (Anderson, Schirmer, and Abjorensen 2012), it was found that some local communities could not access proper information about the project and did not have the resources to negotiate and engage with the project partners. This resulted in passive acceptance from the community as they did not have the capabilities to make their voices heard. Consequently, even when the project started to disrupt their businesses and cause some personal injuries, it did not result in open protest although it led to increasing dissatisfaction with the project (Anderson, Schirmer, and Abjorensen 2012). Similar issues were found in research that compared how two communities with different material and social resources reacted to a CCUS project. They found that the community that was socially and economically disadvantaged had the same concerns about the potential risk of the projects as the more affluent community, but the disadvantaged did not expect to have their voices heard when addressing these issues due to a sense of disempowerment (Wong-Parodi and Ray 2009).

Given these findings, it is important to consider how to move beyond passive tolerance and acceptance of projects. One suggested approach is to focus on capacity building of the local communities so that they are able to fully access all relevant information about the project and so that they are supported in their efforts to influence how the project is carried out and negotiated (Anderson, Schirmer, and Abjorensen 2012). One small example of how this could be done was the ZeroGen project where a partnership consultation process was established in the planning phase and legal and technical resources were provided to the involved indigenous communities to increase their capacity to influence the project. This consequently led to a sense of partnership between the indigenous communities and the project partners. Although there could still be disagreements the consultation was conducted in an atmosphere of trust (Simpson and Ashworth 2009). These findings also resonate with other research that indicates that communities that feel empowered by their capacity to influence projects and mitigate any potential risks are more likely to accept pilot projects (Netto et al. 2020).

Our review found that there was scope to engage more critically with how acceptance is conceptualised and understood by the project partners. Looking at the wider policy discourse on climate mitigation and adaptation, the concept of communities as passive recipients of climate mitigation and adaptation initiatives goes against many United Nations (UN) agreements, ranging from the Aarhus Convention that guarantees the right for information, participation, and justice in relation to environmental decision making (UNECE 1998) to the more recent Paris agreement that emphasises the importance of participatory approaches, local knowledge systems and the rights of communities and vulnerable groups (UNFCCC 2015). Moving away from top-down technocratic solutions to a participatory process that seeks active community acceptance and support could be argued to be crucial to ensure the sustainability of climate mitigation and adaptation technologies (Barr 2003; McNamara and Buggy 2017). In focusing exclusively on acceptance there is a risk of overlooking other responses and attitudes, such as apathy, uncertainty, and support (Batel, Devine-Wright, and Tangeland 2013), that may be informative in the development and deployment of industrial process technologies.

To conclude, although acceptance is mostly approached as a lack of resistance in the literature, this kind of approach has been contested by a few studies that emphasise the importance of community capacity building to enable a more active form of acceptance. Nonetheless, there are still some gaps in the literature on CCUS projects and learning from the wider research and policy discourse on climate change and mitigation will enable a more robust understanding of the issues around how acceptance is approached as a part of community engagement practices

4.1.2 Acceptance and community engagement practices

Despite different views on what constituted social acceptance, we found some consensus around the importance of continued engagement with key stakeholders and communities to work towards community acceptance. Issues with the community engagement process were often found to be at least one of the explanatory factors behind why projects might be abandoned (Brunsting et al. 2011;Oltra et al. 2012).

One important element in shaping the engagement process was the timing of engagement. A lack of early engagement might be considered by some communities as an indication that their concerns were not being taken seriously, which might in turn increase resentment towards the project (Brunsting et al. 2011; Beddies 2015). As far as possible, communities should therefore be involved early in the process, allowing time to for them to digest the information (Ashworth, Bradbury, Wade, Feenstra, et al. 2012). Preferably the community should be engaged before any final decisions are made in terms of whether to implement the project at all, although that can be practically difficult to achieve (Mabon et al. 2015).

The importance of early community involvement also relates to wider issues of justice examined in some papers. In the CCUS site-specific literature we found three interrelated notions of justice that were used to enhance the community engagement project, namely: procedural, distributional. and epistemic justice.

Procedural justice refers to whether the decision-making process is considered to be fair, transparent and participatory. This could refer to the timing of the community engagement as mentioned above, and also related to past experiences. For communities that had been through a consultation process for other industrial and environmental projects, there could be an expectation that the engagement process would be merely procedural (Williams et al. 2021). This could then result in a negative circle where a perceived lack of procedural fairness resulted in reduced willingness to participate in community engagement initiatives (Shaw et al. 2015).

Distributional justice relates to both how the benefits and risks of CCUS projects are distributed and what the benefits and risks are perceived to be. Whether it was the questions raised about the fairness of how the risk of CO_2 leakage and the benefits of enhanced water recovery were distributed in Queensland (Witt, Ferguson, and Ashworth 2020), or rural Ontario communities' view that they had to shoulder most of the risks so that urban centres could receive the energy and industrial benefits (Shaw et al. 2015), issues of distributional fairness were found to have an impact on how communities perceived projects. Concerns about project motives could also play into a sense of unfairness in how the benefits and risks were understood. For example, there could be scepticism towards whether the project was about addressing CO_2 emissions or facilitating capital accumulation for project partners (Shaw et al. 2015). This focus on distributional justice informs the policy focus on '*just transitions'* that seeks to ensure that communities and workers are not left behind or disadvantaged in the transition away from carbon-intensive industries (Swennenhuis et al. 2020).

Epistemic justice goes beyond distributional and procedural concerns to consider how people may feel marginalised and excluded when it comes to shaping the types of questions that are being asked and accessing the knowledge that is being created in CCUS projects (Mabon and Shackley 2015). Community participants were sometimes found to express notions of epistemic injustice if the CCUS project was seen as being part of a bigger policy where it was assumed that widespread CCUS deployment would and should happen (Mabon and Shackley 2015). For example, in the Barendrecht project, questions about the necessity of CCUS and potential alternatives were deemed irrelevant and suppressed in the community engagement (Brunsting, Desbarats, et al. 2011) This lead to increasing public resistance against the projects that made the project politically problematic and ended with the abandonment of the project (Brunsting et al. 2011).

Whilst notions of procedural, distributional and epistemic justice highlight important factors that can shape community impacts and acceptance, there were perhaps fewer examples of how to overcome these issues. One approach to addressing them was by seeking to use particular forms of community engagements such as "*deliberate engagement process"* and "*deliberative workshops*" (Coyle 2016; Thomas, Pidgeon, and Roberts 2018). These approaches would focus on active listening, the co-creation of knowledge, and the inclusion of diverse views from communities and stakeholders with the hope that, by seeking to foster collaboration, power imbalances between the local community and project stakeholders might be addressed (Coyle 2016; Thomas, Pidgeon, and Roberts 2018).

Although using more collaborative engagement processes is promising in terms of addressing some issues of injustice, it is still unclear to what extent they would be able to deal with procedural, distributional, and epistemic justice concerns. In the wider literature on climate mitigation and adaptation initiatives there has been criticism of the notion that project procedures, no matter how well-intended and how much they seek to be participatory, can end up being symbolic, ignoring structural inequalities and how communities are shaped by influenced by political, social, economic, and environmental factors beyond their control (Smit and Wandel 2006; Kwiatkowski 2011; Fenton et al. 2014; McNamara and Buggy 2017; Westoby et al. 2020).

To sum up, although there was agreement in most papers that the practices of engaging communities could play a role in shaping acceptance, the scope and aim of community engagement practices differed in the literature. Whilst some only focused on the timings and content of the community engagement practices (e.g. Terwel, Ter Mors, and Daamen 2012; Steeper 2013; Szizybalski et al. 2014), other papers conceptualised the scope in much wider justice terms (e.g.Mabon and Shackley 2015; Shaw et al. 2015; Swennenhuis et al. 2020;Witt, Ferguson, and Ashworth 2020). It was however not always clear to what extent community engagement practices in themselves could address the range of issues and concerns that shaped community acceptance.

4.1.3 Acceptance through social learning

Most of the literature approached community acceptance as a barrier that community engagement practices could overcome. However, there were a few papers that examined how the involvement of communities in the CCUS process could be beneficial in terms of contributing to the social learning of CCUS projects. Whilst projects are often framed as part of a technical process, where scientific methods are utilised to establish objective facts that to be communicated to the public and other stakeholders, findings from social science have questioned many of these assumptions (Latour and Woolgar 1986; Law 2004;Stephens, Markusson, and Ishii 2011). CCUS projects, like other technological developments, are characterised by many uncertainties (Mabon et al. 2015) and consist of complex social processes *“that not just about learning technical facts, but also learning about other aspects of the technologies integration into society*” (Stephens, Markusson, and Ishii 2011, 6249).

A paper by Markusson et al (2011) illustrates how a broader social framing of project scope could facilitate social learning. By examining three projects in the United States (US), United Kingdom (UK) and Japan they found that projects that moved beyond technological learning objectives also enabled lessons to be learnt regarding wider social factors as they relate to CCUS projects. For example, the Yubari project in Japan had a technocratic focus on establishing technical and scientific facts that resulted in minimal community engagement with consequently little chance to learn about wider social aspects of CCUS technologies. In contrast, the FutureGen (US) and Longannet (UK) projects sought to look at broader social aspects such as acceptance, education and legal regulations. This allowed more comprehensive social learning lessons to be achieved, although there was still much scope for wider community engagement in these projects (Markusson, Ishii, and Stephens 2011).

Similar issues can be found in the piece by Vercelli and Lombardi (2009) where they reflect on their own journey as dissemination experts in the CCUS field. They started out in their work with a narrow technocratic framing of the issues that resulted in a top-down approach that assumed that they as experts knew what the problem and its solutions was, and that the “public” was nothing but a barrier lacking insight and understanding. Yet as they became more involved in projects they realised that this approach did not *“recognize all the complex socio-cultural aspects that support innovation and problem-solving at the social level*” (Vercelli and Lombardi 2009, 4839).

We identified few concrete examples of how to better facilitate social learning beyond framing the goals of the project more widely to include more community engagement. One suggestion was to try to move towards approaches based on mutual learning patterns. To exemplify the benefits of this approach the researchers engaged with school children aged 9-10 and illustrated how this engagement had helped the researchers clarify the concepts they used whilst illuminating the wider social context of CCUS (Vercelli and Lombardi 2009). Approaching the project assets as *“unstructured problems”,* acknowledging where there are still large uncertainties around whether the technology is appropriate in that particular social setting (Suzanne Brunsting et al. 2011), was another approach that sought to frame the project in a way that would allow better community engagement and more appropriate project and learning outcomes.

Despite these promising examples of how to open up for more social learning, most of the research on CCUS projects has not paid much attention to the relationship between how community acceptance and engagement is approached. This could partly be due to the focus on communities as potential barriers to technological progress rather than as complex and knowledgeable social actors that, just like official expert groups, can contribute to the social learning outcomes of a project.

4.2 Communities

As communities are considered to play a central part in the social acceptance of CCUS technologies, it is critical to examine what is meant by *“communities*”. In the literature, we found that terms like communities and stakeholders[3] were frequently used, but what was meant was mostly implied. Given the importance placed on community acceptance, it was perhaps a surprise that definitions of communities were seldomly discussed in-depth, highlighting an area to be further developed in the CCUS project literature.

Key findings

1. Communities are complex fluid phenomena and community definitions will always to some extent be incomplete, vague and subjective, underlining the need to identify, define and engage with communities for the implementation of CCUS projects.
2. Communities are context-dependent on the scope and particularities of the CCUS project. For projects like ConsenCUS, comprising multiple aspects of CCUS, there is a need to engage with multiple different communities

[3] Although communities and stakeholders as terms to some extent emerge out of different research traditions it is beyond the scope of this review to explore this. Instead, we will approach them as together as the papers mostly did not clearly delineate those terms in the way they were used

3. Relevant communities can be co-defined and co-created together with project participants as a learning process. Communities should be part of the processes that shape our understandings of what relevant communities are and how best to include them in the CCUS project activities.

4.2.1 Communities are dynamic

Our findings identified a range of different ways to implicitly conceptualise communities and stakeholders[4]. Some studies approached communities in terms of geographical boundaries (Anderson, Schirmer, and Abjorensen 2012a; Witt, Ferguson, and Ashworth 2020), whilst others based their definition of communities and stakeholders around social interests in the project (Simpson and Ashworth 2009; Kainiemi, Toikka, and Järvinen 2013; Van Os, Herber, and Scholtens 2014). Others used more ad hoc approaches such as equating the readership of the local newsletter with the community (Steeper 2013). Other descriptions of communities included stakeholders such as governments, NGO's, academia, industries, expert communities (van Egmond and Hekkert 2015; Van Os, Herber, and Scholtens 2014; Vercelli and Lombardi 2009); local communities including, farmers, local residents, and landholders (Szizybalski et al. 2014; Thomas, Pidgeon, and Roberts 2018); and the public including the local population and media and as a representation of the public (Dütschke 2011;Oltra et al. 2012; Thomas, Pidgeon, and Roberts 2018).

Most studies provided no definition or description of *the studied community*. Dütschke, (2011) did not conceptualize that study's community, but rather communities were mentioned as being affected or being informed in the two different projects. Instead, generic social groups are referred to (such as the local public, community representatives, citizens, scientists, opponents), but no specific description is given as to what membership of these groups might comprise. Some studies adopted the characteristics of their participants as the characteristics of an overall community. This was a problematic approach as it often summarised an entire community with between 10 and 20 interviewees. Where definitions of the community were offered, they were vague. For example in a study conducted in Priddis, Canada, participants were grouped as *"1) the general population of the area and 2) those who had a particular stake in the development*

[4] The relationship between communities and stakeholders can be conceptualised in multiple different ways and they will often draw on somewhat different research traditions. However, we found that this relationship was not explored in the site specific CCUS literature and that it was often assumed that stakeholders equalled communities. When talking about communities we therefore also refer to how stakeholders are conceptualised in the literature.

or played a clear role in the opposition of the project" (Boyd 2017, 190). It is not clear here whether a participant opposed to the project (Group 2) was also a member of the general population (Group 1), as all the interviewees were residents of the area too.

This issue of definition hints at the complexity involved in studying communities. Notions of communities as simple, natural, discreet and static parts of the social world have been criticised for being based on unstated assumptions rather than a critical examination of what communities are in all their complexity (Gold 2005). How communities are being formed, contested, understood and experienced relates to a range of local and global social, economic, material, and political processes (Harrington, Curtis, and Black 2008; Bruhn 2011). Whilst communities are often studied and conceptualised as a single unit tied to place or interests, it has been highlighted that actors interrelate across networks that often transcend these imagined community boundaries (Watts 2000). Furthermore, an overemphasis on communities of place and interest fails to attend to ways in which micro-level interactions shape and rework these communities (Studder & Walkerdine, 2016). This is challenging for CCUS projects as environmental issues tend to interlink and move across the scales of historically constituted imagined communities (Anderson 1991; Ribot 2014; McNamara and Buggy 2017). Whilst there can be many reasons why communities in CCUS projects have often been narrowly approached and left unexplored, we argue that it is crucial to consider the wider consequences of the ways in which communities are defined and identified for how community acceptance and impact is approached and made sense of in relation to CCUS projects.

4.2.2 Communities and CCUS processes

Our review suggests that the majority of the research focuses on the connection between community acceptance and the storage of CO_2 rather than other CCUS processes (Figure 6). Transportation was the CCUS process studied the least with two of the reviewed studies exploring transportation impacts.

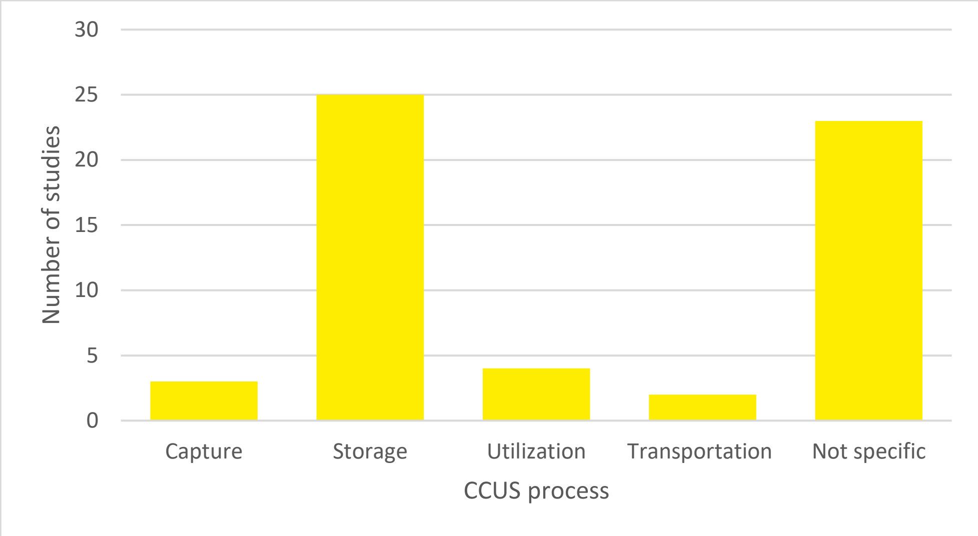

Figure 6. CCUS and the different components studied

As many of the most (in)famous and impactful examples of community resistance have happened around suggested storage sites (e.g. Ashworth, Bradbury, Wade, Feenstra, et al. 2012; van Egmond and Hekkert 2015; Van Os, Herber, and Scholtens 2014), it could be argued that it makes sense to focus exclusively on communities near storage sites as this is where resistance has been most visible. However, this approach utilises a goal-rational framework where communities are seen as risks and barriers that can disrupt CCUS projects at different stages (e.g.Oltra et al. 2012). As mentioned in the discussion on acceptance, this fails to acknowledge justice and human rights issues of climate mitigation initiatives and the potential for community participation to enrich social learning and project outcomes (Stephens, Markusson, and Ishii 2011).

Although the cases that have received most research attention have been storage projects abandoned due to visible public protest, this should not be assumed as an accurate reflection of all CCUS projects, nor does it mean that this pattern will replicate for all projects as some community responses will be contextual and/or determined by the conduct of the particular project. As CCUS covers a range of integrated and connected suites of processes, examining communities solely in relation to one aspect of this technology (e.g., storage) can limit our understandings of underexplored but crucial aspects of community acceptance as it relates to the whole CCUS process.

As discussed, communities can be conceptualised in a range of different ways and it can therefore make sense to define communities in relation to the particular research context and framework. Consequently, research studies should utilise concepts of what a community is as determined by the particularities of that project, rather than on how this has been done in other projects with different sets of characteristics. For some CCUS projects where the storage element is central to the project aims it might make sense to focus on local communities near storage sites. In contrast, for projects such as ConsenCUS, comprising multiple aspects of CCUS, there is a need to engage with several different communities as each community might relate differently to the various processes encompassed within the project.

4.2.3 Communities as co-created and defined

In much of the research reviewed, it was the sole purview of the researcher to define, delineate and determine the project relevant communities, suggesting a view of communities as easily distinct, unchanging, and clearly visible entities. Given the highly context-dependent and ever-transforming nature of communities, as they relate to CCUS projects, this approach is problematic as there will be many unknowns about who the communities might comprise. This is especially pertinent for a project like ConsenCUS that examines multiple aspects of the CCUS process in different social, economic, and geographical clusters. To deal with this complexity it is necessary to engage with potential key actors from across the project who, with their insightful knowledge, can help facilitate a better understanding of the full sets of complex and interrelated communities. As definitions of communities have impacts on who is consulted at which points, and how benefits and risks are distributed, having a distant research team select and predetermine who is relevant might also be perceived as procedural, distributional, and epistemic injustice.

We identified some examples of how to explore communities without reverting to predetermined categories. For example, focus groups conducted at two potential CCUS project sites in England left it open for the participants to deliberate on how to define communities in relation to potential CCUS projects (Gough, Cunningham, and Mander 2018). Within these discussions complex understanding of relevant communities and stakeholders emerged. Issues of scale were found to be conceptualised partly in relation to the specific part of the CCUS process. This meant that when it came to the capture part it was the local place-based community that was seen as key. In contrast, community interests and conflict were conceptualised at the national level in relation to off-shore storage (Gough, Cunningham, and Mander 2018).

These kinds of reflections also informed how CCUS project expert communities approached the issues around engaging with and acquiring social license from relevant communities. Focus groups highlighted the complexity involved in defining and locating the “right” kind of community to engage with. For example, the problematic nature of locating “local communities” when the storage site was located in far-away offshore storage sites was highlighted. Interestingly, it was pointed out that ideally the local community should be sparsely populated as that would make community engagement more manageable (Dowd and James 2014).

How communities are defined, located and engaged with will, to some extent, be shaped by the specific project's concerns and goals. Yet, as far as possible, communities should be part of the processes that shape our understandings of what relevant communities are and how best to include them in CCUS project activities.

4.3 Impacts

The review found that how community acceptance impacted CCUS projects to a large extent related to how risk and benefits were perceived. Although CCUS is often framed as a necessary and beneficial technology, like any other technology there can be potential risks that need to be taken into consideration when evaluating the impact of these new technologies (Fischhoff et al. 1978; Hungerbühler et al. 2021). Risk can however have positive connotations and be associated with potential rewards, benefits and opportunities as often seen within management and businesses (Hillson 2003). Although risks and benefits are sometimes approached separately they can be inversely related to each other, and interlink with different technological, health, business, financial, and environmental aspects of our daily lives (Savadori et al. 2004; Kempf, Merkle, and Niessen-Ruenzi 2014; Gupta et al. 2017; Fiedler et al. 2021).

How risk and benefits are perceived and contested has been shown to play an important role in shaping people's attitudes to technology, such as nuclear energy (Kristiansen, Bonfadelli, and Kovic 2018), renewable energy (Sposato and Hampl 2018), as well as carbon capture and utilisation technologies (Arning et al. 2020). Some perspectives on risk and benefits approach them mainly as "objective" factors where it is possible to calculate the probability for an action to take place and estimating the uncertainties around the consequences of that action (Blacker and McConnell 2015; Yates and Stone 1992). Yet risks and benefits cannot be narrowed down to objectivist estimates that can then be communicated to unknowing publics (Freudenburg and Pastor 1992). Instead, it is important to examine what factors, dynamics and contestations shape risk and benefit perceptions amongst different communities and stakeholders.

Key findings

1) Impacts are contextually shaped. How particular technological, financial, and environmental factors impact people's risk and benefit perceptions cannot be predetermined and should be examined in relation to the particular community context.
2) How to predict and estimate impacts are complex and full of uncertainties. Although expert knowledge is crucial to estimate these impacts, the limitation of this knowledge

should be openly recognized and collaboration with local communities should be facilitated to draw on wider sets of knowledge.

3) How impacts are communicated and dealt with in the community engagement practices can shape community trust in the project. Although no particular engagement practice can guarantee the establishment of trust, more collaborative ways of communicating and dealing with impacts can facilitate more trust in the CCUS project.

4.3.1 Impacts as contextually-dependent

The plethora of risks and benefits associated with CCUS technology can be related to four key aspects of risk, namely: 1) financial; 2) environmental; 3) health; and 4) socio-cultural related. Often the perceived risk of CCUS projects stemmed from uncertainty regarding the technology used, lack of trust in the project owner, lack of technical knowledge, previous experiences with similar projects and technologies and the lack of involvement in decision making (Anderson, Schirmer, and Abjorensen 2012; Coyle 2016;Dowd and James 2014; Oltra et al. 2012). How these different factors end up shaping risk and benefit perceptions is however not predetermined. Throughout the reviewed literature it was common for certain issues e.g., financial and environmental, to be perceived both as a risk and as a benefit by different actors. This distinction often depended on the role of the respondent.

The environmental dimension of risks and benefits is a good example of this distinction. One of the environmental benefits associated with CCUS is as a potential means of climate change mitigation as suggested by some participants (Anderson, Schirmer, and Abjorensen 2012; Ashworth, Bradbury, Wade,Feenstra, et al. 2012; Mulyasari et al. 2021). At the same time, the environmental dimension was perceived as a risk associated with groundwater and soil contamination, marine pollution, natural disasters, and impacts on biodiversity (Ashworth, Pisarski, and Thambimuthu 2009;Boyd 2016;Mabon, Kita, and Xue 2017;Netto et al. 2020; Thomas, Pidgeon, and Roberts 2018).

Another example of differing perceptions of risks and benefits is how financial aspects are often perceived as a risk to the implementation of big-scale CCUS projects by corporations and employees (Mabon and Littlecott 2016; Mander et al. 2011; Markusson, Ishii, and Stephens 2011). Conversely, the potential economic transformation such large scale projects can bring to an area might also be considered as one of the main benefits amongst communities (Gough, Cunningham, and Mander 2018). More specific factors might also elicit different interpretations. In some cases, CCUS projects might be seen as potentially damaging to local tourism and real estate values (Oltra et al. 2012), whereas in other project site locations with different local and social characteristics participants believed that CCUS would attract tourists and financial benefits for the community (Dütschke 2011).

The particular characteristics of CCUS technologies can have an impact on how risk and benefits perceptions form. As a high impact technology (Renn and Zwick 1997), characterised by spatially wide-reaching networks and potential social and environmental impacts across multiple scales, the risk and benefit profile presents some particular challenges as they can often be unequally distributed (Renn and Benighaus 2013). These kinds of concerns links with concerns regarding CCUS and distributional and procedural justice. Some communities might feel they are being exposed to most of the risks whilst others reap the benefits (Shaw et al. 2015; Witt, Ferguson, and Ashworth 2020) and that they are not being involved in decision-making processes that take place outside their communities (Dreyer et al. 2009; Williams et al. 2021).

To sum up, although CCUS projects can have a range of different types of impacts be they economic, environmental, social, or health-related, how these impacts are perceived cannot be predetermined before engaging with the impacted communities.

4.3.2 Impacts and uncertainty

That different factors can be interpreted in multiple different ways only covers part of the complexity involved in determining risks and benefits in relation to CCUS projects. Examining the wider research on risk illustrates how people with different worldviews, identities and experiences will perceived risk differently (Douglas and Wildavsky 1983). These perceptions are formed by wider cultural structures (Douglas and Wildavsky 1983; Kahan, Jenkins-Smith, and Braman 2011). The difficulties of examining risk speaks to the tension between risk as an abstract concept that is shaped by different social factors and the notion of risk as physical reality with material properties (Blacker and McConnell 2015).

In relation to CCUS projects, both risks and benefits are dynamic constructs that can change throughout a project (Ashworth, Pisarski, and Thambimuthu 2009; Simpson and Ashworth 2009). There are different risk and benefit associated dynamics for the various dimensions of CCUS, i.e., capture, storage, utilisation and transportation (Arning et al. 2019; Barker, Hua, and Neville 2017; Jones et al. 2017; Perdan, Jones, and Azapagic 2017). Furthermore, it can be difficult to fully predict how the specific technologies interact with complex environmental processes. For example, the risk of CO_2 leakage (Wennersten, Sun, and Li 2015), could have multiple implications in human health, biodiversity, and groundwater contamination (Gao et al. 2018; Koornneef et al. 2012). Whilst the focus might be on the immediate risk (leakage), the implications can be multiple, and their risk profile can be difficult to evaluate in isolation.

Given that risk is such a complex phenomenon it can be tempting to leave it entirely to the technical, scientific, and social experts to deal with. However, the literature reviewed found that lay people provided with some basic information about the technology can comprehend and address complex issues associated with the risks and benefits of CCUS projects (Mabon, Shackley, and Bower-Bir 2014). Although CCUS experts will have more knowledge about technical aspects any differences in risk perceptions do not relate to greater technical knowledge, but rather to other aspects such as familiarity with the technology, attitudes, emotions, and cultural differences (Oltra et al. 2012).

In some studies, communities illustrated this complex understanding of the issue by recognising that there would always be risk involved with any kind of project. However, this did not mean that they unconditionally approved of the project as they still were uncertain about whether the project team recognised the limitations of their expert knowledge and had made adequate preparations to address any unexpected outcomes (Mabon et al. 2015). When experts and laypeople participated together in citizens panels it was found that the two groups' risk perceptions converged after the panel meetings had taken place (Mander et al. 2011). Whilst impacts of CCUS projects are complex phenomena full of uncertainties and experts will have more in-depth knowledge about the technology, there should still be room to reflect on the robustness and limitations of this knowledge, as well as providing a foundation for open and collaborative community engagement.

4.3.3 Impacts through practice

Whilst we found some examples of collaboration between experts and local communities that enabled a better sense of the risks and benefits, local communities often contested the information provided by the CCUS project partners. The potential risks, dangers and benefits were often found to be the main points of disagreement amongst companies and local community members. To mitigate these points of conflict, communication and public engagement were important considerations to how risks and benefits were perceived by the local community members. Ashworth et al (2012) reported that amongst five different projects they reviewed, the projects that involved early communication and outreach were the ones that experience the least resistance against them. Often that success was due to trust-building amongst companies and local communities, as the local public trusted that the project owners would take all the required risk and safety measures to ensure the smooth operation of the facility (Boyd, 2015; Brunsting et al., 2011). On the other hand, companies often failed to establish any trust with the impacted communities, thus what companies reported as risk and safety measures were seen as inadequate by the public (Williams et al. 2021;Witt, Ferguson, and Ashworth 2020; Wong-Parodi and Ray 2009).

The importance of communicating and engaging constructively with communities in relation to risk can also be seen in the wider literature on risk perceptions. Risk perception is how we understand and acknowledge the risk. Risk perception has been studied both from a cognitive and an affective perspective (Finucane et al. 2000; Loewenstein et al. 2001; Skagerlund et al. 2020), as well as a dual approach process where both cognitive and affective assessments are deliberated (Altarawneh, Mackee, and Gajendran 2018). Cognitive risk perceptions refer to logical and analytical decision making, whereas an affective risk perception is associated with emotional and heuristic-based decisions (Slovic and Peters 2006). In extension, Renn & Benighaus, (2013) describe technological risk perception as the process where a person takes into account the "*physical signals and/or information about potential hazards and risks associated with a technology and the formation of a judgment about seriousness, likelihood, and acceptability of this technology."* (p.293). That judgment is a combination of knowledge, values and feelings towards the technological risk (Renn and Benighaus 2013). It is very important to consider how risk is being framed and communicated in relation to CCUS projects, as it plays an important role in how the risk is perceived by policymakers as well as the public (Greenaway and Fielding 2020; McHugh, Lemos, and Morrison, n.d.)

To conclude, how impacts are perceived is often an area of conflict between the communities and the particular CCUS project. The practices of community engagement and communication can play a role in shaping understandings of impacts. Although there are no set practices that can guarantee particular outcomes, more collaborative forms of communication and engagement can in some circumstances help facilitate more or less trusting relationships between the CCUS project partners and the communities involved.

5 Discussion

The previous sections gave an overview of some of the key dimensions that shape community acceptance and social impacts. The overall aim of this report is to enhance our understanding of community acceptance and social impacts of CCUS projects and consider how these findings might inform the project practices of the ConsenCUS project.

In this section, we discuss evidence-based suggestions and recommendations on how to best incorporate CCUS technologies on projects based on the three practices of:

1) Providing transparency;
2) Acknowledging uncertainty;
3) Encouraging collaboration.

It is important to note that, although at first glance transparency, uncertainty, and collaboration might be perceived as independent processes, there are numerous overlaps amongst them and often one leads to another. For example, lack of transparency may lead to more information uncertainty, and lack of collaboration might lead to lack of transparency. Vice versa, collaboration might lead to decreased levels of uncertainty and greater levels of transparency.

These suggested practices should be seen as guiding practices, but how exactly they can and should be interpreted and implemented is something that will depend on the particular context, the project partners, and communities. ConsenCUS involves activities across several countries involving partners and communities with different cultural, social, and political characteristics which can all influence what is possible in terms of community engagement. Nonetheless, these suggested practices can hopefully help inform beneficial community engagement practices.

5.1 Transparency

Transparency is important as it denotes open decision making, decreased concerns on corruption and makes people and organizations accountable for their actions (Ball 2009). Several reviewed studies reported that participants were concerned that either the government or the project owners were not being truthful with different elements of the project. Vattenfall's (Swedish energy company) site in Brandenburg, Germany, has been used in literature as an example of lack of transparency. Both politicians and the public requested safety-related information from the company, but Vattenfall did not provide them with such information (Beddies 2015). Individuals were concerned that the company would not publish the results from their exploration work (Dütschke 2011), thus reducing their mode of transparency. Another example of lack of public transparency was Shell's project in Barendrecht, Netherlands, where both the government and the company were perceived as not being transparent about the costs, and impacts associated with the project (Oltra et al. 2012). Both Brandenburg and Barendrecht projects were cancelled due to public opposition.

Whether a project is deemed to be transparent relates to how trustworthy the project partners are perceived to be and there is no single set of procedures that can guarantee certain outcomes. Nonetheless, we recommend that throughout the ConsenCUS project as much information as possible about the different aspects of the project are made visible to the public in an easily accessible manner. Importantly, this information should represent a diverse range of views on the piloted technology and the significance of the project. Platforms where contested questions and concerns can be raised and discussed in the open may well help in the transparency process.

5.2 Uncertainty

Innovative CCUS projects, such as ConsenCUS, that seek to provide technological and social learning opportunities will always involve some element of uncertainty. In other CCUS projects both expert and public uncertainty seems to have been associated with lack of knowledge and understanding of the technical aspects of CCUS, as well as functions and processes of ecosystems and the natural environment. From an expert perspective, the uncertainty could be associated with the low technological readiness level (TRL) of CCUS, and not being where it was anticipated to be a decade ago (Bui et al. 2018). On the other hand, based on the analysis of pertinent literature, the public appears to be less concerned about how the technology works and be more concerned about the unknown processes linking CCUS' potential negative impacts on the natural environment as well as public health (Beddies 2015; Boyd 2016).

How this uncertainty is dealt with and how social learning opportunities are created is something that partly depends on how project processes are implemented. A project process that plays down uncertainties while promoting expert knowledge as the only useful way of knowing the world risks alienating impacted communities and stakeholders. Similar results may occur from project processes that ignore aspects of climate treaties and, most importantly, miss a learning opportunity to develop and improve the outcomes of the technology. Instead, by recognising the uncertainties surrounding the technology and opening up opportunities to learn from different stakeholders and communities, the inherent uncertainties of innovative CCUS projects like ConsenCUS can be dealt with more optimally.

5.3 Collaboration

The third and final suggestion is to design and engage in collaboration with communities to achieve social learning. Although collaboration through public engagement cannot ensure the success of a project, examples of previous projects indicate that CCUS projects actively engaging with the public have better chances of being successful compared to projects that do not engage the public. A case study reported that collaborating with the public through independent scientists could bring success to a CCUS project (Coyle 2016). The author emphasized the importance of communities and stakeholders learning from each other as they both possess different types of knowledge. Similar results were found in a study that explored social learning through a comparative analysis of three different carbon capture and storage (CCS) demonstration sites in Japan, the United States, and the United Kingdom (Stephens, Markusson, and Ishii 2011). A notable distinction on the purpose of learning amongst the three sites was that the United States and United Kingdom based projects incorporated both the technical and social dimensions of CCS, whereas the project based in Japan was focused exclusively on the technical dimension of CCS. Stakeholders' concerns should be addressed to encourage a wider scope for learning. This could be achieved through collaboration and engagement activities (Mulyasari et al. 2021;Oltra et al. 2012).

Collaboration can play an important part in developing more comprehensive levels of community engagement. Community perceptions of procedural, distributional, and epistemic justice are deeply interlinked with their active acceptance of CCUS technologies. If communities feel powerless to influence the project it can lead to disruptions to their social acceptance. It is important to find ways of encouraging and enabling community involvement and collaboration to allow more comprehensive, meaningful and sustainable levels of acceptance to be achieved for the project.

6 Conclusion

This meta-narrative review has examined research findings on community acceptance and the social impacts of Carbon Capture Utilisation and Storage (CCUS) projects. 53 research papers were identified and analysed according to the meta-narrative principles of pragmatism, pluralism, reflexibility, contestation, historicity, and peer-review.

We found that acceptance, community, and impact were key areas of contestation that had been conceptualised and approach in a variety of ways within the literature. Our analysis identified a further nine dimensions that illustrated the underlying dynamics shaping understandings of acceptance, community, and impacts. Please consult Figure 1 for an overview of these dimensions.

Although the literature highlighted some important aspects of community acceptance, impact and CCUS projects, we identified many gaps left unexplored. Findings suggest engagement with the wider research on acceptance, community, and impacts, as well as climate mitigation and adaption initiatives, could play a role in developing the field further. Given that research on this topic is relatively new it is perhaps not surprising that these gaps exist. Nonetheless, it means that there is scope to address these evidence gaps.

Despite these limitations in the research literature, there are still some important lessons to be learned. As demonstrated by this review, the relationship between community acceptance, impacts, and CCUS projects is complex, involving many different factors and processes in combinations that may be unique to each project. This means that it is not possible to provide best practice guidelines that will ensure particular outcomes. There are however important methods of engaging communities that could potentially facilitate more comprehensive social learning outcomes.

Based on the findings from the areas of contestation and key dimensions we identified three pillars that can inform project and community engagement practices in ConsenCUS and potentially help improve the social learning opportunities of the project. The pillars were:

1) Providing transparency
2) Acknowledging uncertainty
3) Encouraging collaboration

How these pillars can be translated into specific project practices will depend on the particular context and is not something that can nor should be decided from the top-down. Our aspiration is that these suggestions will be helpful in advising different ConsenCUS project partners and communities as to how to navigate community acceptance and social impacts in this multi-faceted, challenging, and innovative project.

Figure 1 (as shown in the executive summary) overview of findings

7 Appendices

7.1 Appendix 1: Meta Narrative Principles

We detail here the six meta-narrative principles we utilised in this review.

1) P*ragmatism*-The review was guided by the authors' understanding of what would promote sense-making in relation to the ConsenCUS project as well as time constraints. This pragmatic approach resulted in a gradual narrowing of the scope of the literature review from the initial focus on community acceptance and CCUS technologies *in general* to community acceptance in relation to *specific* CCUS demonstration sites as we considered this more useful for the target audience of the report. The particularities of the research design and aim of the ConsenCUS project also meant that rather than focus exclusively on the peer-review principle as something that happens before publication, we aim for this literature review to be the start of an ongoing discussion and "invitation of critical comment from others"(Greenhalgh et al. 2005, 28).

2)*Pluralism*- This principle refers to how simple universal solutions to complex problems seldom exist and that no single theoretical framework will enable a comprehensive understanding of the research findings that explore "wicked" and complicated problems. In practice, this meant that we included studies that used a plurality of methods and theoretical frameworks in their analysis and we also kept the scope of the study wide enough to encompass research no matter what parts of the multidimensional CCUS process they focused on.

3)R*eflexivity*- Meta-narrative reviews is an iterative process that requires reflexivity throughout the process and a willingness to "continually reflect, individually and
as a team, on the emerging findings" (Wong et al. 2013, 7). One of the consequences of this reflexivity was that we moved away from the principle of historicity that explores research traditions as they unfold over time (Wong et al. 2013, 7). As our analysis progressed, we found that the social aspects of CCUS are a relatively new research topic in the social sciences with site-specific literature only starting to be published in 2009 (see Figure 7 and 8). We, therefore, thought it would not add much to the sense-making of the body of evidence on the topic. This also resulted in a choice of taking areas of *contestation* as starting point to elicit sense-making which is a slight shift from other meta-narrative approaches that uses "'storied' accounts of the key research traditions" (Greenhalgh et al. 2005a, 427) to make sense of the literature.

4)*Contestation-* This principle ended up being the starting point for our sense-making of the literature. As our review uncovered a range of findings and recommendations in relation to community acceptance and CCUS projects that could seem contradictory we treated these "conflicting findings as higher-order data"(Greenhalgh et al. 2005, 420) that could be used to move from "simple description" to "higher-level interpretation" (Greenhalgh et al. 2005, 428). Consequently, we found that conflicting findings and understandings of acceptance, community, and risk & benefits were central to how much of the research literature was shaped and we explored what we could learn from these differences.

5)*Historicity-* In meta-narrative reviews, the research is situated in the historical context in which it emerges in order to illustrate how it has been formed by different research traditions. In our bibliometric analysis, it was clear that the literature on CCUS projects had only started to be published recently in 2009. Examining the literature we furthermore also found that the papers were less shaped by well-established research traditions than was perhaps seen in other meta-narrative reviews (Greenhalgh et al. 2005; J. Kim et al. 2020). Given that the research into community acceptance and impact for CCUS projects are relatively new and given that these projects are often characterised by interdisciplinarity it is perhaps not surprising that research traditions are less entrenched than in other research topics. This does however not mean that the papers are not formed by particular research paradigms that influence what types of questions are asked and what research designs and methods are used (Wong et al. 2013). However, it did mean that we choose to focus on the areas of contestation rather than to trace out research traditions that are still only very vague in the field.

6)*Peer-review* receiving critical feedback and reflections on the research is important in all academic work, but for meta-narrative research, it is particularly important as it seeks to cover a range of different research traditions(Greenhalgh et al. 2005). Whilst the peer-review tend to mainly take place before the publication of the work, we decided to try to open up for peer-reviews to shape the findings after the publication. So although we have received some feedback in the process leading up to the publication, we consider this review the starting point of a wider process of co-creating knowledge with everyone involved in and impacted by the ConsenCUS project. As our review indicated the idea of experts having a monopoly on knowledge relating to complex areas characterized by many unknowns is problematic, and we were therefore also hesitant to take such a position in this review. As we receive feedback from the wider community on our findings we hope to update them accordingly in an online version of this document.

7.2 Appendix 2: Identification of relevant literature

To allow for a comprehensive literature search, four separate search phases were conducted. Each phase is described below and is depicted in Figure 3.

Phase 1: Online searches

Three online databases were searched: Google Scholar, Scopus and Web of Science. 13 separate searches were performed in each database with the search dates range starting on 1/1/1997 and ending on the current date of each search. The starting date of 1/1/1997 was selected because that was the year the Kyoto Protocol was signed and before that point, any research on CCUS in relation to climate change was very limited (Karimi and Khalilpour 2015). The specific end dates can be seen in Appendix 3 together with the search terms.

As each search term could elicit thousands of results, we decided to only screen the title and abstract of the first 200 papers sorted by relevance. We furthermore filtered the papers for the following criteria:

- Focus on perceptions, green technology and carbon capture technologies;
- Available in the English language;
- Peer-reviewed journals articles, book chapters; reports and conference papers.

The exclusion criteria were:

- Not available in English;
- Grey literature such as editorials and opinion pieces. [This exclusion was done mainly due to resource limitations and we recognize that by excluding other language resources and grey literature important perspectives and findings might not be included in this review and that this will also further the bias towards projects in Organisation for Economic Co-operation and Development (OECD) countries. We hope in the future to be able to engage more with learning experiences from other similar projects, especially the ones that are part of Horizon 2020 and from geographical areas not covered in this review]

Each search was saved in the respective database for future reference. From this first search phase, 784 publications were identified as useful: 273 from *Scopus*, 276 from *Web of Science*, and 235 from *Google Scholar.* After duplicates were removed there were 531 identified sources. The identified documents were uploaded in Zotero ((version 5) 2017), a referencing software, in a shared group database for the researchers.

Phase 2: Abstract screening

The abstracts of the 531 publications were further screened and reduced to 246 based on our initial inclusion and exclusion criteria.

The inclusion criteria were:

- Empirical studies based on primary data;

- The main focus on CCS/ CCU/CCUS.

The exclusion criteria were:

- Studies focusing on green technologies other than CCUS (e.g. renewables);
- Empirical studies based on secondary data;
- Review paper.

Phase 3: First Snowballing

The 246 publications were further reduced to 37 publications according to the following criteria.

The inclusion criteria were:

- Site-specific studies;
- Studies of several site-specific projects;
- Studies of planned project(s) with at least preliminary permissions.

The exclusion criteria were:

- Nationwide publications;
- Conceptual/fictitious projects.

Those 37 publications were then sorted by highest citation score based on Google Scholar. The 21 studies with more than 10 citations were reviewed as full texts, and a forward and backward citation was performed. 14 extra publications were identified from the forward and backward citation process bringing the total to 51.

Phase 4: Second Snowballing

A final snowball forward and backward citation was conducted in the two extra publications, resulting in two new studies, giving 53 papers for review. At this point, after consensus was reached amongst the researchers, it was agreed that saturation was reached, and the literature search was ended.

7.3 Appendix 3: Search terms and dates

	Search term	Google Scholar	Scopus	Web of Science
1	Carbon capture storage AND communities	13/7/21	27/7/21	15/7/21
2	Carbon capture utilisation AND storage and communities	13/7/21	27/7/21	15/7/21
3	Carbon capture storage impacts AND communities	13/7/21	27/7/21	15/7/21
4	Carbon capture utilisation AND storage impacts and communities	13/7/21	27/7/21	15/7/21
5	Carbon capture storage impacts AND public	13/7/21	27/7/21	15/7/21
6	Carbon capture utilisation AND storage impacts and public	13/7/21	27/7/21	15/7/21
7	Carbon capture storage benefits	13/7/21	27/7/21	14/7/21
8	Carbon capture utilisation AND storage benefits	14/7/21	27/7/21	14/7/21
9	Carbon capture storage risks	14/7/21	27/7/21	14/7/21
10	Carbon capture storage AND utilisation risks	14/7/21	27/7/21	14/7/21
11	Carbon capture storage awareness	14/7/21	27/7/21	14/7/21
12	Carbon capture storage AND utilisation awareness	14/7/21	27/7/21	14/7/21
13	Carbon capture AND social	14/7/21	27/7/21	14/7/21

Appendix 1. Search terms with search dates

7.4 Appendix 4: Bibliometric analysis of research publications

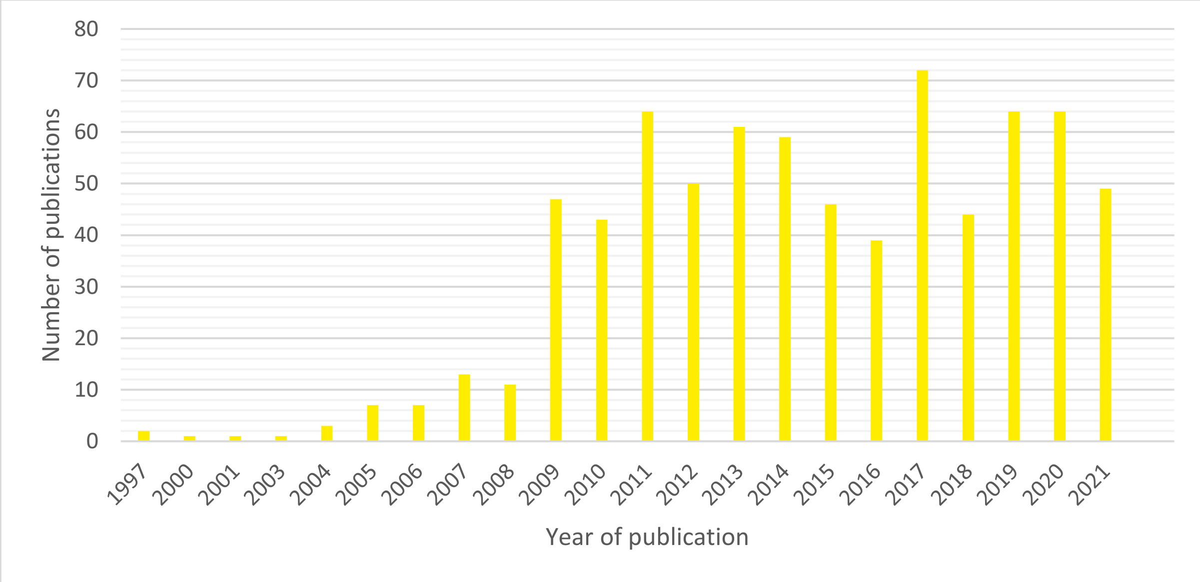

Figure 7. Bibliometric analysis according to study's criteria in phase 1

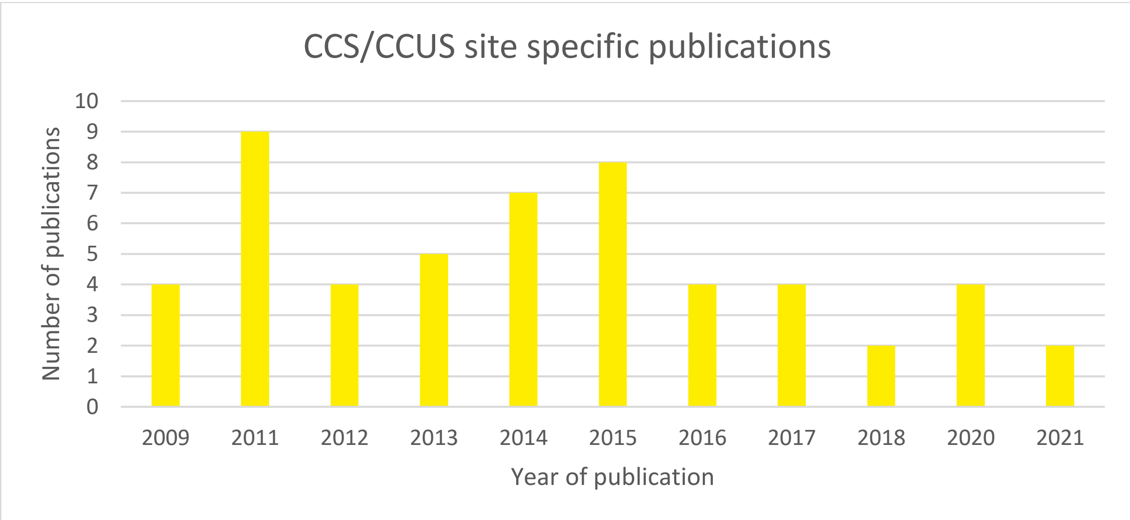

Figure 8. Bibliometric analysis according to study's criteria in phase 4

7.5 Appendix 5: Studies included in the systematic review

	Citation	Number of citations	Location	Methods	Type of CCUS
1	Terwel, B. W., ter Mors, E., & Daamen, D. D. (2012). It's not only about safety: Beliefs and attitudes of 811 local residents regarding a CCS project in Barendrecht. *International Journal of Greenhouse Gas Control*, *9*, 41-51.	79	The Netherlands, Barendrecht	Quantitative	Storage
2	Brunsting, S., de Best-Waldhober, M., Feenstra, C. Y., & Mikunda, T. (2011). Stakeholder participation practices and onshore CCS: Lessons from the Dutch CCS Case Barendrecht. *Energy Procedia*, *4*, 6376-6383.	63	The Netherlands, Barendrecht	Qualitative	Storage
3	Dütschke, E. (2011). What drives local public acceptance–comparing two cases from Germany. *Energy Procedia*, *4*, 6234-6240.	61	Germany, Ketzin-CO2sink, Beeskow-Vattenfall	Qualitative	Storage
4	Markusson, N., Ishii, A., & Stephens, J. C. (2011). The social and political complexities of learning in carbon capture and storage demonstration projects. *Global Environmental Change*, *21*(2), 293-302.	50	Japan, Yubari, Scotland Longannet, USA, FutureGen	Qualitative	CCS
5	Ashworth, P., Bradbury, J., Wade, S., Feenstra, C. Y., Greenberg, S., Hund, G., & Mikunda, T. (2012). What's in store: lessons from implementing CCS. *International Journal of Greenhouse Gas Control*, *9*, 402-409.	44	Australia, OTWAY, ZeroGen, The Netherlands, Barendrecht, USA,Carson, FutureGen	Qualitative	CCS

6	Oltra, C., Upham, P., Riesch, H., Boso, À., Brunsting, S., Dütschke, E., & Lis, A. (2012). Public responses to CO2 storage sites: lessons from five European cases. *Energy & Environment*, *23*(2-3), 227-248.	43	Germany, Beeskow, Ketzin-CO2sink, The Netherlands, Barendrecht, Poland-Belcatow, Sitechar, Spain, Hontomin	Qualitative	CCS
7	Shaw, K., Hill, S. D., Boyd, A. D., Monk, L., Reid, J., & Einsiedel, E. F. (2015). Conflicted or constructive? Exploring community responses to new energy developments in Canada. *Energy Research & Social Science*, *8*, 41-51.	41	Canada, Priddis, Weyburn,	Qualitative and quantitative	CCS
8	Mabon, L., Shackley, S., & Bower-Bir, N. (2014). Perceptions of sub-seabed carbon dioxide storage in Scotland and implications for policy: a qualitative study. *Marine Policy*, *45*, 9-15.	37	Scotland, Argylle, Peterhead	Qualitative	Storage
9	Kern, F., Gaede, J., Meadowcroft, J., & Watson, J. (2016). The political economy of carbon capture and storage: An analysis of two demonstration projects. *Technological Forecasting and Social Change*, *102*, 250-260.	30	Scotland, Longanett, Canada, Alberta-Shellquest	Qualitative	CCS
10	Cuppen, E., Brunsting, S., Pesch, U., & Feenstra, Y. (2015). How stakeholder interactions can reduce space for moral considerations in decision making: A contested CCS project in the Netherlands. *Environment and Planning A*, *47*(9), 1963-1978.	27	The Netherlands, Barendrecht	Qualitative	Storage

11	Anderson, C., Schirmer, J., & Abjorensen, N. (2012). Exploring CCS community acceptance and public participation from a human and social capital perspective. *Mitigation and Adaptation Strategies for Global Change*, *17*(6), 687-706.	27	Australia, OTWAY,	Qualitative	CCS
12	Boyd, A. D., Liu, Y., Stephens, J. C., Wilson, E. J., Pollak, M., Peterson, T. R., ... & Meadowcroft, J. (2013). Controversy in technology innovation: Contrasting media and expert risk perceptions of the alleged leakage at the Weyburn carbon dioxide storage demonstration project. *International Journal of Greenhouse Gas Control*, *14*, 259-269.	26	Canada, Weyburn	Qualitative	Storage
13	Thomas, G., Pidgeon, N., & Roberts, E. (2018). Ambivalence, naturalness and normality in public perceptions of carbon capture and storage in biomass, fossil energy, and industrial applications in the United Kingdom. *Energy Research & Social Science*, *46*, 1-9.	23	England, Shelby-Drax	Qualitative	CCS
14	van Os, H. W., Herber, R., & Scholtens, B. (2014). Not Under Our Back Yards? A case study of social acceptance of the Northern Netherlands CCS initiative. *Renewable and Sustainable Energy Reviews*, *30*, 923-942.	23	The Netherlands, Northern-Netherlands	Qualitative and quantitative	Storage
15	Gough, C., Cunningham, R., & Mander, S. (2018). Understanding key elements in establishing a social license for CCS: an empirical approach. *International Journal of Greenhouse Gas Control*, *68*, 16-25.	22	England, Teeside	Mixed methods	Storage

16	Gough, C., & Mander, S. (2014). Public perceptions of CO2 transportation in pipelines. *Energy Policy*, *70*, 106-114.	22	England, Barmston, Holme on Spalding-Moor, Lancashire,	Qualitative	Transportation
17	Wong-Parodi, G., & Ray, I. (2009). Community perceptions of carbon sequestration: insights from California. *Environmental Research Letters*, *4*(3), 034002.	21	USA, WESTcarb	Qualitative	Storage
18	Ashworth, P., Pisarski, A., & Thambimuthu, K. (2009). Public acceptance of carbon dioxide capture and storage in a proposed demonstration area. *Proceedings of the Institution of Mechanical Engineers, Part A: Journal of Power and Energy*, *223*(3), 299-304.	20	Australia, IGCC	Qualitative	CCS
19	Mabon, L., & Shackley, S. (2015). Meeting the targets or re-imagining society? An empirical study into the ethical landscape of carbon dioxide capture and storage in Scotland. *Environmental Values*, 465-482.	19	Scotland	Qualitative	CCS
20	Kuijper, I. M. (2011). Public acceptance challenges for onshore CO2 storage in Barendrecht. *Energy Procedia*, *4*, 6226-6233.	19	The Netherlands, Barendrecht	Qualitative	Storage
21	Boyd, A. D. (2017). Examining community perceptions of energy systems development: The role of communication and sense of place. *Environmental Communication*, *11*(2), 184-204.	18	Canada, Priddis	Qualitative	CCS

22	Mander, S., Polson, D., Roberts, T., & Curtis, A. (2011). Risk from CO2 storage in saline aquifers: a comparison of lay and expert perceptions of risk. *Energy Procedia*, *4*, 6360-6367.	16	England, Lincolnshire, Scotland, Firth of Forth	Qualitative	Storage
23	Dowd, A. M., & James, M. (2014). A social licence for carbon dioxide capture and storage: how engineers and managers describe community relations. *Social Epistemology*, *28*(3-4), 364-384.	15	General as Australia	Qualitative	CCS
24	Mabon, L., Kita, J., & Xue, Z. (2017). Challenges for social impact assessment in coastal regions: a case study of the Tomakomai CCS demonstration project. *Marine Policy*, *83*, 243-251.	15	Japan, Tomakomai	Qualitative	Storage
25	Boyd, A. D. (2015). Connections between community and emerging technology: Support for enhanced oil recovery in the Weyburn, Saskatchewan area. *International Journal of Greenhouse Gas Control*, *32*, 81-89.	14	Canada, Weyburn	Mixed methods	Utilisation
26	Mabon, L., Shackley, S., Blackford, J. C., Stahl, H., & Miller, A. (2015). Local perceptions of the QICS experimental offshore CO2 release: Results from social science research. *International Journal of Greenhouse Gas Control*, *38*, 18-25.	13	Scotland, Argylle	Qualitative	Storage
27	Brunsting, S., Pol, M., Mastop, J., Kaiser, M., Zimmer, R., Shackley, S., ... & Rybicki, C. (2013). Social Site Characterisation for CO2 storage operations to inform public engagement in Poland and Scotland. *Energy Procedia*, *37*, 7327-7336.	11	Scotland, Moray Firth, Poland,Załęcze and Żuchlów	Quant and Qual	CCS

28	Pietzner, K., Schwarz, A., Duetschke, E., & Schumann, D. (2014). Media coverage of four Carbon Capture and Storage (CCS) projects in Germany: analysis of 1,115 regional newspaper articles. *Energy Procedia*, *63*, 7141-7148.	10	Germany, Altmark, Bradenburg, Ketzin-C02sink,North Frissia	Qualitative and quantitative	CCS
29	Mabon, L., & Littlecott, C. (2016). Stakeholder and public perceptions of CO2-EOR in the context of CCS–results from UK focus groups and implications for policy. *International journal of greenhouse gas control*, *49*, 128-137.	10	England,Peterhead, and Yorkshire	Qualitative	Utilisation
30	Coyle, F. J. (2016). 'Best practice'community dialogue: The promise of a small-scale deliberative engagement around the siting of a carbon dioxide capture and storage (CCS) facility. *International Journal of Greenhouse Gas Control*, *45*, 233-244.	10	New Zealand, Taranaki	Qualitative	CCS
31	Brunsting, S., Desbarats, J., de Best-Waldhober, M., Duetschke, E., Oltra, C., Upham, P., & Riesch, H. (2011). The public and CCS: the importance of communication and participation in the context of local realities. *Energy Procedia*, *4*, 6241-6247.	10	Germany,Beeskow, Ketzin-CO2sink, Bradenburg-Vattenfall, The Netherlands, Barendrecht,	Qualitative	Storage
32	Steeper, T. (2013). CO2CRC Otway Project social research: assessing CCS community consultation. *Energy Procedia*, *37*, 7454-7461.	10	Australia, OTWAY,	Qualitative and quantitative	Storage
33	Hund, G., & Greenberg, S. E. (2011). Dual-track CCS stakeholder engagement: Lessons learned from FutureGen in Illinois. *Energy Procedia*, *4*, 6218-6225.	8	USA, FutureGen,	Qualitative	CCS

34	Szizybalski, A., Kollersberger, T., Möller, F., Martens, S., Liebscher, A., & Kühn, M. (2014). Communication supporting the research on CO2 storage at the Ketzin pilot site, Germany–a status report after ten years of public outreach. *Energy Procedia*, *51*, 274-280.	8	Germany, Ketzin-CO2sink	Qualitative	Storage
35	Ha-Duong, M., Gaultier, M., & deGuillebon, B. (2011). Social aspects of Total's Lacq CO2 capture, transport and storage pilot project. *Energy Procedia*, *4*, 6263-6272.	7	France, Total Lacq	Qualitative	Storage
36	van Egmond, S., & Hekkert, M. P. (2015). Analysis of a prominent carbon storage project failure–The role of the national government as initiator and decision maker in the Barendrecht case. *International Journal of Greenhouse Gas Control*, *34*, 1-11.	7	The Netherlands, Barendrecht	Qualitative	Storage
37	Brunsting, S., Mastop, J., Kaiser, M., Zimmer, R., Shackley, S., Mabon, L., & Howell, R. (2015). CCS acceptability: social site characterization and advancing awareness at prospective storage sites in Poland and Scotland. *Oil & Gas Science and Technology–Revue d'IFP Energies nouvelles*, *70*(4), 767-784.	6	Scotland, Moray Firth, Poland	Quantitative and qualitative	CCS
38	Lupion, M., Pérez, A., Torrecilla, F., & Merino, B. (2013). Lessons learned from the public perception and engagement strategy-experiences in CIUDEN's CCS facilities in Spain. *Energy Procedia*, *37*, 7369-7379.	6	Spain,Cubillos del Sil, Hontomin	Qualitative	Capture and Transport

39	Swennenhuis, F., Mabon, L., Flach, T. A., & De Coninck, H. (2020). What role for CCS in delivering just transitions? An evaluation in the North Sea region. *International journal of greenhouse gas control*, *94*, 102903.	5	Scotland, Aberdeen- ACORN, The Netherlands, Rijnmond. Also Norway, but not site specific	Qualitative	CCS
40	Kahlor, L. A., Yang, J., Li, X., Wang, W., Olson, H. C., & Atkinson, L. (2020). Environmental risk (and benefit) information seeking intentions: The case of carbon capture and storage in Southeast Texas. *Environmental Communication*, *14*(4), 555-572.	4	USA, SouthEast Texas	Quantitative	CCS
41	Boyd, A. D. (2016). Risk perceptions of an alleged CO2 leak at a carbon sequestration site. *International Journal of Greenhouse Gas Control*, *50*, 231-239.	4	Canada, Priddis, Weburn,	Qualitative	Storage
42	Vercelli, S., & Lombardi, S. (2009). CCS as part of a global cultural development for environmentally sustainable energy production. *Energy Procedia*, *1*(1), 4835-4841.	4	Italy, Ciampino	Qualitative	CCS
43	Kainiemi, L., Toikka, A., & Jarvinen, M. (2013). Stakeholder perceptions on carbon capture and storage technologies in Finland-Economic, technological, political and societal uncertainties. *Energy Procedia*, *37*, 7353-7360.	3	Filand, Western Finland	Qualitative	CCS
44	Simpson, P., & Ashworth, P. (2009). ZeroGen new generation power–a framework for engaging stakeholders. *Energy procedia*, *1*(1), 4697-4705.	3	Australia, ZeronGen	Qualitative	CCS

45	Kaiser, M., Zimmer, R., Brunsting, S., Mastop, J., & Pol, M. (2014). Development of CCS projects in Poland. How to communicate with the local public?. *Energy Procedia*, *51*, 267-273.	3	Poland, Sitechar	Qualitative and quantitative	CCS
46	Stephens, J. C., Markusson, N., & Ishii, A. (2011). Exploring framing and social learning in demonstration projects of carbon capture and storage. *Energy Procedia*, *4*, 6248-6255.	2	Japan, Yubari, Scotland Longannet, USA, FutureGen	Qualitative	Capture and storage
47	Netto, A. L. A., Câmara, G., Rocha, E., Silva, A. L., Andrade, J. C. S., Peyerl, D., & Rocha, P. (2020). A first look at social factors driving CCS perception in Brazil: A case study in the Recôncavo Basin. *International Journal of Greenhouse Gas Control*, *98*, 103053	2	Brazil, Rencocavo	Qualitative	Storage
48	Mabon, L. (2017). Responsible Risk-Taking, or How Might CSR Be Responsive to the Nature of Contemporary Risks? Reflections on Sub-seabed Carbon Dioxide Storage in Scotland and Marine Radioactive Contamination in Fukushima Prefecture, Japan. In Corporate Social Responsibility (pp. 205-222). Springer, Cham.	2	Japan, Tomakomai, Scotland, Argylle	Qualitative	Storage
49	Mulyasari, F., Harahap, A. K., Rio, A. O., Sule, R., & Kadir, W. G. A. (2021). Potentials of the public engagement strategy for public acceptance and social license to operate: Case study of Carbon Capture, Utilisation, and Storage Gundih Pilot Project in Indonesia. *International Journal of Greenhouse Gas Control*, *108*, 103312.	1	Indonesia, Gundih	Qualittative	Capture, transport and utilisation

50	Williams, R., Jack, C., Gamboa, D., & Shackley, S. (2021). Decarbonising steel production using CO2 Capture and Storage (CCS): Results of focus group discussions in a Welsh steel-making community. *International Journal of Greenhouse Gas Control*, *104*, 103218.	1	Wales, Port Talbot	Qualitative	Storage
51	Witt, K., Ferguson, M., & Ashworth, P. (2020). Understanding the public's response towards 'enhanced water recovery'in the Great Artesian Basin (Australia) using the carbon capture and storage process. *Hydrogeology Journal*, *28*(1), 427-437.	1	Australia, Great Artesian Basin	Qualitative	Utilisation
52	Beddies, L. (2015). Towards a Better Understanding of Public Resistance: Carbon Capture and Storage and the Power of the Independent-minded Citizen. *MaRBLe*, *5*.	0	Germany, Bradenburg,	Qualitative	Storage
53	Pigeon, J. (2017). What Carbon Capture and Storage (CCS) is Expected to? Describing Potential Future of a CO2 Mitigation Technological System in the Seine Waterway Axis. *Energy Procedia*, *114*, 7333-7342.	0	France, Seine Waterway Axis	Qualitative	CCS

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