MAPPING OF NON-TECHNICAL ASPECTS AND STAKEHOLDER NEEDS

D2.1 Document-repository that offers overview and insight into non-technical aspects.

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Purpose of this Document

The development of Hubs and Clusters for Carbon Capture Utilisation and Storage (CCUS) involves complex non-technical challenges and issues pertaining to the involvement of many different sectors, various actor-types and complex regulatory, and legal conditions as well as the need for coherent monitoring, reporting and verification and development of robust business cases for CCUS value chains. Such complexity pervades both the technical and engineering realm as well as a broad range of non-technical issues.

This document does three things:

1. It offers a **mapping of non-technical issues** that may need to be considered and addressed throughout the development of CCUS value chains. These include current and potential future challenges that may arise or already have emerged during development of CCUS value chains. Such issues are identified through social, political, economic, and legal dimensions. Issues can arise for local, regional, and cross-border activities.

2. The document **serves as a document repository** that links to key literatures and documents for more detailed examination of the issues identified. It does so in a systematic manner by presenting issues in a systematized manner in *issue profiles* which ought to help the user navigate the challenges and – while doing so – gain an overview of the challenges and their interconnections.

3. The document points to opportunities and **steps to resolve such challenges** – for private sector actors, industries or sector representatives as well as for national government.

This document has been developed by the WP2 sub-task leading project partners and benefited from inputs received from networking partners through a survey, individual conversations, online workshops and in-person discussion at CCUS ZEN meetings. As such, it seeks to integrate analytical work with the practical observations and demands of CCUS practitioners.

In carbon emissions mitigation, two concepts are vital: Carbon Capture and Storage (CCS) - capturing CO2 from industries and storing it underground, and Carbon Capture and Utilisation (CCU) - converting CO2 into valuable products. To eliminate confusion between these distinct concepts, this document uses the term CCS when specifically referring to carbon capture and storage. Similarly, CCU is employed to indicate exclusive interest in the utilisation aspect, where CO2 is converted into valuable products. Moreover, the term CCUS is utilized when discussing both CCS and CCU together.

How to use this Document

This document does not present as a report, but rather a systematic collection – a repository – of issues presented in a consistent format. It is designed to be navigated by using the embedded links (rather than read from front to back).

On the following page the user will find a visual overview of the different non-technical issues. The user can navigate through the document as follows:

- Click on any box in the overview to view the corresponding issue profile.
- Click “return” to get back to the overview, or
- jump to other related issues by clicking on the links within an issue profile, or
- find public documents and literatures pertinent to the identified issue.

For the less visually inclined, there is also a table of contents in the page following the visual overview, which can be used in similar fashion.

Overview of Non-Technical Issues Identified (clickable)

Social | Political

- Political development
- Societal challenges
- Public awareness of CCUS
- Social acceptability
- Communication and the ‘information deficit’
- Risk and benefit perceptions
- NIMBY or not?
- Trust in stakeholders
- Cultural factors

Economic

- Business models
- Interaction w. other de-carbonisation tech.
- Complexity of the CCUS value chain
- Marine and land use planning
- Long-term storage liability

MRV | Accounting

- MRV Readiness
- EU CCS Directive Operationalisation
- EU CRCF
- Compensation for leakages
- Voluntary Carbon Market standards
- MRV Methodologies
- Liability in Storage Hubs and Clusters
- Accounting Readiness
- Unclear accounting of BECCS
- Unclear accounting of DAC
- Accounting/reporting of storage and

Legal

- EU CCS Directive
- London Protocol
- Helsinki Convention
- Lack of incentives under the EU ETS
- Transport modalities

Table of Contents

1 Social and political aspects

Social **Political**

- Political development
- Societal challenges
- Public awareness of CCUS
- Social acceptability
- Communication and the 'information deficit'
- Risk and benefit perceptions
- NIMBY or not?
- Trust in stakeholders
- Cultural factors

Back to the Overview of Non-Technical Issues

1.1 Political development

Short name	Political development	Long name	Political development for expediting CCUS
Geographical scope	National level, international level		
Description of how this issue tends to manifest	Currently, two main factors have been changing the political landscape vis-à-vis CCUS in Europe: meeting the climate goals set by the EU and war. Some of the major European countries are lagging their climate goals; hence, seemingly, they need to consider all possible alternatives.[1] Furthermore, after the Russian invasion of Ukraine, the whole process of the energy transition in Europe is under shadow for the seemingly mid-term, while the approach to energy security and security of supply needs to be revisited. In this light, CCS is going to receive more attention as an option to secure energy supply from undesired alternatives like fossil fuels for the short-term and biomass while curbing CO_2 emissions.		
Key examples where this issue manifests	Currently, several countries in Europe, such as a couple of the Nordic[2],[3] (e.g., Sweden and Denmark), Baltic States[4] and Poland[5][6], have revisited their policies against CCUS. These countries are gradually shifting towards supporting CCUS to reduce their CO_2 emissions while securing supply via lesser-desired alternative fuels.		
Other issues this affects	Social acceptance will be affected by political will and favourable policies		

Back to the Overview of Non-Technical Issues

[1] Euractiv. (n.d.). Germany's CO2 emissions stagnate despite renewables expansion. Germany's CO2 emissions stagnate despite renewables expansion
[2] Vangkilde-Pedersen, T., & Skovbjerg, H. (2022). Carbon Capture and Storage (CCS) - the Danish Perspective. Danish Energy Agency. Carbon Capture and Storage (CCS) - the Danish Perspective
[3] Swedish Government Official Reports. (2020). Vägen till en klimatpositiv framtid Statens Offentliga Utredningar: Vägen till en klimatpositiv framtid [The road to a climate-positive future].
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1.2 Societal challenges

Lack of social acceptance and acceptability of CCUS technology, particularly storage	
Geographical scope	National and regional levels, issues identified in Denmark, the Baltic States, Germany; large uncertainties in other countries
Description of how this issue tends to manifest	Lack of social acceptance has historically hindered the development of the technology and led to adverse regulatory action, not least in Germany and the Baltic States. Societal engagement with CCUS and knowledge of its importance for climate change mitigation is, in many countries, very limited and civil society organisations have actively lobbied against CCUS in the past, especially when CCS was presented as an option to decarbonize fossil fuel-based energy infrastructures. Low (climate change mitigation) benefit perception as most laypeople does not reflect on how the industry could be decarbonized and much public discourse focuses on more salient everyday behavioural measures such as recycling.[1] Lack of knowledge of CCUS in general, and limited knowledge on differences between specific value-chains of CCS, CCU, CCUS, BECCS makes for a high level of abstraction (and a low level of perceived benefit). Low benefit perception can increase risk perceived (see the issue profile of risk and benefit perceptions).[2]
Key examples where this issue manifests	• Cancellation of projects in Finland, Germany, and the Netherlands • Challenge of authorities in Denmark with social acceptance • High degree of uncertainty in political commitments. • Uncertain status of some forms of CCUS within policy instruments and limited advocacy for meaningful support.
Other issues this affects	• Lack of compensation and/or support schemes for local communities. • The energy crisis as the aftermath of the Russian invasion of Ukraine might change the perception of the public. • How to shift from social acceptance to social acceptability

Back to the Overview of Non-Technical Issues

[1] Karimi, F., & Komendantova, N. (2017): Understanding experts' views and risk perceptions on carbon capture and storage in three European countries. GeoJournal, 82(1), 185–200

[2] Akerboom, S., Waldmann, S., Mukherjee, A., Agaton, C., Sanders, M., & Kramer, G. J. (2021): Different This Time? The Prospects of CCS in the Netherlands in the 2020s. Frontiers in Energy Research, 9, 193.

1.3 Public awareness of CCUS

Public awareness and knowledge of CCUS – magnitude, gaps, and variation	
Geographical scope	Most research on public perceptions of CCUS focuses on research in European nations (either single countries or comparative).[1,2] North American and East Asian nations are also regularly represented in the research literature.
Description of how this issue tends to manifest	Numerous studies have assessed level of public awareness and specific knowledge about CCUS.[3,4,5] Knowledge and awareness vary cross-nationally, and regionally within countries as well (places with more exposure to industrial projects or government discourse and planning show higher knowledge).[6,7] Nevertheless, across virtually all studies to date, the common finding is that public understanding of CCUS is quite limited.[8] Even if people have heard of it, they know little about it. Over the last two decades of public perceptions research knowledge and awareness are climbing, but slowly.[1,1,1,1,1]
Key examples where this issue manifests	This lack of knowledge could be seen as beneficial for governments or industries seeking to expand deployment of CCUS. If people are poorly informed about a new technology, then this is seen in social psychology as an object to which public attitudes would generally be malleable.[99] There might be potential for further information, and targeted communication, to influence level of support and acceptance. Social scientific research on CCUS repeatedly champions the need for effective communication on this topic – indeed, identifying messages, messengers, visuals, dissemination pathways, and specific language that will lead to higher public acceptance of CCUS is the primary purpose of many such studies.[10]
Other issues this affects	Public support for CCUS, public engagement with CCUS, cross-national variations in CCUS attitudes and beliefs

Back to the Overview of Non-Technical Issues

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1.4 Social acceptability

Social acceptability i.e., the emergence of social acceptance	
Geographical scope	Local level, community level
Description of how this issue tends to manifest	Social acceptability is a combination of social acceptance and social support. Social acceptability[1] is a more democratic and socially inclusive concept than social acceptance, which is a top-down concept and mainly evaluates whether stakeholders and laypeople are not actively opposing or contesting a technology. Social acceptability pertains to engagement of local communities in developing CCS projects[2,3,4,5,6].
Key examples where this issue manifests	• Similar projects are becoming central for renewable energy development. • How a local community can benefit from CCUS projects directly (i.e., social acceptability relates to benefit perception as well). Here benefit perceptions are different: tackling climate change is a primary perception for some, whereas economic benefits for others or both (i.e., tackling climate change and economic benefits)[7] • Local communities initiate CCUS projects[8,9]
Other issues this affects	Lack of legal and policy instruments; complexity of engaging local communities constructively in CCUS projects (not least to provide assurance of liability, and justify high costs).[10]

Back to the Overview of Non-Technical Issues

[1] Social acceptance of low carbon energy and associated infrastructures: A critical discussion
[2] Social acceptance of carbon capture and storage (CCS) from industrial applications
[3] Framing effects on public support for carbon capture and storage
[4] Understanding key elements in establishing a social license for CCS: An empirical approach
[5] Towards a Low-Carbon Society via Hydrogen and Carbon Capture and Storage: Social Acceptance from a Stakeholder Perspective
[6] Public acceptance of CCS system elements: A conjoint measurement
[7] How do people perceive carbon capture and storage for industrial processes? Examining factors underlying public opinion in the Netherlands and the United Kingdom
[8] Not Under Our Back Yards? A case study of social acceptance of the Northern Netherlands CCS initiative
[9] Understanding key elements in establishing a social license for CCS: An empirical approach
[10] Public perception of CCS: A Review of Public Engagement for CCS Projects

1.5 Communication and the 'information deficit'

Short name	Communication and the 'information deficit'	**Long name**	Public communication about CCUS – is it just a case of information deficit?
Geographical scope	Most research on public perceptions of CCUS focuses on research in European nations (either single countries or comparative)[1,2]. North American and East Asian nations are also regularly represented in the research literature.		
Description of how this issue tends to manifest	[Please see the 'Public Awareness' issue profile first for relevant context.] Scholarly attention to communication of CCUS has been critiqued by some scholars; we discuss three reasons here. First, even in studies that reveal a genuine statistically significant empirical connection suggesting that certain information or messages can lead to, or are associated with, higher acceptance, the magnitude (and therefore real world meaningfulness) of the effect is often small. For example, a shift in acceptance of 0.15 on a 1-5 scale of support/opposition, brought on by a new approach to communicating about CCUS, could be statistically significant, but will mean very little for acceptance of a real project[3]. Second, although appeals for effective CCUS communication are nearly universal in the research literature, there are also several claims about 'information deficit' – an empirically invalid assumption that people simply lack information and will necessarily change their views when gaining additional knowledge[4]. The actual evidence from the public perception and communication studies shows a broad mix of additional information marginally increasing support for CCUS, decreasing support, or having no effect[5]. Third, even if communication were to increase acceptance, some scholars question whether this should be the goal[6]. Several studies point to communication (and information design) as one step in a public engagement process, but only an incremental stage that follows understanding of perceived risks and benefits[7], but is then followed by robust and credible public engagement and a transparent decision-making process that reflects the engagement[8,9]. The relational context matters for any energy project, and CCUS deployment is no exception;		

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[2] Selma, L., Seigo, O., Dohle, S., & Siegrist, M. (2014). Public perception of carbon capture and storage (CCS): A review. *Renewable and Sustainable Energy Reviews*, *38*, 848-863.
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	for example, the role of trust in social acceptance is discussed in several other issue profiles[1,2,3,4].
Key examples where this issue manifests	A key consideration for any government or industry actor engaged in CCUS governance or project management will be how to approach communication and interactions with local and national publics. The social scientific literature provides indications that simple messaging and information provision is likely inadequate and more participatory, detailed, and iterative forms of engagement might be helpful[33-36].
Other issues this affects	Public support for CCUS, public engagement with CCUS, public awareness of CCUS, trust in government and industry actors

Back to the Overview of Non-Technical Issues

[1] Broecks, K., Jack, C., Ter Mors, E., Boomsma, C., & Shackley, S. (2021). How do people perceive carbon capture and storage for industrial processes? Examining factors underlying public opinion in the Netherlands and the United Kingdom. *Energy Research & Social Science*, *81*, 102236.
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[3] 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.
[4] 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.

1.6 Risk and benefit perceptions

Short name	Risk and benefit perceptions	**Long name**	Status of knowledge on public perceptions of risks and benefits of CCUS
Geographical scope	There is considerable research into public perceptions of CCUS focuses on research in European nations (either single countries or comparative) but there is no universal alignment between these different studies that would allow inferring generally higher or lower ratios of benefit-risk perception in the general population. North American and East Asian nations are also regularly represented in the research literature.		
Description of how this issue tends to manifest	Numerous studies show evidence that the perception of risks and benefits is inversely correlated. The low perceived benefits of proposed infrastructures often enhance any concerns over possible risks. Nearly all research on public perceptions of CCUS examines beliefs about risks and benefits attributed to the technology and its implementation[1]. Over a multitude of studies, key risks of CCUS have been identified as: 1. CCUS only addressing symptoms of problematic carbon emissions and not the causes[2,3], 2. Incentivisation of CCUS leading to reduced policy incentives to mitigate carbon emissions further (“mitigation deterrence”), 3. Safety concerns over physical leaks of CO2 or explosions due to over-pressurisation, 4. High cost/expenses of the technology resulting in public expenditure or rising product prices[4], 5. Physical uncontrollability of the technology, and 6. Public and scientific uncertainty about the technology[5]. Benefits that are often mentioned include: 1. Reducing carbon emissions, thereby mitigating climate change[1,6,7], and 2. Economic investment in jobs and communities where projects occur. Trust in institutional actors responsible for implementing or regulating projects is regularly revealed as the most important factor that shapes both risk and benefit perceptions[8]. Trust reliably has a much larger effect on risk and benefit perceptions than knowledge of CCUS does[8].		

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Key examples where this issue manifests	Public perceptions research commonly alleges that risk and benefit perceptions are key determinants of support for CCUS, with benefit beliefs being seen as more important for predicting support and acceptance to CCUS generally, and risk beliefs being seen as more important in relation to acceptance of specific local projects[9].
Other issues this affects	Public support for CCUS, public engagement with CCUS, communication about CCUS, cross-national comparisons of CCUS perceptions

Back to the Overview of Non-Technical Issues

1.7 NIMBY or not?

Short name	NIMBY or not?	**Long name**	Is 'Not In My Backyard' a useful explanation for public responses to CCUS?
Geographical scope	Most research on public perceptions in European nations (single countries or comparative). North American and East Asian nations are also regularly represented in the research literature.		
Description of how this issue tends to manifest	Several researchers, and industry actors, focused on energy development siting have termed local opposition to energy projects NIMBY – not in my backyard[1,2]. Nevertheless, leading scholars in this area recommend against such a simplistic and unnuanced description of differential acceptance levels at local and national scales[3]. People local to a project have more awareness of things that could be threatened (or advanced) through the project – e.g., local tourism, cultural meanings, and job prospects[4]. They might also have specific experiences with prior energy development – such as coal mining – which could evoke comparisons to previous industrial problems or accidents, or to loss of trust in industrial and/or government actors that were not good neighbours to local communities[5,6]. The reasons for local opposition are often complex, but do mean that context specific understanding is essential for assessing the viability of specific CCUS projects[7,8].		
Key examples where this issue manifests	Industry, government, and public commentary on CCS opposition has not infrequently labelled (and denigrated) public opposition as 'simply' NIMBY sentiments[9]. The key point here is that higher levels of opposition for populations close to a project need to be examined in depth to understand why this is, and whether there is prospect to address the public concerns. Dismissing public reactions as NIMBY does little to further the goals or viability of a given CCUS project.		
Other issues this affects	Public support for CCUS, public engagement with CCUS, communication about CCUS, spatial comparisons of CCUS perceptions (e.g., local vs national)		

Back to the Overview of Non-Technical Issues

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1.8 Trust in stakeholders

Short name	Trust in stakeholders	**Long name**	Public trust in various stakeholders impacts the acceptance
Geographical scope	National level		
Description of how this issue tends to manifest	Trust in main stakeholders, such as a government, is an important factor in risk perception and acceptance of technology[1]. Higher trust in stakeholders leads to lower risk perception. It seems trust in governments and industry in the Nordic countries is higher[2] cf. rest of Europe, particularly the Mediterranean sea region[3]		
Key examples where this issue manifests	Trust in research and academic sectors and NGOs is consistently ranked high[4]. Consequently, the public relies on what they advocate or verify and prefers to involve with them in decision-making processes rather than stakeholders from industry.		
Other issues this affects	Design of communication materials and deliberation processes		

Back to the Overview of Non-Technical Issues

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[2] Rodriguez, E., Lefvert, A., Fridahl, M., Grönkvist, S., Haikola, S., & Hansson, A. (2021). Tensions in the energy transition: Swedish and Finnish company perspectives on bioenergy with carbon capture and storage. Journal of cleaner production, 280, 124527. https://www.sciencedirect.com/science/article/pii/S0959652620345716
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1.9 Cultural factors

Short name	Cultural factors	**Long name**	Common cultural denominators affect all stakeholders
Geographical scope	National level		
Description of how this issue tends to manifest	Common cultural denominators[1] affect all stakeholders (i.e. laypeople and experts) and shape their risk perceptions in one society similarly. Each society has its very own understanding that decides what is of concern, how to deal with the risk, and what should be given higher priority[2,3].		
Key examples where this issue manifests	Utilising the overlooked impact of common cultural denominators when dealing with the risks and uncertainties of CCUS is crucial for risk governance of CCUS projects vis-à-vis social acceptance. It is likely that country-specific attitudes influence CCUS acceptance (e.g. Germany vs. Sweden).		
Other issues this affects	Common cultural denominators affect other important factors like trust in stakeholders in societies		

Back to the Overview of Non-Technical Issues

[1] Common cultural denominators is 'the collective programming of the mind', such as shared societal values which distinguishes the members of one society from another.
[2] Karimi, F. (2021). Stakeholders' risk perceptions of decarbonised energy system: Insights into patterns of behaviour. Energies, 14(21), 7205.
[3] Karimi, F., & Toikka, A. (2018). General public reactions to carbon capture and storage: Does culture matter?. International Journal of Greenhouse Gas Control, 70, 193-201.

2 Economic aspects

Economic

- Business models
- Interaction w. other de-carbonisation tech.
- Complexity of the CCUS value chain
- Marine and land use planning
- Long-term storage liability

Back to the Overview of Non-Technical Issues

2.1 Business models

Short name	Business models	**Long name**	Development of business models that encourage investment in CCS
Geographical scope	Across all regions		
Description of how this issue tends to manifest	CCS does not produce a 'product' in the traditional sense, so it requires government intervention to make it happen: this can be in the form of government ownership of projects, regulatory requirements, government funding or other measures (see GCCSI 2019[1] for more detail). Different approaches have their merits, but no country has yet found one that drives investment in CCS in the long term (after the end of any initial subsidy period / government investment) and prevents 'carbon leakage' from high-emitting industries moving overseas. Carbon capture and storage can represent a very significant cost-increase with varying shares of output between industries: high capture rate CCS add anywhere from +60% to +100% to the cost of making cement.[2,3] Specific issues include: The need to mitigate and underwrite cross-chain risks, which are particularly high for first-of-a-kind projects. The need for financial security to underwrite CO_2 storage permits. How to address both supply and demand: demand mechanisms could include certification of low-carbon products, accompanied by public procurement rules that require low-carbon materials to be used in major projects; alternatively, governments could set standards for carbon intensity of products. The risk of carbon leakage due to emissions standards or a high carbon price (such as in the EU ETS) can be mitigated by a carbon border adjustment mechanism (CBAM) such as is being developed by the European Commission[4]. The EU CBAM will initially apply to cement, iron and steel, aluminium, fertilisers, electricity and hydrogen, and the transitional phase is due to begin in October 2023. The phasing in of the CBAM will align with the phasing out of free allocations in the EU ETS.		
Key examples where this issue manifests	Enabling all players to make a good business case is crucial: • Having clear economic incentives to realize projects. • EU or country level funding mechanisms • More programs, and with higher budget, like Horizon Europe, the Connecting Europe Facility and the EU ETS Innovation Fund. • Country or EU level compensation mechanisms must be put in place to mitigate the business exposure of the different parties in the value chain if another party underperforms.		

[1] GCCSI (2019) *Policy Priorities to Incentivise Large Scale Deployment of CCS*. Available at: https://www.globalccsinstitute.com/wp-content/uploads/2020/04/TL-Report-Policy-options-for-CCS-investment-digital.pdf
[2] IEA. (2020a). *Energy Technology Perspectives* 2020. Energy Technology Perspectives. https://www.iea.org/reports/energy-technology-perspectives-2020
[3] Kearns, D., Liu, H., & Consoli, C. (2021). *Technology Readiness and Costs of CCS*. https://www.globalccsinstitute.com/resources/multimedia-library/technology-readiness-and-costs-of-ccs/
[4] Carbon Border Adjustment Mechanism

	• Dedicated funding for each project scope. The need for integrated projects, with multiple players, hampers access to funding • Temporary incentives / funding of the gap between CO2 taxes and cost of CCUS • Access to low-cost capital • Massive subsidising scheme for shared CO2 infrastructure • Allow and promote state-aid for the development of infrastructure. Promotion of carbon contracts for difference (CCfDs). Certainty is another important ask: stakeholders also wanted greater certainty on the price of CO_2 to be able to demonstrate a viable business case for investment in CCS projects; they also raised the issue that a change in government can mean changes to subsidy regimes, which make a long-terms business case risky. This raises the importance of cross-party political support for CCUS developments, as well as the importance of subsidy regimes in the form of contracts rather than tax credits or similar incentives, to allow certainty over future income. As well as the funding for projects, stakeholders raised the issue of partnership and ownership structures within projects.
Other issues this affects	Complexity of the CCUS value chain

Back to the Overview of Non-Technical Issues

2.2 Interaction with other decarbonisation technologies

Short name	Interaction with other decarbonisation technologies	**Long name**	Interaction with other decarbonisation and low-carbon technologies
Geographical scope	All regions		
Description of how this issue tends to manifest	Development of CCUS clusters will not happen in a vacuum: at the same time as major CCUS capital and infrastructure projects, similarly large net zero-aligned project such as renewable energy, hydrogen infrastructure and oil and gas decommissioning will also be developed. These projects are likely to be in competition for resources, funding and skilled workers, so long-term strategic planning is needed to ensure that all the activity that needs to happen to reach net zero is able to be done. This includes: • Developing fabrication capacity, including fabrication yards and skilled workers • Ensuring there is sufficient clean energy to run processes (particularly CO_2 utilisation) • Understanding the timing and sequencing of big projects • Where workers are expected to re-train and/or move sector, enabling a just transition. CCUS hubs and clusters can be initiated by a variety of different types of actors, such as state entities, trade or dedicated local industry associations, group of major emitters, or oil and gas operators. The important thing is to have or gain the trust of the other parties in order to build momentum and bring everyone on board in a mutually beneficial and transparent manner. Stakeholders have highlighted the need for a framework that allows cooperation rather than promoting competition for funding: for example, the UK Government Cluster Sequencing Competition has selected the first two clusters to be developed in the UK, both in the north of England. While two clusters will received capital support from the CCS Infrastructure Fund and revenue support through the business models which are being developed, clusters and projects which were not selected are understood not to be eligible to access the revenue subsidies provided by the business models, even if they were able to raise the necessary capital to build their projects. Related to this is a need for an industrial vision for carbon neutrality, particularly within clusters. By working together towards the goal of net zero, industries can benefit from economies of scale and provide reassurance to their supply chain about the ongoing need for products, services and workers. Industries in a cluster that do not have a decarbonisation goal may find it hard to make the case to participate. There are tensions to be addressed between having enough transparency to effectively work together, realise cost-efficiency and avoid monopolies and windfall profits; and protecting competition and trade secrets.		
Key examples	In the UK, industrial clusters have been funded to develop roadmaps for their transition to net zero: the Scottish Net Zero Roadmap[1], Humber		

[1] SNZR Limited; https://snzr.co.uk, United Kingdom.

where this issue manifests	Industrial Cluster Plan[1], South Wales Industrial Cluster[2], Net Zero North West Cluster Plan[3], Repowering the Black Country[4] and Net Zero Tees Valley Cluster Plan[5]. In the UK the CCSA and Nuclear AMRC published a *CCUS Supply Chain Intervention Strategy*[6]. Key recommendations were: • Develop a schedule of key components • Launch a supplier development programme • Increase competitiveness with improved and new production processes • Execute a CCUS-wide supply chain analysis programme In order to avoid conflicts and bottlenecks, this work should extend to all decarbonisation and low-carbon infrastructure. The Scottish Government has established a Just Transition Commission[7], initially to advise Scottish Ministers on how to apply just transition principles[8], and subsequently to provide scrutiny and advice on Scottish Government-led sectoral just transition plans[9]. Stakeholders who responded to the survey additionally highlighted the need to understand the lifecycle cost of renewable energy
Other issues this affects	Complexity of the CCUS value chain

Back to the Overview of Non-Technical Issues

[1] Humber Industrial Decarbonisation Cluster Plan; https://www.humberindustrialclusterplan.org/, United Kingdom.
[2] South Wales Industrial Cluster; https://www.swic.cymru/, United Kingdom.
[3] Net Zero North West; https://netzeronw.co.uk, United Kingdom.
[4] Black Country Local Enterprise Partnership; Repowering the Black Country, https://www.blackcountrylep.co.uk/our-strategy/place/repowering-the-black-country/, United Kingdom.
[5] Innovate UK; Net Zero Tees Valley, https://www.ukri.org/about-us/how-we-are-doing/research-outcomes-and-impact/innovate-uk/net-zero-tees-valley/, United Kingdom.
[6] Namrc.co.uk; CCUS Supply Chain Intervention Strategy, https://namrc.co.uk/wp-content/uploads/2022/03/CCUS-supply-chain-intervention-strategy.pdf, United Kingdom.
[7] Scottish Government (2020): Just Transition Commission reports: Interim Report, https://www.webarchive.org.uk/wayback/archive/20210529112742/https://www.gov.scot/publications/transition-commission-interim-report/
[8] Summarised as: Plan, invest and implement a transition to environmentally and socially sustainable jobs, sectors and economies, building on Scotland's economic and workforce strengths and potential; Create opportunities to develop resource efficient and sustainable economic approaches, which help address inequality and poverty; and Design and deliver low carbon investment and infrastructure, and make all possible efforts to create decent, fair and high value work, in a way which does not negatively affect the current workforce and overall economy.
[9] Just Transition Commission reports include:
Scottish Government (2020): Just Transition Commission reports: Interim Report, https://www.webarchive.org.uk/wayback/archive/20210529112742/https://www.gov.scot/publications/transition-commission-interim-report/
Scottish Government (2020): Advice for a Green Recovery https://www.webarchive.org.uk/wayback/archive/20200730180449/https://www.gov.scot/publications/transition-commission-advice-green-recovery/
Scottish Government (2021): A National Mission for a fairer, greener Scotland https://www.gov.scot/publications/transition-commission-national-mission-fairer-greener-scotland/
Scottish Government (2022): Making the Future – second Just Transition Commission: initial report https://www.gov.scot/publications/making-future-initial-report-2nd-transition-commission/
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2.3 Complexity of the CCUS value chain

<table>
<tr><td>Short name</td><td>Complexity of the CCUS value chain</td><td>Long name</td><td>Complexity of the CCUS value chain</td></tr>
<tr><td>Geographical scope</td><td colspan="3">All regions</td></tr>
<tr><td>Description of how this issue tends to manifest</td><td colspan="3">
The CCUS value chain – CO_2 capture, CO_2 transport and CO_2 storage or utilisation – is likely to involve different, and perhaps multiple, companies at each stage. This establishes cross-chain risk between the different stages of the CCS chain: for example, the CO_2 store developer needs assurance that there will be a supply of CO_2 before they will invest, while a CO_2 emitter will need to be sure there is a destination for the CO_2 before investing in carbon capture.
This cross-chain risk may be compounded in a CCUS cluster, where there are even more organisations that need to reach agreement. CCS has historically been conceived as part of large single-source-to-single-store projects (usually applied thermal power generation using fossil fuel), but as its potential for decarbonising many other industrial sources of CO_2 is increasingly well understood, the need for a multisectoral approach grows. This can include a shared CO_2 transport and storage system which is available for all users; and means that support for infrastructure needs to be available at a time which lines up with support for capture at individual industries.
Additional complexity comes with projects that cross national or regional boundaries and jurisdictions: this is particularly important for the ‘ownership’ of, and long-term liability for, stored CO_2.
Clusters will need to consider:
Availability and maturity of permanent and temporary CO_2 storage – including whether there are companies operating in the transport and storage sector.
Availability of CO_2 transport infrastructure: this includes pipeline and non-pipeline transport. For shipping, attention will need to be paid to the availability and suitability of ships and port infrastructure. This is being explored by the EverLoNG project[1].
Readiness of value chain and operators – this links back to Interaction with other decarbonisation technologies, and issues of competition for resources, funding and skilled workers.
Beyond these headline considerations, other issues include:

Allowing hydrogen or syngas into the gas grid, in order to create a market for gases that have been produced using CCS
Consistent approaches to CO_2 handling and CO_2 specifications across countries
Ability of ships to handle different types of gas

</td></tr>
<tr><td>Key examples where this issue manifests</td><td colspan="3">Survey respondents highlighted the complexity of the value chain and the importance of defining project roles and responsibilities, and contractual arrangements. The uncertainty around the development of CCS and its place in the market also adds to the risks.</td></tr>
</table>

[1] Evergrowing project; (n.d.):Initial report on CO_2 shipping interoperability. https://everlongccus.eu/about-the-project/results

	Some viewed timely development of transport and storage infrastructure as the key to unlocking the economics for CCUS clusters and providing industries with the opportunity to us CCUS to decarbonise. This echoes the view of the UK's 2016 report *Lowest cost decarbonisation for the UK: the critical role of CCS.*[1]
Other issues this affects	Business models, Interaction with other decarbonisation technologies

Back to the Overview of Non-Technical Issues

[1] Oxburgh (2016) Lowest cost decarbonisation for the UK: the critical role of CCS. https://www.research.ed.ac.uk/en/publications/oxburgh-2016-lowest-cost-decarbonisation-for-the-uk-the-critical-

2.4 Marine and land use planning

Short name	Marine and land use planning	**Long name**	Economic implications of complex marine and land-use planning processes
Geographical scope	All		
Description of how this issue tends to manifest	Marine and land-use planning can support or hinder deployment of CCS, depending how they are done. The lack of experience with CO2-storage sites and related infrastructure causes severe uncertainties, which affects the economic viability and attractiveness. Planning policies are determined at the member state, region or more local level and determine what can be built where. Development planning can include a spatial determination of which developments are suitable for which locations, and/or policies to enable planners to decide applications for new developments or change or use / alterations to existing developments. Plans and planning policies can take many years to put in place, and may not be designed to deal with new classes of development such as CCS and hydrogen infrastructure. All of this risks causing excessive barriers to entry and thus can have a deterrent effect on financing. Issues that need to be addressed in spatial planning include how to deal with the potential for competing uses of the sea and seabed, such as for offshore wind, fishing, leisure, nature conservation etc. Competing use-cases for the same surfaces thus can raise the economic threshold for CCUS viability.[1] Onshore, there may be the need for planning authorities to work together on cross-border infrastructure projects. Complex planning applications can take years and can threaten economic viability if this is not factored in at an early stage. Planning is often associated and has interrelationships with environmental and health and safety consenting and permitting. There is likely to be a need for training and capacity building for planners and regulators to know how to deal with new developments including CO_2 capture, and pipeline transport; and lack of capacity and knowledge can delay the process. Excessive planning durations could lead to partners giving up early, thus challenging previously established business cases (as projections of cost and revenues change).		
Key examples where this issue manifests	The UK's Energy Integration Project[2] explores how different offshore energy systems (oil and gas, renewables, hydrogen and carbon capture and storage) could be co-ordinated across the UK Continental Shelf (UKCS) for environmental and efficiency gains, including identifying technical, regulatory and economic hurdles. In 2001 the Scottish Government and partners carried out a regulatory test exercise to understand the many processes and permits required to develop a CCS project; based on this, Scottish Carbon Capture &		

[1] The National Subsea Research Initiative (NSRI); (n.d.): Energy Integration, https://www.nstauthority.co.uk/the-move-to-net-zero/energy-integration, United Kingdom.
[2] https://www.nstauthority.co.uk/the-move-to-net-zero/energy-integration/

	Storage developed a *CCS Regulatory Toolkit*[1]. A review of the regulations around CCS in Scotland has since been updated, but has not been published.
Other issues this affects	Permitting processes, complexity of value-chains, business models,

Back to the Overview of Non-Technical Issues

[1] Scottish Carbon Capture and Storage (SCCS); (2016): CCS Toolkit, https://www.sccs.org.uk/images/expertise/reports/toolkit/CCS-Toolkit-Full.pdf

2.5 Long-term storage liability

Short name	Long-term storage liability	**Long name**	Economic implications of ambiguities in long-term storage liability
Geographical scope	All regions		
Description of how this issue tends to manifest	The CO_2 Storage Directive requires that sometime after closure (to be determined by the competent authority, but at least 20 years) the responsibility for a CO_2 storage site can be transferred from the operator to the competent authority. Differences in MS operationalisation of the storage directive causes economic uncertainty esp. regarding cases of bankruptcies before transferral to national authorities. Storage operators are required to provide financial security (or an equivalent, as determined by the competent authority) to ensure that all obligations under the directive can be met, including taking corrective measures to address and leakages and paying and surrendering EU ETS emissions trading allowances for any escaped CO_2. This has economic implications and any ambiguities (e.g. in permitting processes) can cause problems for the economic viability.		
Key examples where this issue manifests	Are governments prepared to take on the long-term liability for storage once stores have closed? Does it make a difference whether the CO_2 in them is from domestic or international sources?		
Other issues this affects	Business models, GHG accounting, liability in hubs, liability (in the legal sense)		

Back to the Overview of Non-Technical Issues

3 MRV and Accounting aspects

MRV | **Accounting**

- MRV Readiness
- EU CCS Directive Operationalisation
- EU CRCF
- Compensation for leakages
- Voluntary Carbon Market standards
- MRV Methodologies
- Liability in Storage Hubs and Clusters
- Accounting Readiness
- Unclear accounting of BECCS
- Unclear accounting of DAC
- Accounting/reporting of storage and

Back to the Overview of Non-Technical Issues

3.1 MRV Readiness

Short name	MRV Readiness	**Long name**	Readiness of industry practitioners to monitor, report, and verify results
Geographical scope	All regions		
Description of how this issue tends to manifest	MRV is an important element of carbon markets to ensure transparency and accuracy in tracking emissions reductions. MRV typically involves measuring and verifying emissions reductions through various methods, such as on-site inspections, data analysis, and remote sensing. Third-party verifiers are often used to ensure impartiality and accuracy in the MRV process. MRV requirements may differ depending on the type of carbon market and the specific project or program involved. Compliance with MRV requirements is necessary to generate carbon credits and participate in carbon markets, which can provide financial incentives for emissions reductions. Project developers must provide detailed monitoring, reporting, and verification of their emissions reductions or removals, which are then reviewed by independent auditors or verifiers to ensure compliance with established standards and methodologies.[1]		
Key examples where this issue manifests	Expert judgement based on the following factors: • Known presence of geological survey companies • Known previous participation of key actors in carbon markets • Existence of (plans for) CCS activities • Oil/gas industry activity • Existence of a carbon tax or other policy requiring monitoring of CO2-flows		
Other issues this affects	CRCF, EU CCS Directive, MRV methodologies, VCM Standards, Liability (in hubs), Leakage penalties		

Back to the Overview of Non-Technical Issues

[1] Poralla, M.; Honegger, M.; Gameros, C. et al. (2022): Tracking greenhouse gas removals: baseline and monitoring methodologies, additionality testing, and accounting, Perspectives, Germany
Intergovernmental Panel on Climate Change (IPCC) (2019): 2019 Refinement to the 2006 IPCC Guidelines for National GHG Inventories
Intergovernmental Panel on Climate Change (IPCC) (2006): 2006 IPCC Guidelines for National Greenhouse Gas Inventories

3.2 EU CCS Directive Operationalisation

Short name	EU CCS Directive Operationalisation	**Long name**	Operationalisation of Directive 2009/31/EC on the geological storage of carbon dioxide (+ amending Directives) in member states
Geographical scope	European Union (+ Norway)		
Description of how this issue tends to manifest	The EU Directive provides a legal framework for the safe geological storage of CO_2 within the EU, including risk assessment and liability determination. Member states (MS) have the authority to decide whether to allow or prohibit geological storage within their own territory. This Directive follows the regular legislative process between the EU and MS, which involves the Directive being put into national law and all MS informing the Commission of their transposition measures. As of the latest implementation report dated October 2019, 16 MS are fully conforming to the Directive.[1]		
Key examples where this issue manifests	• MS that are not yet conforming to the Directive may fail to adhere to common monitoring and reporting standards. • Diverging national legislation risks causing inconsistencies in the tracking of carbon flows due to diverging definitions and monitoring practices (the EU Directive serves as a common denominator) • The Directive only applies to EU states, so any collaborations (Partnerships/Joint infrastructure) with non-MS countries should be based on agreements and provisions that ensure consistency regarding MRV		
Other issues this affects	MRV Readiness, Liability in hubs		

Back to the Overview of Non-Technical Issues

[1] European Parliament; Council (2009): Directive 2009/31/EC of the European Parliament and of the Council of 23 April 2009 on the geological storage of carbon dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006
European Commission (n.d.): Implementation of the CCS Directive, website
European Commission (n.d.): A legal framework for the safe geological storage of carbon dioxide, website
Deutscher Bundestag (2022): Evaluierungsbericht der Bundesregierung zum Kohlendioxid-Speicherungsgesetz, Drucksache 20/5145
UCL (n.d.): CO2 transport for storage: Regulatory regimes, website
Shogenova, A.; Piessens, K.; Holloway, S. et a. (2014): Implementation of the EU CCS Directive in Europe: Results and Development in 2013

3.3 EU CRCF

Short name	EU CRCF	Long name	EU Carbon Removal Certification Framework[1]
Geographical scope	EU member states (potentially non-EU projects might become eligible also)		
Description of how this issue tends to manifest	The European Union (EU) is developing a regulatory framework for certifying carbon removal. Currently there are significant uncertainties regarding the scope, operation and ultimate use of this framework, which will likely prevail for several years as the instrument matures. Certificates are expected to be generated in a process similar to voluntary carbon market standards, but the EU commission will decide on project types and MRV methodologies. Project types included span three very different categories of carbon dioxide removal projects: 1) permanent removals involving geological storage, 2) removals involving durable storage in products, and 3) "carbon farming" removals. Categories 1 and 2 are relevant for CCU and CCS projects. It is imaginable that categories 1 and 2 might eventually become eligible for creating revenues from the EU ETS. The relevance of these credits to other EU climate policies, such as the Green Deal, EU ETS, ESR, LULUCF, Farm to Fork, and the circular economy, is also uncertain. It is unclear how "approved" credits under the CRCM will be differentiated from other voluntary carbon market credits.		
Key examples where this issue manifests	• The framework might become a meaningful revenue source for operation of CCUS projects in the long term • Fundamental uncertainties about the nature and operation of the framework during the coming years • Will the framework regulate all certification (even when done for voluntary carbon market transactions)? • What will be the demand for CRCF certified credits? • High transaction costs (with unclear added benefit compared to voluntary carbon market) • Unclear embedding in overall EU policy landscape		
Other issues this affects	MRV: the CRCF complicates communication of what the different standards are and how their quality may be judged Accounting: the CRCF obfuscates the relationship between voluntary carbon markets and compliance efforts and their already complex relationship with national GHG inventory accounting		

Back to the Overview of Non-Technical Issues

[1] European Commission (2023): Carbon Removal Certification, website landing page

3.4 Compensation for leakages

Short name	Compensation for leakages	**Long name**	Penalties for leakages and other disturbances in national legislation
Geographical scope	National + International		
Description of how this issue tends to manifest	Does national legislation – or do the permitting provisions – forsee compensation requirements imposed on the operator in case of leakage and other disturbances in CCUS value chains – which actor is to be penalised if leakage and other disturbances happen (capture, transport, storage provider)?[1] Carbon market standard setters have developed instruments to regulate any financial harm arising from leakage (e.g. Verra's non-permanence risk tool for geological storage). National regulators arguably need to have regulations or permitting-provisions in place in order to impose penalties on private operators of CO2 transport and storage sites. The EU CCS Directive provides for some such guidance, but national legislation needs to operationalize them. Some uncertainty also pertains to the liability distribution amongst carbon market standard setters, project proponents and national governments.		
Key examples where this issue manifests	• What about leakage happening in shared, cross-border infrastructure? • What about various entities operating along the CCS value chain? • What about leakage happening during CO2 transport via ships, who are in international waters?		
Other issues this affects	MRV - who is responsible for reporting leakage?		

Back to the Overview of Non-Technical Issues

[1] Vinca, A.; Emmerling, J.; Tavoni, M. (2018): Bearing the Cost of Stored Carbon Leakage

3.5 Voluntary carbon market standards

Short name	Voluntary carbon market standards	**Long name**	Ongoing VCS methodology development
Geographical scope	Global		
Description of how this issue tends to manifest	CCS is an important mitigation solution, but there has not been a comprehensive set of methodologies available for various CCS projects to access voluntary carbon markets and generate carbon revenue. However, an industry consortium called CCS+[1] is currently developing a methodological framework with robust requirements for monitoring, reporting, and verification (MRV) and additionality. Public consultations on these new methodologies are ongoing and can be accessed at https://verra.org/consultations/. In 2023, methodologies for a full range of CCS projects, including those that reduce emissions and those that involve carbon capture and utilisation (CCU) and carbon removals, will become available through Verra's Voluntary Carbon Standard (VCS).		
Key examples where this issue manifests	• Awareness of the fundamental MRV requirements involved in carbon market methodologies among carbon market stakeholders is low • Consequent adoption of high-quality and consistent methodologies is important for environmental integrity and credibility. • CCS is seen by some NGOs and publics as risky, consistent messaging on MRV requirements is key to build trust		
Other issues this affects	MRV Readiness, MRV methodologies		

Back to the Overview of Non-Technical Issues

[1] CCS+ Initiative (2023): CCS+ Initiative

3.6 MRV methodologies

Short name	MRV methodologies	**Long name**	Lack of harmonised framework for monitoring, reporting and verification (MRV)
Geographical scope	National + International		
Description of how this issue tends to manifest	• Lack of internationally developed, and adopted MRV framework • Those MRV methodologies that are available are limited in terms of geographical scope, activity types or linkage to specific market mechanisms/regulatory frameworks • Building upon and harmonising best practices • Environmental integrity principles need to be at the centre of these methodologies[1]		
Key examples where this issue manifests	• CCS+ initiative working on internationally available (under Verra's VCS) MRV framework • Available methodologies to date also differ in terms of their quality: environmental integrity vs. practicality		
Other issues this affects	MRV Readiness, Liability in hubs		

Back to the Overview of Non-Technical Issues

[1] Poralla, M.; Honegger, M.; Gameros, C. et al. (2022): Tracking greenhouse gas removals: baseline and monitoring methodologies, additionality testing, and accounting, NET-Rapido Consortium and Perspectives Climate Research, London, UK and Freiburg i.B., Germany
Intergovernmental Panel on Climate Change (IPCC) (2019): 2019 Refinement to the 2006 IPCC Guidelines for National GHG Inventories
Intergovernmental Panel on Climate Change (IPCC) (2006): 2006 IPCC Guidelines for National Greenhouse Gas Inventories

3.7 Liability in Storage Hubs and Clusters

Short name	Liability in Storage Hubs and Clusters	**Long name**	Liability for leakages and other disturbances in joint hubs and clusters
Geographical scope	National + International		
Description of how this issue tends to manifest	In a storage hub CO2 from multiple different sources is being stored. In case of a leakage along a mixed capture, transport and storage chain it is somewhat unclear how to physically attribute a specific ton of CO2 to a specific source. Therefore, a clear liability regime is needed, which provides for rules for legal attribution that fits with the monitoring practices along the value chain to provide legal clarity in such cases. While the storage provider is liable for leakage from the storage site, agreements between the storage provider and CO2 suppliers could also foresee sharing some of the corresponding financial risk, but this would have to be based on a clear attribution rule.[1]		
Key examples where this issue manifests	While the national GHG inventory accounting guidelines are clear that leakage emissions are to be reported by the country in which the leak occurs, the legal liability might be less clear, should the country have legislation in place to hold the operator to account in a cases of leakage events – especially at intersections in the CCUS chain, where liability might not be clearly attributable to one single actor and where the CO2 stream already stems from multiple sources. Does the storage provider (e.g. Northern Lights) and/or jurisdiction (e.g. Norway) take full responsibility for leakage (or only if all entities are Norwegian?)		
Other issues this affects	Accounting Readiness, Liability, MRV Readiness, Bilateral agreements		

Back to the Overview of Non-Technical Issues

[1] Havercroft, I.; Macrory, R (2014): Legal liability and carbon capture and storage
International Energy Agency (2022): Legal and Regulatory Frameworks for CCUS

3.8 Accounting Readiness

Short name	Accounting Readiness	**Long name**	Readiness of the national GHG inventory responsible office
Geographical scope	All regions		
Description of how this issue tends to manifest	Accurate and transparent GHG inventories at national levels are crucial for tracking progress towards emissions reduction targets and informing climate policy decisions. A robust inventory system helps ensure that countries are held accountable for their emissions and can lead to increased trust and cooperation in international climate negotiations. It also helps to identify areas where emissions reduction efforts can be targeted most effectively.		
Key examples where this issue manifests	Expert judgment based on the following factors: - previous engagement on CCS-related accounting questions - overall quality of previous GHG inventory reports including accuracy, completeness, comparability, transparency, and consistency over time		
Other issues this affects	Liability in Hubs, Accounting of leakage, Accounting of DACS, Accounting of BECCS		

Back to the Overview of Non-Technical Issues

3.9 Unclear accounting of BECCS (negative emissions)

Short name	Unclear accounting of BECCS (negative emissions)	**Long name**	Lack of clarity where (which sub-sector) BECCS is reported in GHG inventories
Geographical scope	All regions, International		
Description of how this issue tends to manifest	Engineered greenhouse gas removals need to be included in national accounting and reporting, otherwise there is little incentive to do them. While the voluntary carbon removal market is growing as companies are willing to pay to offset their emissions, without a legal basis and standards for measuring or calculating CO_2 removals, there is little certainty or incentive for companies with existing biogenic CO_2 emissions to invest in capturing and storing them. The EU Climate Law allows for engineered greenhouse gas removals to be counted in its inventory, but it is unclear whether this is the case in national law		
Key examples where this issue manifests	The UK Energy Bill[1] includes a provision to amend the Climate Change Act 2008[2] so that engineered greenhouse gas removals can be counted – previously "removals" would only be counted if they came from land-use, land-use change and forestry.		
Other issues this affects	Accounting Readiness		

Back to the Overview of Non-Technical Issues

[1] UK Parliament; (2021): Energy Bill, https://bills.parliament.uk/bills/3311, London, United Kingdom.
[2] The National Archives; (2008): Coroners and Justice Act 2009, https://www.legislation.gov.uk/ukpga/2008/27/contents, London, United Kingdom.

3.10 Unclear accounting of DAC (negative emissions)

Short name	Unclear accounting of DAC (negative emissions)	**Long name**	Lack of clarity where (which sub-sector) DAC is reported in GHG inventories
Geographical scope	International		
Description of how this issue tends to manifest	National greenhouse gas inventories serve for tracking developments in national emissions and removals. Direct air capture of CO2 is a novelty and has not yet been reported in GHG inventories. Accordingly, there is some level of uncertainty regarding where to properly report the CO2-captured (for durable storage). Furthermore, removals have to date essentially only been recognized in the Land-use sector, it may thus be confusing to report negative values for emissions within a sector sub-category.[1] CO2-removal from direct air capture may be most appropriately reported under the sector *Industry - Category 2.H.3. Other.*[2]		
Key examples where this issue manifests	Pioneering countries including notably Iceland will soon start to capture volumes of CO2 through DAC. As these pioneers start reporting in inventories, the IPCC taskforce on inventory guidance should adopt corresponding language in the next version that clarifies where DAC should be reported.		
Other issues this affects	Accounting readiness, Project specific monitoring reporting and verification practices		

Back to the Overview of Non-Technical Issues

[1] Poralla, M.; Honegger, M.; Gameros, C. et al. (2022): Tracking greenhouse gas removals: baseline and monitoring methodologies, additionality testing, and accounting, NET-Rapido Consortium and Perspectives Climate Research, London, UK and Freiburg i.B., Germany
Intergovernmental Panel on Climate Change (IPCC) (2019): 2019 Refinement to the 2006 IPCC Guidelines for National GHG Inventories
Intergovernmental Panel on Climate Change (IPCC) (2006): 2006 IPCC Guidelines for National Greenhouse Gas Inventories
International Energy Agency (IEA) (2022): Direct Air Capture - A key technology for net zero
[2] This suggestion has been discussed as a possible resolution, which appears fully in line with GHG inventory guidance, but – to the authors' knowledge is not yet established common practice.

3.11 Accounting/reporting of storage and leakage

Short name	Accounting/reporting of storage and leakage	**Long name**	Missing or inadequate accounting/reporting practices at the national level
Geographical scope	National level – esp. in countries with no prior experience with reporting on underground storage.		
Description of how this issue tends to manifest	Whenever a new type of capture, transport or storage process is first piloted, staff tasked with updating the national GHG inventory may not be aware of- or lack guidance for how to report these mitigation activities. For some types of CCU or CCS value-chains GHG inventory guidance may even be entirely missing.		
Key examples where this issue manifests	Direct air capture does not unambiguously fit any existing GHG inventory reporting (sub-)sector-category. Category *2.H.3. Other.* may be appropriate, however.[1]		
Other issues this affects	Accounting readiness, Accounting of DAC, Accounting of BECCS, Project specific monitoring reporting and verification practices		

Back to the Overview of Non-Technical Issues

[1] This suggestion has been discussed as a possible resolution, which appears fully in line with GHG inventory guidance, but – to the authors' knowledge is not yet established common practice.

4 Legal and contractual aspects

Legal

- EU CCS Directive
- London Protocol
- Helsinki Convention
- Lack of incentives under the EU ETS
- Transport modalities

Back to the Overview of Non-Technical Issues

4.1 CCS Directive

Short name	CCS Directive	**Long name**	Implementation of the EU CCS Directive
Geographical scope	EU Member States		
Description of how this issue tends to manifest	The EU CCS Directive provides a comprehensive regulatory framework for CCS that EU member states must transpose into national law.[1] The Directive contains provisions for the whole value chain, i.e., capture, transport, and storage. It covers storage site selection and exploration permits, storage permits, operation closure and post-closure obligations, third party access, as well as general provisions. All Member States have the Directive. How MS have chosen to transpose the directive into national law has varied in terms of e.g. amendment of existing legislation v. implementation of new legislative framework, permitting storage, and length of post-close monitoring periods prior to transfer of liability. Also, there is a varying degree of maturity and details in the national frameworks, with respect to e.g. permitting regime and regulatory oversight. The degree of implementation will be studied and included in WP3.		
Key examples where this issue manifests	Some of the regulators may not be ready to issue permits at this stage, irrespective of positive results related to geologic mapping. Lack of maturity and details in the implemented framework may further represent legal uncertainty and confusion for market participants, which in turn may deter new projects. Also, variation in the implementation of CCS related legislation can create uncertainty regarding the long-term liability of project participants. This can cause problems with enforcement of rules foreseen by the CCS Directive, including the consistent monitoring of storage sites. Any inconsistencies between national legislation can cause challenges to the cross-border collaboration between two countries to store CO2 as all details have then to be clarified in advance.		
Other issues this affects	Investment certainty (economic issue), permitting process, liability.		

Back to the Overview of Non-Technical Issues

[1] Directive 2009/31/EC; Official Journal of the European Union; https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32009L0031
Report from the Commission to the European Parliament and the Council on Implementation of Directive 2009/31/EC on the Geological Storage of Carbon Dioxide (COM(2014) 99 final, Brussels, 25.2.2014) (First Implementation Report); https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014DC0099&from=EN
Report from the Commission to the European Parliament and the Council on Implementation of Directive 2009/31/EC on the Geological Storage of Carbon Dioxide (COM(2017) 37 final, Brussels, 1.2.2017 (Second Implementation Report); https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52017DC0037&from=EN
Report from the Commission to the European Parliament and the Council on Implementation of Directive 2009/31/EC on the Geological Storage of Carbon Dioxide (COM(2019) 566 final, Brussels, 31.10.2019 (Third Implementation Report); https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52019DC0566&from=EN
Shogenova, A., et al. (2014). Implementation of the EU CCS Directive in Europe: results and development in 2013. Energy Procedia, 63, 6662-6670. https://www.sciencedirect.com/science/article/pii/S1876610214009533
CO2GeoNet. (2021). State-of-play on CO2 geological storage in 32 European countries — an update. https://www.co2geonet.com/en/capacity-building/library-of-publications/technical-reports-and-scientific-publications/state-of-play-on-co2-geological-storage-in-32-european-countries-an-update/

4.2 London Protocol

Short name	London Protocol	**Long name**	Contracting Party to the London Protocol
Geographical scope	International + national		
Description of how this issue tends to manifest	The London Protocol prohibits the dumping of wastes and other matter in the marine environment. In 2006, the Contracting Parties to the London Protocol adopted amendments to Annex 1 to allow for CO2 storage, thereby creating a legal basis in international environmental law to regulate CO2 storage in sub seabed geological formations. In 2009, article 6 was amended to allow export of CO2 for storage in sub-seabed geological formations, with the introduction of a new paragraph. The new paragraph, 6.2, makes clear that Contracting Parties need an agreement or arrangement to transport CO2. The amendment is not in force awaiting a sufficient number of ratifications. The 2019 resolution sought to accelerate the operationalisation of the amendment and allow states to provisionally apply the 2009 amendment, provided they have deposited a formal declaration of provisional application to IMO.[1]		
Key examples where this issue manifests	This issue poses a necessary condition for the legality of CO2 storage offshore. The agreement or arrangement must include a confirmation and allocation of permitting responsibilities between the exporting and receiving countries, consistent with the provisions of the protocol, and international law. In the case of export to a non-Contracting Party, the agreement or arrangement must contain provisions at a minimum equivalent to those contained in the London Protocol.		

[Back to the Overview of Non-Technical Issues]

[1] International Maritime Organisation. (1996). Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Waste and Other Matter 1972.
International Maritime Organisation. (n.d.). Guidance on the implementation of article 6.2 on the export of CO2 streams for disposal in sub-seabed geological formations for the purpose of sequestration. Available on the IMO website: https://www.imo.org/en/OurWork/Environment/PollutionPrevention/Garbage/Documents/LC%2035-15%20Annex%206.pdf
International Maritime Organisation. (2006). Resolution LP.1(1) (Adopted on 2 November 2006) on the Amendment to Include CO2 Sequestration in sub-seabed geological formation in Annex 1 to the London Protocol.
International Maritime Organisation. (2009). Resolution LP.3(4) (Adopted on 30 October 2009) on the amendment to Article 6 of the London Protocol.
International Maritime Organisation. (2019). Resolution LP.5(14) (Adopted on 11 October 2019) on the Provisional Application of the 2009 Amendment to Article 6 of the London Protocol.

4.3 Helsinki Convention

Short name	Helsinki Convention	**Long name**	Convention on the Protection of the Marine Environment of the Baltic Sea Area
Geographical scope	Baltic Sea area		
Description of how this issue tends to manifest	The Helsinki Convention prohibits all dumping in the Baltic Sea area, with the exception of dredged material (which is subject to a prior special permit issued by the appropriate national authority in accordance with the provisions of Annex V). Thus, on the face of it, storage of CO_2 is prohibited in the BSR as CO_2 is not explicitly included as an exception. An amendment is likely going to be required to allow geological storage of CO_2.[1]		
Key examples where this issue manifests	Storage is prohibited in the Convention area (Baltic Sea Area), which for the purpose of the convention is the Baltic Sea and the entrance to the Baltic Sea bounded by the parallel of the Skaw in the Skagerrak at 57° 44.43'N. It includes the internal waters, i.e., for the purpose of the convention waters on the landward side of the base lines from which the breadth of the territorial sea is measured up to the landward limit according to the designation by Contracting Parties. (article 1).		

Back to the Overview of Non-Technical Issues

[1] HELCOM (2014): Convention on the Protection of the Marine Environment of the Baltic Sea Area, Link: https://helcom.fi/wp-content/uploads/2019/06/Helsinki-Convention_July-2014.pdf
Rütters, H. (2022): National and international legislation and regulations with respect to CO2 geological storage, CO2GeoNet Webinar, Link: http://www.co2geonet.com/media/76245/co2geonet-webinar_legislation_clear.pdf

4.4 Lack of incentives for BECCS and DAC

Short name	Lack of incentives for BECCS and DAC	**Long name**	No policy instrument supporting BECCS or DAC in the EU
Geographical scope	EU member states		
Description of how this issue tends to manifest	The EU ETS is the primary policy instrument to generate revenue for CCUS activities in EU member states. However, as biogenic carbon is counted as climate neutral in the ETS any carbon captured and stored from biogenic sources does not generate a monetizable result under the ETS. These CO2 volumes are currently not accounted for in any other policy instrument either. The ETS Directive Article 24 provides for an option for MS to include other volumes and activities than those directly comprised by the directive on a case by case basis, which results in an option for value chains to be deployed and BECCS or DAC to be incentivized under the ETS scheme. Biomass based CCUS installations may be piloted through direct funding from the Innovation fund, however, they lack a pathway for long-term viability and are thus not properly incentivized. The same is true for installations that have mixed streams of carbon from fossil (or mineral in case of cement) and biomass origin.[1]		
Key examples where this issue manifests	There is presently no incentivisation for the operation of CCUS projects based on biomass or DAC. The case by case inclusion of the CO2 volumes stemming from biomass or DAC further cases lack of predictability, delays and the need for increased resources to deploy such value chains, in e.g. the permitting and MRV process.		
Other issues this affects	Incentivisation of CCUS, MRV		

Back to the Overview of Non-Technical Issues

[1] European Biogas Association. (2022). Biogenic CO2 from the biogas industry: A mature business opportunity to enhance sustainable carbon cycles and untap the circularity and climate benefits of biogas production. Retrieved from https://european-biogas.eu/publications/biogenic-co2-from-the-biogas-industry/
Zero Emissions Platform. (2021). ZEP position paper on EU ETS. Retrieved from https://zeroemissionsplatform.eu/wp-content/uploads/ZEP-position-paper-on-EU-ETS.pdf

4.5 Transport modalities under the EU ETS

Short name	Transport modalities under the EU ETS	**Long name**	Unclear status of the various transport modalities for transportation of CO2 under the EU ETS
Geographical scope	EU member states		
Description of how this issue tends to manifest	This issue manifests in EU member states, whereby lack of clarity as to the legal status of various modes of CO2 transportation, including liability questions, accentuates the challenges of pursuing cross-border CCUS cooperations, as well as national value chains. The CCS Directive defined 'transport networks' as "network of pipelines, included associated booster stations, for the transport of CO2 to the storage site". The ETS Directive only included pipelines in the ETS as the method of transporting CO2 for the purpose of storage; excluding all other transport modalities. This creates a 'gap' in the value chain, making it impossible to transport CO2 via ship or other modalities for storage and have the CO2 counted as not emitted under the ETS. The ETS Directive is, however, currently being revised to include other modes of transportation. This entail that the CO2 captured and transported via e.g. ship before being permanently stored can be counted as not emitted in the future. The ETS is currently the main policy instrument that incentivizes CCUS. Any uncertainty as to the eligibility of various transportation means can undermine the financial feasibility of CCUS projects. The issue stems in part from the need to maintain traceability and accurate quantification and verification methodologies of CO2 throughout the value chains.[1]		
Key examples where this issue manifests	Currently the EU ETS does not provide for any other transport modality than pipeline. There are, however, plans for this to be rectified such that transboundary CCUS activities may fully benefit from the incentivisation of the EU ETS. Ships will be included from 2024.		
Other issues this affects	Incentivisation of CCUS, MRV, Liability		

Back to the Overview of Non-Technical Issues

[1] European Union (2003). Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community. Official Journal of the European Union, L 275/32.
European Commission (2019). European Green Deal. https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en
Council of the European Union (2022). Position of the Council (general approach) on the Revision of the EU Emissions Trading System. https://data.consilium.europa.eu/doc/document/ST-10096-2022-INIT/en/pdf
European Parliament (2022). Position of the European Parliament on the Revision of the EU Emissions Trading System. https://www.europarl.europa.eu/doceo/document/TA-9-2022-0246_EN.html

MAPPING OF NON-TECHNICAL ASPECTS AND STAKEHOLDER NEEDS

D2.1 Document-repository that offers overview and insight into non-technical aspects

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