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CCS and Climate Neutrality

Developing a Pathway for Germany

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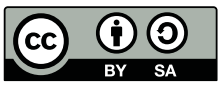


DESCRIPTION

"CCS and Climate Neutrality: Developing a pathway for Germany" is a policy brief resulting from EPICO KlimaInnovation's and the Konrad-Adenauer-Stiftung's third sprint of the Policy Accelerator for Climate Innovation. The two-day long workshop took place in Berlin on 17 and 18 November 2023.

Since 2021, EPICO and the Konrad-Adenauer-Stiftung have partnered to host the Policy Accelerator, where a diverse team of experts from academia, politics, industry, and civil society are brought together to tackle challenges topping the agenda to decarbonise the economy. During the workshops, domain experts known as "Challengers" join the process for interview sessions, where they provide insights on the chosen topic and challenge the ideas that the team produces.

The following individuals participated in the Policy Accelerator workshop and contributed to this policy brief: **Eadbhard Pernot** (Policy Manager, Carbon Capture, Clean Air Task Force), **Luisa Keßler** (Policy Advisor Sustainable Hydrogen Economy, Bellona), **Matthias Poralla** (Consultant, Perspectives Climate Group), **Maximilian Lauer** (Policy Specialist Energy Markets, EPICO KlimaInnovation), and **Martin Schebesta** (Policy Advisor Energy and Resources, Konrad-Adenauer-Stiftung e. V.).

We would like to express our gratitude to our esteemed Challengers for their valuable contributions during the workshop: **Carolin Boßmeyer**, Head of Liaison Office Berlin, Heidelberg Materials), **Oliver Grundmann MdB** (Member of the German Bundestag), **Dr Anne-Mette Cheese** (Country Lead CM& H2 Denmark, Wintershall Dea), **Oscar Schily** (Climate Policy Analyst, Climeworks), **Arnd Ulland** (Trade Commissioner Clean Technologies at the Embassy of Canada to Germany), and **Dr Daniel Kitscha** (Investment Policy Officer – Low Carbon Solutions, European Commission).

This paper is the result of a process in which representatives of the participating organisations have contributed their personal expertise. The scope of the final paper does not necessarily reflect the positions of the organisations represented.

AT A GLANCE

The German industry faces enormous challenges: the goal to reach climate neutrality by 2045, high energy prices, higher interest rates, and geopolitical tensions. Although reducing greenhouse gas emissions is the prime climate mitigation strategy, unavoidable or hard-to-abate emissions remain. Reaching climate neutrality and sustaining the competitiveness of German industry will hence require carbon capture and storage (CCS).

Yet, there are significant barriers to CCS deployment, most prominently political neglection, viz. lack of sufficient political attention and a reputational problem, a policy and legal bottleneck where private actors require political action to advance projects, uncertainty due to lack of coordination by the state, and missing know-how.

This policy brief develops the following policy recommendations to overcome those challenges:

1

1. Development of a comprehensive and positive CCS narrative

a. Develop a clear and positive narrative for carbon capture and storage (CCS) as a critical tool for reducing CO_2 emissions and enabling a net zero future

b. Communicate the role of CCS in reducing difficult-to-abate and unavoidable emissions, particularly from industrial processes

c. Use sound science to build arguments and narratives, avoiding oversimplification and addressing stakeholder concerns

2

2. Overcoming the CCS bottleneck

a. Overcome legal and regulatory barriers to facilitate the development of CCS projects

b. Create access to storage sites in Germany and establish a national regulatory framework for CCS

c. Promote the publication of areas suitable for CO_2 storage and develop CO_2 infrastructure to reduce costs

3

3. Cluster strategy for CCS development

a. Identify and develop CCS clusters where multiple sources of CO_2 emissions are geographically close to achieve economies of scale for CO_2 infrastructure

b. Prioritise the development of industrial clusters to demonstrate the benefits of CCS

4

4. Government coordination and support

a. Define the role of government in CCS development, focusing on early-stage support for project development

b. Provide site characterisation, regulatory frameworks, and early-stage communication with the public

c. Promote knowledge sharing through a CCS Centre of Knowledge and "Reallabor" (real-world testing and implementation)

d. Changing public perception from "Not under my backyard" (NUMBY) to "Yes under my backyard" (YUMBY) by involving local communities and offering them economic benefits in CCS projects

CONTENTS

INTRODUCTION 1.

As the effects of global warming become ever-more prevalent, the need to accelerate climate action has never been more pronounced. At the same time, European industries face considerable challenges, as energy prices, higher interest rates, new industrial policy approaches of leading economies and geopolitical tensions have created an uncertain future for key industrial sectors. While the majority of emissions reductions will come from measures like electrification, improvements in energy efficiency, and use of clean energy sources, there is a necessity to also scale carbon management as a climate measure. Carbon management technologies, which include carbon capture and storage (CCS), carbon capture and use (CCU) as well as negative emissions technologies like direct air capture (DACCS) or bioenergy with carbon capture and storage (BECCS), can play a key role in various mitigation applications.

The need to advance effective climate solutions, i.e., technologies and processes which can rapidly reduce greenhouse gas emissions, has never been clearer. Doing so at the lowest possible cost is essential to ensure maximum public support for climate action over the long term. As has been outlined by all leading pathways to reach climate neutrality, significant deployment of CCS will be needed if Europe is to reach its climate goals. These analyses include the European Commission (European Commission, 2018), DNV (DNV, 2021), Intergovernmental Panel on Climate Change (Intergovernmental Panel on Climate Change, 2022), the European Scientific Advisory Board on Climate Change (European Scientific Advisory Board on Climate Change, 2023), and the International Energy Agency (International Energy Agency, 2020). At least 300 million tonnes of annual CO_2 capture and storage capacity will need to be available by 2050 if Europe is to reach its climate goals.

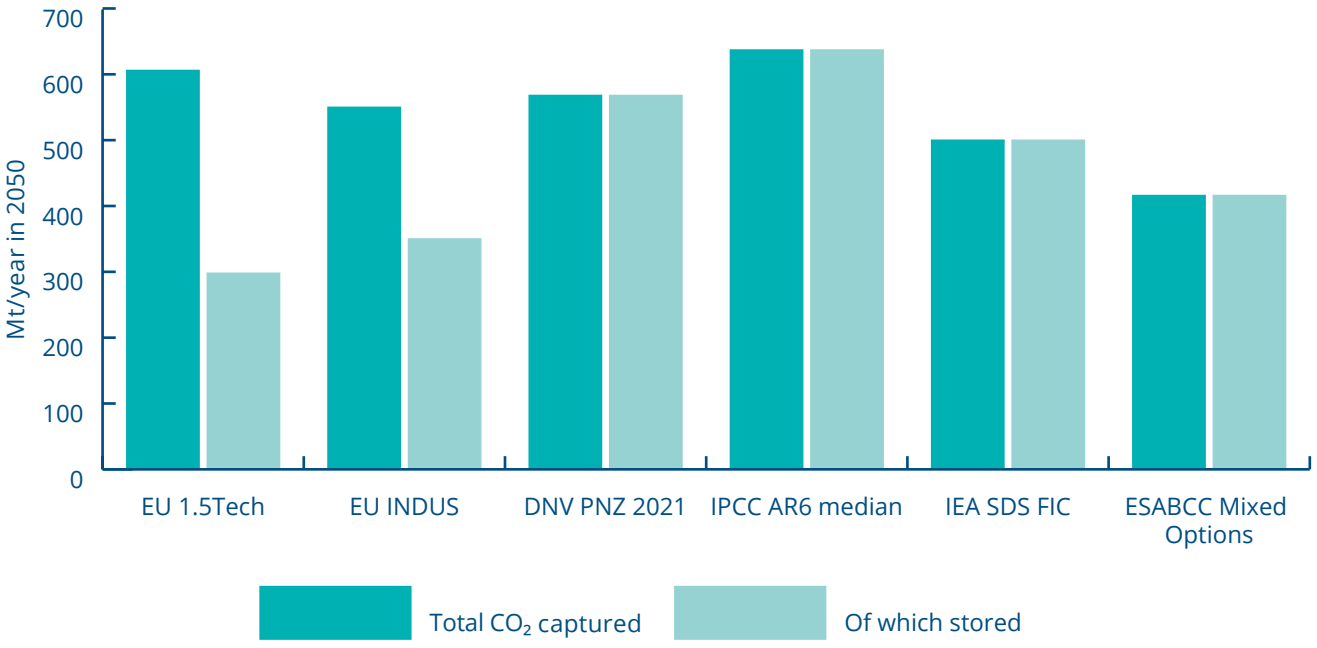


Figure 1: The annual quantities of CO_2 captured and storage in Europe by 2050, consistent with reaching climate neutrality

In Germany, carbon management will also be a critical solution for reaching its legally binding target of climate neutrality by 2045. Figure 2 shows leading scenarios from the Ariadne Project (Kopernikus-Projekt Ariadne, 2021), Agora Energiewende (Prognos, Öko Institut and Wuppertal Institut, 2021), the Deutsche Energie-Agentur (Deutsche Energie Agentur, 2021) and the Bundesverband der Deutschen Industrie (Bundesverband der Deutschen Industrie, 2021), which all make clear that between 34 to 73 million tonnes of CO_2 must need to be geologically stored by 2045.

Currently, there are no operational carbon capture and storage projects in the EU, although two projects are operational in Norway since the 1990's. Reaching the levels of carbon management deployment required to meet the climate goals in Germany, and the EU more broadly, will require significant action from policymakers, industry, and wider society, in order to ensure that the climate goals are reached.

In the past year, policymakers in the EU and Germany have both outlined a clear intention to advance CCS. In 2024, the European Commission is set to publish the Industrial Carbon Management Strategy, which aims to provide a policy framework for CCS development in the EU. In addition, Germany has committed to developing a Carbon Management Strategy, due to be published by the Federal Ministry of Economic Affairs and Climate Action (BMWK) in 2023.

Both initiatives aim to provide, inter alia, a clear roadmap to deploy CCS technologies. There are several key hurdles which currently impede this.

This paper aims to outline a pathway to developing carbon management to ensure Germany's climate goals can be met. While the development of carbon management includes the utilisation of captured CO_2 (CCU) as well as the use of negative emissions technologies like DACCS and BECCS, the focus of this paper is principally on CCS, particularly on applications in the industrial sector only. This sector is characterised by emissions which are unavoidable or otherwise hard-to-abate, which cannot be mitigated easily. Furthermore, while the development of CCS is critical for the EU, the primary focus of this paper is the development of CCS in Germany.

The paper is structured as follows: First, this paper aims to outline the key problems which currently provide the greatest barriers to carbon management development. Next, this paper aims to provide solutions to these issues, focusing primarily on problems which must be addressed in the short term (i.e., before 2026). Finally, this paper aims to provide solutions to longer-term issues which will need to be solved well before 2030.

Quantities of geologically stored CO_2

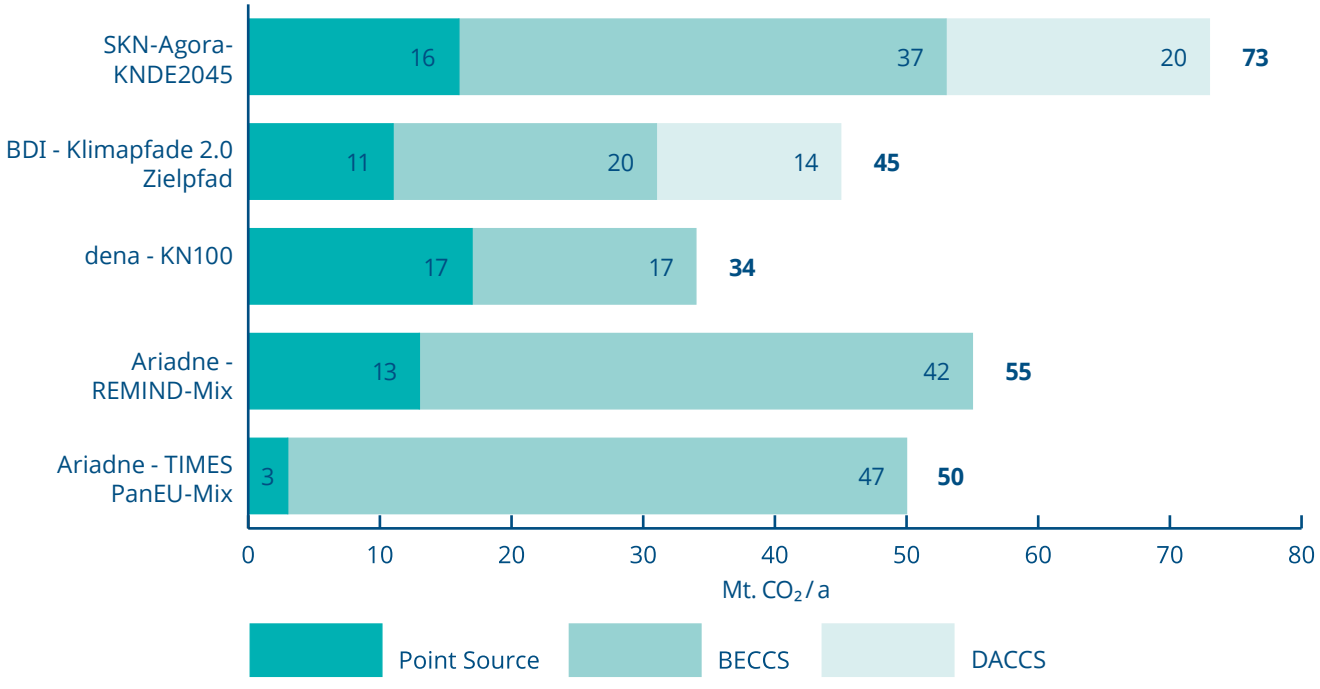


Figure 2: Quantities of CO_2 required to be geologically stored per year in Germany by 2045

CHALLENGES 2.

This section aims to provide an overview of the most significant barriers to CCS deployment today as well as those which will need to be addressed before 2030.

I. POLITICAL NEGLECTION OF CCS

A key barrier which currently impedes the deployment of CCS in Germany is the lack of sufficient attention it receives at political levels, regarding other climate technologies. CCS is an established technology which has been deployed at commercial scale globally for several decades and has manageable and well-known risks. However, CCS continues to suffer from a reputational problem, particularly in the media, and is regularly dismissed as a "greenwashing" tool promoted by the fossil fuel industry as a distraction to divert resources and political action away from other mitigation solutions. However, as the scientific evidence shows, CCS is a crucial technology to reduce CO_2 emissions, especially from industrial processes with unavoidable emissions. Moreover, carbon capture technologies have been used safely and effectively for around 100 years (IEA Greenhouse Gas R&D Programme, 2013), while CO_2 storage has been done for over 50 years (Gulf Coast Carbon Center, 2021; Krevor et al., 2023). There are more than 20 commercial-scale carbon capture facilities operating globally, permanently capturing and storing close to 50 million tonnes of CO_2 annually (Global CCS Institute, 2023).

II. THE POLICY AND LEGAL BOTTLENECK

Despite the increased attention CCS has received politically in recent years, a major policy bottleneck, i.e., where private actors require policymakers to act in order to enable a project to proceed, is currently stifling the development of first-mover projects. Legal barriers, such as the non-ratification of the amendment to the London Protocol, which de facto prohibits the export of CO_2 by sea for the purposes of storage, currently hamper projects in Germany.[1] Moreover, the CO_2 Storage Law (Kohlenstoffspeicherungsgesetz, KSpG) de facto prohibits the storage of CO_2 in commercial scale projects. The consequences of these legal barriers mean that proposed CCS projects in Germany face unfavourable investment circumstances (Bellona Deutschland, 2022).

In July, Heidelberg Materials announced the first CCS project in Germany in almost a decade (Heidelberg Materials, 2023). The GeZero project in Geseke, North Rhine Westphalia, was selected by the EU Commission's Innovation Fund and aims to be operational by 2029. While the project is partly funded by the Commission and intends to sign a grant agreement before the end of this year, which would result in it being required to become operational in just over five years, there is currently no legal framework in Germany which would allow for its development. Furthermore, the development of a Carbon Contracts for Difference (CCfD) scheme,[2] which has been promised by the Federal Government for over two years, has yet to be implemented. As the Federal Government has yet to publish the Carbon Management Strategy, CCS projects are not eligible in the first round of the CCfD scheme.

The result is that a bottleneck currently impedes the development of projects which aim to capture, transport, and store CO_2 either in Germany or abroad.

III. LONG-TERM ROLE OF THE STATE

A key issue which remains unresolved currently is defining the role of the state in CCS development. In the past, efforts to develop CCS relied entirely on the EU Emissions Trading System (ETS) price to provide the primary economic driver for CCS. However, since the EU ETS price remained low for over a decade, no economic incentive for CCS was provided. Moreover, the fluctuations in the ETS price make for a challenging investment case (Clean Air Task Force, 2022).

Financing large CO_2 infrastructure projects is a challenge, especially when assessing the applications for which CCS should be used and the state subsidies that will be available. On the one hand, CCS will be particularly important for unavoidable emissions, e.g., process emissions from cement production. However, cement plants are typically small and located inland, far from the coast or major pipelines. As the experience with the development of large CO_2 infrastructure projects like Porthos has shown (Clean Air Task Force, 2023), it will be necessary to develop large CCS hubs that leverage applications where the separation costs per tonne are comparatively lower and the initially transported and stored CO_2 quantity is sufficiently large to justify the investments.

CCS includes three stages of a value chain: capture, transport, and storage. Rather than developing integrated CCS projects, where one undertaking or a joint venture assumes the risk of investing in all three stages, more recently, projects are being de-risked by involving different undertakings across the separate stages. However, there are significant challenges to this 'cross-chain' risk, such as liability for undertakings if CO_2 is not captured or storage sites are not operating at sufficient capacity. Defining where and how the state can provide a constructive and coordinating role to overcome these differences is necessary to scaling CCS. Furthermore, given that Germany is a Federal Republic with sixteen Federal States, defining the responsibilities between the Bund and Länder will be critical to ensuring project developers know who is responsible for what.

IV. KNOW-HOW

Another major problem with CCS currently appears to be the lack of know-how both within industries and government. Industries who may need CCS, such as cement, have naturally focused on hiring staff and shaping their companies around those industries. While some have taken more proactive approaches and have already built departments or teams specifically for CCS activities, others, particularly smaller entities or Stadtwerke, in the case of waste-to-energy facilities, are unable to simply hire staff to support CCS activities. Furthermore, a lack of know-how related to CCS presents issues for administrators in government, particularly at regional or local levels. This can impede project development in Germany.

1 The London Protocol is an international environmental regulation, designed to prohibit the dumping of waste at sea. Currently, CO_2 is listed as a prohibited substance which, in practice, renders the cross-border transport of CO_2 at sea for the purposes of offshore storage illegal. The London Protocol was amended by contracting parties in 2009 to allow for cross border transportation of CO_2 for sub-seabed storage, but the amendment must be ratified by two thirds of contracting parties to enter into force. It is unlikely that this will occur in the near term. Some countries have entered into bilateral agreements to circumvent this issue, such as Belgium and Denmark, which have successfully done so.

2 Carbon contracts for difference function as a policy instrument to incentivise low carbon technologies like CCS through the offer of long-term contracts from governments to pay for the difference between the current carbon price and the actual CO_2 abatement cost.

SOLUTIONS TO UNLOCK CCS 3.

There are various solutions which could be implemented to deploy CCS. This section provides an overview of the key options to rapidly accelerate the deployment of CCS in Germany.

I. CRAFTING A NUANCED, YET POSITIVE, CCS NARRATIVE

In order to improve the reputational issues which CCS currently suffers from, it is critical to ensure that CCS is recognised as a critical tool for climate and that one 'gets CCS out of the corner'. The following considerations and solutions can help create a meaningful narrative and provide some hands-on recommendations and strategies.

"CCS as crucial for a net-zero future"

Given that CCS can significantly reduce emissions as well as realise carbon removals, it is important to recognise the opportunities that CCS can offer as an enabler of a net-zero future. On the one hand, CCS can significantly reduce hard-to-abate and otherwise unavoidable emissions while also becoming a partner for the Energiewende. Given that wind and solar are resource-intensive technologies and require materials such as steel and cement, decarbonising the industries which are necessary for their production can dramatically reduce their embodied emissions.

On the other hand, the same transport and storage infrastructure needed for emission reductions with CCS is also required for realising carbon dioxide removals such as DACCS and BECCS, which are yet another essential mitigation solution for achieving net-zero emissions.

Developing simple, easy-to-understand and positive narratives and images why we need CCS in all its forms is going to be paramount. In doing so, emphasis should be placed on advancing fact-based knowledge of CCS and the contribution it can make to climate mitigation. Furthermore, this should be done in a reasonable manner and not repeat past mistakes or oversimplify greenwashing concerns, fears or risks that stakeholders might associate with CCS, but build all arguments and narratives on a sound scientific basis.

"CO_2 infrastructure as an economic resource"

As German industries seek to decarbonise over the coming years, CO_2 infrastructure is a critical factor in ensuring economic competitiveness. CCS is not a per se expensive measure to decarbonise industrial processes. However, the costs of CCS can increase significantly, by as much as 5 or 6 times, if emitting installations are located in regions where there is no access to CO_2 transport or storage infrastructure (Lockwood, 2023). As shown in Figure 3, the costs of CCS can be significantly reduced by making CO_2 storage sites and necessary transport infrastructure available. For some facilities, the ETS price alone could sufficiently cover the costs of CCS, although securing final investment decisions can still pose challenges as many industries are not yet fully exposed to the carbon price and the price of EU ETS allowances is still volatile.

Until dedicated CO_2 pipeline networks are developed, transporting large volumes of CO_2 across long distances can be prohibitively expensive for the industry. This is particularly important for smaller industrial producers (i.e., the German Mittelstand), particularly those located inland regions with no access to CO_2 pipelines or inland waterways. Outlining the importance of a non-discriminatory CO_2 infrastructure as a key factor to ensure Germany's competitiveness as a climate-neutral industrial producer, will be key to ensuring the reputation of CCS is improved.

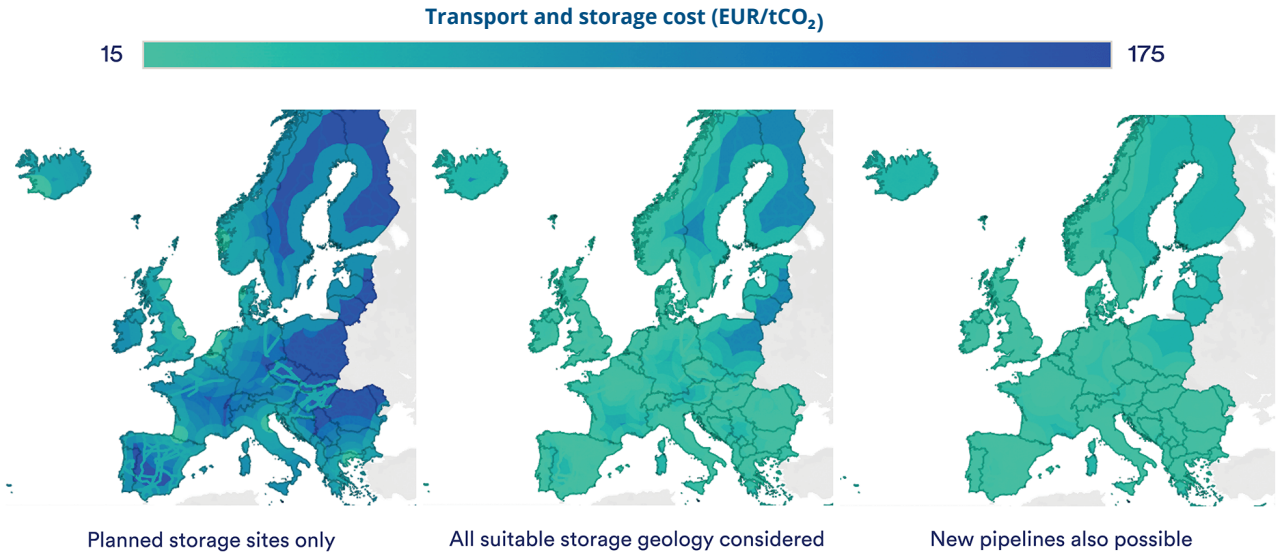


Figure 3: A heatmap outlining the comparative costs of CCS based on availability of storage sites and access to transport infrastructure (Lockwood, 2023)

"CCS Communications Campaign"

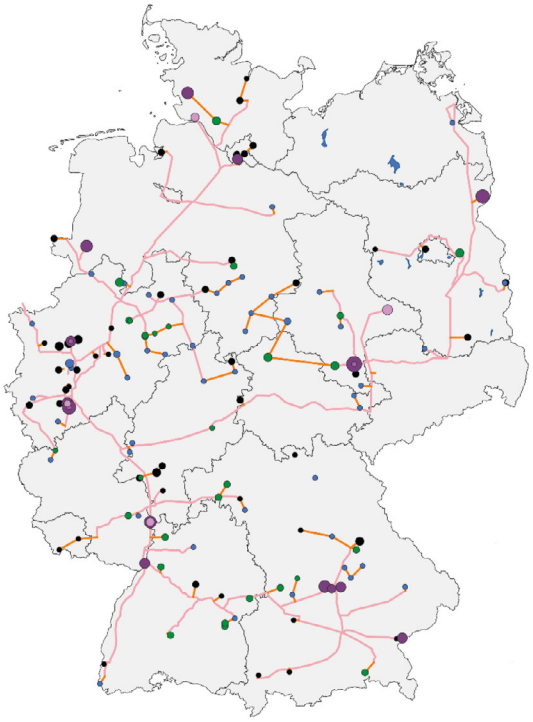
As well as crafting effective CCS narratives, a key issue currently impeding the reputation of CCS and its political will, is the lack of a clear communication strategy. Two aspects are especially noteworthy in this regard: First, a communication strategy must be developed with all relevant state and non-state stakeholders involved to secure necessary buy-in and support from those actors. Moreover, any campaign must ensure long-term and continuous activities along the way, ranging from designing impactful and memorable images, to print and social media outreach as well as deliberative and participatory online and offline discussion fora.

Second, key public and private figures must support these activities and endorse the need for CCS. "CCS Ambassadors" would enable greater positive media exposure for CCS and increased political recognition of its importance as a climate solution. In Germany, it is particularly important to ensure members of the scientific community are given a platform to advocate for the importance of CCS in national and regional media outlets, as has proven effective for other climate technologies.

While the need to accelerate CCS is clear from all leading climate scenarios, the current bottleneck hampering first-mover projects must be overcome. Action to unlock this bottleneck is being taken at EU level. The Commission's proposal for a Net-Zero Industry Act (NZIA) (European Commission, 2023), which is currently being negotiated by co-legislators, provides for several key measures to accelerate CCS starting with an annual injection capacity target of 50 million tonnes of CO_2 by 2030. There are several key measures for EU Member States, such as the requirement to publish areas where CO_2 storage sites can be permitted on their territory. This is an important measure, since creating a European CO_2 Storage Atlas, mapping all areas with suitable geology to store CO_2, will be crucial to enable the scale up of CO_2 storage sites, enabling emitters to decarbonise their industries faster.

In Germany, efforts to accelerate CO_2 infrastructure thus far have focused primarily on the development of domestic transport links. Figure 4 outlines a potential CO_2 transport network in Germany, which would connect all likely emitters to ensure captured CO_2 can be transported. In Germany, the Federal Government has yet published the Carbon Management Strategy at the time of writing.

However, the need to create access to storage in Germany has not yet been explicitly recognised. While the newly published Industry Strategy (Federal Ministry of Economic Affairs and Climate Action, 2023) commits inter alia to preparing "a joint storage strategy together with the European partners", there is currently no plan yet to develop domestic storage sites in Germany. This issue must be addressed in the forthcoming revision of the German CO_2 storage law (KSpG), which currently de facto prohibits the development of storage sites in Germany. Doing so would ensure dramatically reduced costs of CCS for Germany, ensuring greater economic competitiveness in a climate-neutral economy.



CO_2 Quantities in Mt/a
- < 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 2.0 - 3.0
- 3.0 - 4.0
- > 4.0

Map legend
- Carbon sink ammonia products
- Carbon sink methanol production
- Carbon sink olefin production
- Carbon source cement production
- Carbon source lime calcination
- Carbon source waste incineration
- Carbon transportation grid (new construction, no rededication)
- Carbon transportation grid (new construction, rededication possible)

Figure 4: A potential CO_2 transport network in Germany (Federal Ministry of Economic Affairs and Climate Action, 2022)

II. CLUSTER STRATEGY

Identifying and developing CCS Clusters, i.e., locations where several sources of CO_2 are present from industrial sites located in a geographically close area, has proven successful at demonstrating a case for economies of scale for CO_2 infrastructure. In particular, this approach has been used in the Netherlands and the United Kingdom. While the German Government committed itself to developing industrial transformation clusters in the coalition agreement (SPD, Bündnis 90/Die Grünen and FDP, 2021), little progress has been made thus far.

Nonetheless, some states like North Rhine Westphalia, which has considerable amounts of CO_2 emissions resulting from its industrial sectors, have identified and prioritized the use of CCS through the development of clusters as Figure 5 shows.

CO_2 Quantities in kt/yr

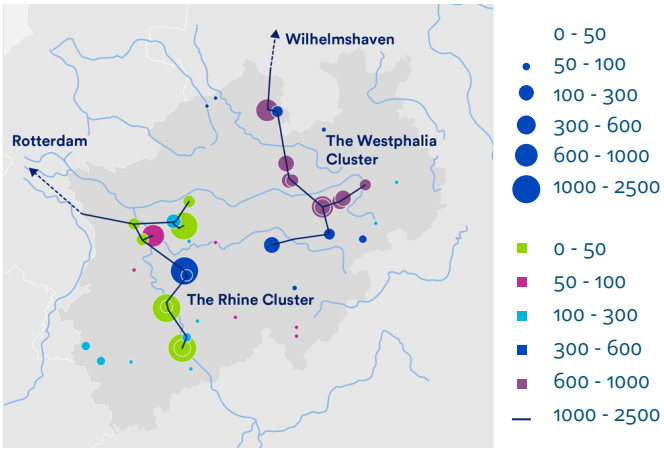


Figure 5: A map of industrial sources of CO_2 in North Rhine Westphalia, which could form CCS clusters (SCI4climate.NRW, 2021)

III. COORDINATION BY THE STATE

The State can provide significant assistance to develop CCS to commercial scale, at which point projects can be financed, developed, and operated entirely by private companies. Getting to this point will require demonstrating CCS at commercial scale, particularly those projects which function as Hubs or Clusters. This means a wave of first mover projects are needed in Germany and the EU, which will need support from the state beyond financial support. There are several ways in which the state can aid CCS projects, including:

- Regulatory framework to licence projects and ensure robust monitoring and fair market access and terms are provided
- Identifying optimal storage sites by providing site characterisation
- Providing early-stage exploratory tasks for storage sites, such as seismic testing
- Providing early-stage communication with the public

In addition, the German Government can provide effective supports for CCS by promoting knowledge-sharing from CCS projects, as well as creating better know-how in local administrations, companies, and communities. For example, a dedicated CCS Centre of Knowledge, could be established in

partnership with leading German research and academic institutions to ensure CCS knowledge and know-how can be effectively spread through, for example, courses on CCS leading to qualified professionals.

Another already well-established format could be a so-called living lab, in which decisionmakers, practitioners from industry as well as representatives from civil society and science come together to discuss, test, and challenge a rollout and implementation of ideas and technologies in a practical manner. Already existing living labs, e.g., on the energy transition, and experiences made and lessons learned from these can serve as a valuable starting point for setting up a dedicate living lab also for CCS. What is key is to draw not only technological lessons from this efficient sandbox approach, but also regulatory lessons to be implemented.

IV. FROM NUMBY TO YUMBY

Much like other energy and climate technologies, CCS has suffered from public opposition to projects in the past. This has created difficulties with a message of "Not under my backyard" being made clear by local communities where CCS projects have been proposed. It is critical that we move away from "Not under my backyard" (NUMBY) toward "Yes under my backyard" (YUMBY).

In other EU Member States, like Denmark, the state has taken a mandatory ownership stake of 20 per cent in all storage projects, ensuring that the economic benefits of CO_2 storage can be obtained by the public. Similarly, in Germany, local communities could obtain economic benefits from CCS projects by taking ownership stakes in them. This would ensure that economic benefits from CCS and, in particular, CO_2 storage projects, can be felt in the local community. Additionally, it is critical that communication with local communities is started as early as possible in the development of potential CCS projects, led by local and regional governments. Be it transport or storage infrastructure, it is critical to ensure that concerns and questions from local communities are effectively addressed and dealt with from the very beginning to ensure maximum trust and public buy-in.

THE WAY FORWARD 4.

In the coming year, European elections will result in a new political agenda in Brussels, while over the course of the next two years, the German Government has significant opportunities to ensure the scale up of CCS. Looking toward 2030, the next German Government must ensure even greater ambition to scale up CCS is provided.

Within the next two years, it is important that the bottleneck currently impeding first-mover CCS projects in Germany is unlocked. The EU Net Zero Industry Act offers the chance for Germany to accelerate project development, while domestically it is critical that the CCfD scheme is finalised to ensure CCS is an economically viable climate tool. Moreover, the German CO_2 storage law (KSpG) must be amended to ensure the development of CO_2 storage sites is provided for in Germany. The development of industrial clusters is also critically important to reduce costs and liabilities and enable knowledge sharing ensuring the first phase of CCS developments in Germany is provided for.

In the long-term, it is critical that the role of the German State is made clear in terms of its involvement in the development of CCS. As international examples, such as Denmark, have shown, there is significant added benefit to state involvement in the early stages of project development. This is particularly important to ensure that the CCS industry is made competitive and not subject to the formation of monopolies controlled by certain industries which risks eroding public trust in this nascent industry. More broadly the Government can ensure greater knowledge sharing and public involvement in CCS in the long term to ensure the maximum climate and economic benefits can be shared by the public.

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