ASMASYS

ASMASYS – Assessing Marine Carbon Removal: Synthesis, Scenarios and Governance

Foresight Workshop Report: Marine Geological Carbon Storage Scenarios for Germany in 2040

Milestone 1.1.2 // Miranda Boettcher

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This report outlines processes and insights from a participatory foresight workshop held in September 2025 at the SWP in Berlin, supported by the German Federal Ministry of Research, Technology and Space (BMFTR) grant number 03F0962C. The report represents the author(s)' summary of and reflection on the workshop and does not necessarily represent the views of the participants or organizations involved.

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1. Introduction

Background on mCDR & mCS

Since net zero greenhouse gas emissions targets have become a keystone of climate policy, there has been increasing debate about the need to actively remove carbon dioxide from the atmosphere in addition to reducing emissions (Schenuit et al. 2022; IPCC 2022) to produce anthropogenic negative emissions.

The ocean already plays a key role in regulating the global climate by absorbing a large proportion of anthropogenic carbon dioxide emissions (Watson et al. 2020: Friedlingstrein et al. 2022). As the technical and political challenges of the land-based carbon dioxide removal approaches are becoming more apparent, the oceans seem to be becoming the new »blue« frontier for marine carbon dioxide removal (mCDR) and marine carbon storage (mCS) approaches (Boettcher et al. 2021; Boettcher et al. 2023).

Some of the proposals being investigated in Germany and elsewhere for enhancing the carbon storage potential of the ocean involve **sub-seabed geological carbon storage**, either in sandstone or in basalt formations in the ocean crust (see Figure 1 & 2)

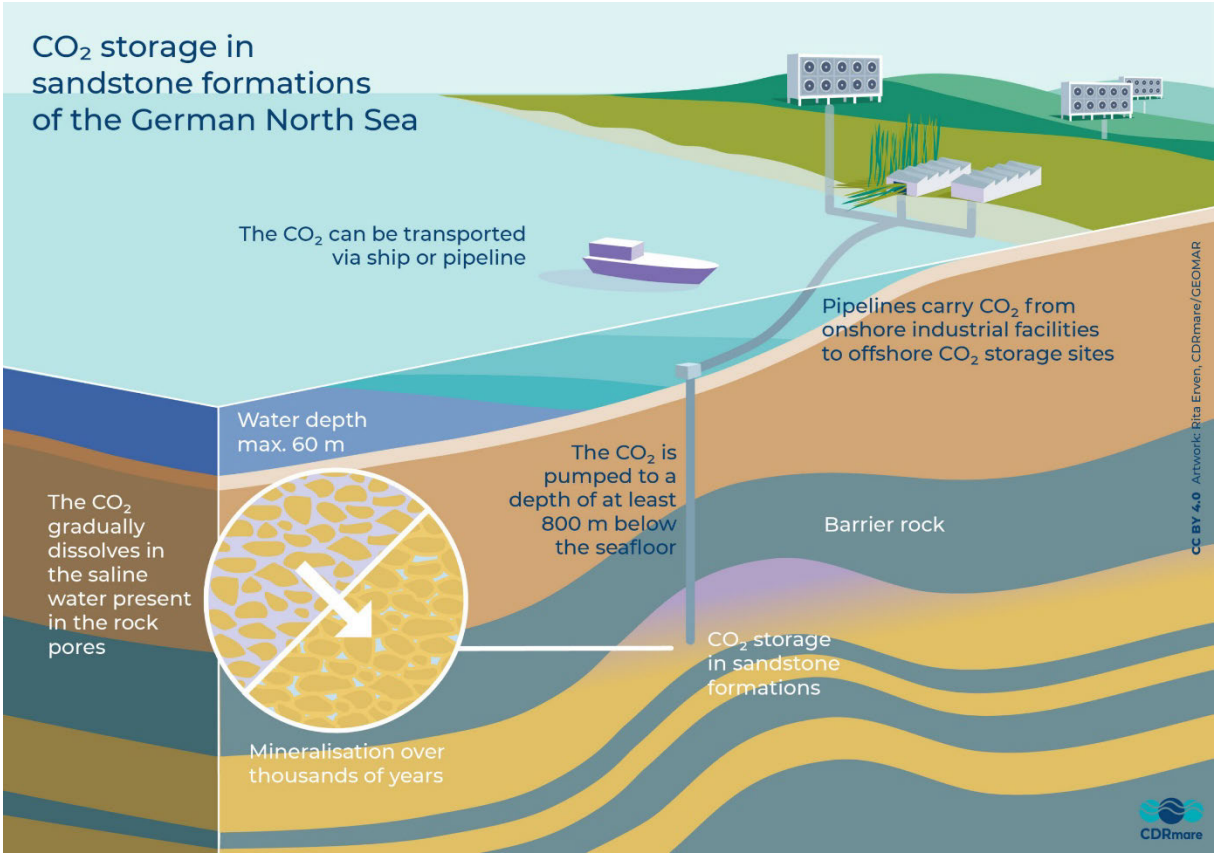


Figure 1. Sub-seabed geological carbon storage in sandstone formations © Rita Erven, CDRmare/GEOMAR.

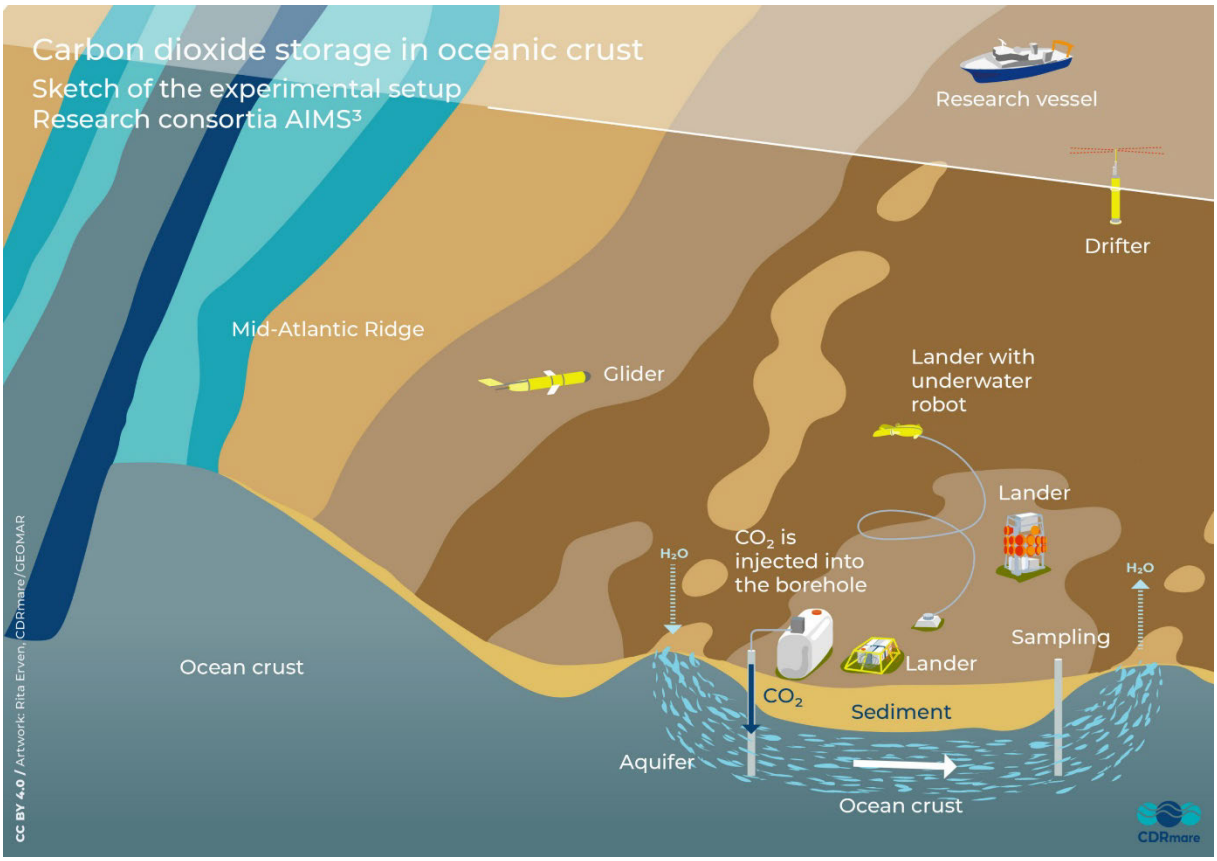


Figure 2. Sub-seabed geological carbon storage in the ocean crust, Artwork: Rita Erven, CDRmare/GEOMAR.

Workshop aims: Developing qualitative scenarios to explore mCS futures for Germany

The foresight workshop described in this report was carried as part of work on a BMFTR-funded research mission on marine CO_2 removal called: »CDRmare: Marine carbon sinks in decarbonisation pathways«. The research mission investigates how the carbon drawdown and storage effect of the ocean may be enhanced in the future. The objectives of the mission are: to explore and assess various marine approaches to atmospheric CO_2 removal (mCDR) and marine carbon storage (mCS) in terms of their potential and environmental, economic, social and political impacts and risks in the context of responsible and sustainable use of the ocean and; to provide information to policy makers and society on future opportunities and risks of marine CO_2 removal/storage approaches and their governance.

One of the proven methods for exploring **plausible futures** is the development of qualitative future scenarios. To ensure that a wide range of relevant barriers and enabling conditions are taken into account, the development of such scenarios on the topic of mCS ideally should involve representatives from relevant permitting and regulatory bodies, as well as other relevant actors from science and civil society. A two-day foresight workshop was therefore held on September 18 & 19 2025, to enable relevant actors to engage in an exploratory process to develop **plausible future mCS scenarios for Germany**.

The workshop aimed switch the mode of thinking about the future of mCS in Germany from predictive to anticipatory: a reorientation from »navigating ›what will be‹« to »thinking through alternative ›what ifs?‹« (Boettcher et al. 2016; Boettcher 2023). The workshop organisers aimed to encourage the participants to engage experimentally with conceptions of the future derived from a broad field of perspectives.

The event was designed to apply a **participatory foresight method** – namely, the construction of qualitative scenarios – to enable structured thinking about complex systems and possible futures containing many unknowns. The workshop furthermore made use of **explorative** scenarios, which focus on the broader context of a topic in order to explore a wider range of alternative future dynamics. Explorative scenarios trace the complex interactions of a broad range of political, economic, technological, and social factors in a variety of hypothetical futures. They act as **hypothetical thought experiments** that aim to open up thinking about alternative assumptions about a wide range of developments in the future. Thus, they do not aim to **predict likely or probable futures** (Gabriel 2014).

Qualitative scenario development processes are designed to draw upon inputs from multiple disciplinary perspectives, as well as alternative assumptions, expectations, and worldviews from a range of stakeholders. As **individual biases can lead to one-sided or linear-extrapolative thinking**, such scenarios are best constructed in a participatory process of group communication. A methodologically sound process for participatory scenario construction promotes critical reflection of the scenario development process, and allows for intersubjectivity, contributing to shared meanings and understandings and **thus widening the range of plausibly imaginable futures**. Participatory scenario construction thus provides a platform for structured communication that facilitates inter- or transdisciplinary thinking about possible futures (Gabriel 2014: 5 – 7).

The qualitative foresight process implemented at this workshop was designed applied in this workshop was conceptualised and facilitated by Dr. Marcel Hadeed and Theresa Schültken from the organisational consultancy Foresight Intelligence (FI) to provide a platform for structured communication about a range of **logically consistent** and **plausible** futures. A **consistent scenario** is composed of logically coherent **factor projections** that, taken together, describe a future situation. A **plausible scenario** also provides a credible and comprehensive illustrative trajectory that leads to a consistent future situation, exemplifying the changes necessary to end up in a certain future situation. A qualitative scenario therefore is not only a **picture of the future**, but it also includes also includes a rich ›**history**‹ **of the future** – a pathway which describes how this imagined future could plausibly come to pass (Gabriel 2014: 3).

The workshop planning team set **two broad guiding conditions** for the participants. The first was the **scope** of the mCS futures being discussed, which was set to focus on **the German context**, but taking wider the EU and international climate policy landscape into account. This choice was made as German climate policymaking is highly embedded in and dependent on EU climate policymaking (Knodt et al. 2020)[1]. Secondly, the **timeframe** for the scenarios was set to the year **2040**. This choice was made based on the current expected timelines for German and wider EU climate policy, which stipulate that Germany should reach net-zero greenhouse gas emissions by 2045 and net negative emissions in 2050 (Presse- und Informationsamt der Bundesregierung 2023). Therefore, the assumption put forward by the organisers was that key decision-making processes on the potential role of mCS in climate policy would be initiated before 2040.

[1] Despite this focus on the German/EU context, linking to the wider context of global emissions scenarios and international climate targets was unavoidable. The group was encouraged to also consider future external influences on EU and German climate policy ambitions.

The workshop planning team also made choices about the **types of participants** to invite to the workshop. Such choices have a significant effect on the workshop outputs, given that – as described above – participatory scenario development processes are designed to draw upon the various knowledge types, perspectives, assumptions, expectations, and worldviews of those involved. The outputs of such processes can thus only be as diverse as the range of voices in the room. The workshop organisers aimed to invite a range of participants from relevant administrative and regulatory bodies, as well as representatives from academia and civil society[2].

The following sections outline the participatory scenario development process (section 2), provide detailed descriptions of the resulting scenarios (section 3), and detail comparative reflections on all scenarios developed (section 4).

2. Participatory scenario development process

Exploring the broader context

The first step of the scenario development process was initiated before the workshop began. The participants were first sent an ›environment scanning‹ survey. This asked them identify a broad range of political, economic, social, technological, environmental, and other factors that could shape mCS policy development in the next 20-odd years. (See annex for full list of factors listed by participants). The resulting collection of factors where then clustered by the foresight facilitation team into **sets of factors** for the next step of the process (see annex for a map of all factors and how they were clustered).

Narrowing down to key uncertainties

Following an expansive first compilation of factors, a second survey was circulated in which the participants conducted an uncertainty-impact analysis to reduce complexity and select »key uncertainties«. This process is designed to identify factors that (in the participants' collective estimation) have a **very high potential impact** on the future of mCS, and whose plausible future outcomes have a significant range or spread, meaning their outcomes are **very uncertain**. Using an online assessment tool designed by FI, the participants were asked **rate the uncertainty and impact** of each of the clustered 30 sets of factors gathered during the environment scanning survey. When they met in person on the first day of the workshop, the group was then presented the consolidated results of their joint ranking, and following several rounds of discussions, **agreed upon six highly ranked ›key uncertainties‹** to continue to work with (See annex for the ranking of all the factors).

[2] See Annex for the anonymized list of participants.

No.	Title & description
KU1	**In other mitigation news: level of success and failures of mitigation options affecting net emissions**
KU2	**Financial Incentives – who pays for mCS?**
KU3	**Storage & transport integrity**
KU4	**Political majorities on mCS in Germany and the EU**
KU5	**Public perception of mCS within Germany:** Perception of the general and local publics about mCS
KU6	**CO_2 storage location:** Where Germany is storing its captured CO_2

Table 1: Key uncertainties

Creating projections for key uncertainties

In small breakout groups, participants then developed at least four distinct outcomes for each key uncertainty in 2040 – a set of »projections« intended to cover the full spectrum of alternative plausible future states of a given key uncertainty. For this activity, the participants were asked to focus on each key uncertainty in isolation from all other factors, and try to imagine (at least) four possible outcomes of that factor in 2040 that were mutually exclusive, comprehensively exhaustive (MECE). Rather than thinking about likely future states of their factor, the groups were asked to come up with a wide range of plausible future states of their respective factor, and reminded that a plausible future state is not to be confused with probable future state. Each group was asked to present their factor projections to the plenary, where they were then discussed, and in some cases adjusted within the larger group. The resulting sets of factor projections are outlined in the table below.

No.	Title & description	Projection A	Projection B	Projection C	Projection D	Projection E
KU1	In other mitigation news: level of success and failures of mitigation options affecting net emissions	Focus on mCS for CDR: marine geological storage as a key part of the overall mitigation puzzle. Focus on removal and geological storage of atmospheric carbon	Focus on mCS for CCS: mCS is taking place, but the majority of the CO_2 being stored is fossil or industrial carbon	Focus on classic mitigation and non-mCS-based CDR measures. We do not use mCS it is not needed due to success elsewhere	The day NetZero died: No mitigation is being actively being pursusd, hence no need for mCS.	

KU2	Financial Incentives – who pays for mCS?	No market for mCS	Compliance Market: mCS/Sub-seabed CO_2 storage financed through the EU ETS. Both avoided emissions through CCS and removals through CDR	Wild West: Free-market removal& storage credits through voluntary carbon markets only	EU/Governme nt funded mCS projects (storage for hard-to-abate and removals, governments decide which sectors are eligible)	ETS and some government funding (through removal credits)
KU3	Storage & transport integrity	No leakage at all	Leakage, resolvable (at cost) Leakages occur but there are solutions for it	Leakage not resolvable Leakages occur and there are no solutions for it	Permanent (minor) leakage, leakages occur, but it below the regulatory threshold	
KU4	Political majorities on mCS in Germany and the EU	EU pro, Germany pro	EU against, Germany pro	EU against, Germany against	EU pro, Germany against	
KU5	Public perception of mCS within Germany: Perception of the general and local publics about mCS	General public pro, local public against	General public against, local public pro	General public against, local public against	General public pro, local public pro	
KU6	CO_2 storage location Where Germany is storing its captured CO_2	No offshore storage, only terrestrial storage in Germany	Storage in Germany only (both onshore & offshore)	No storage in Germany – all CO_2 exported for storage elsewhere	Offshore storage only – in German & neighbouring countries EEZs	No storage – Germany is not storing any captured CO_2

Table 2: Factor projections

Creating scenario frameworks

Participants then created a set of three scenario frameworks. Each scenario framework included one projection from each of the key uncertainties. Even with only four to five projections for each key uncertainty, there were a huge range of possible scenario frameworks. However, not all of them are conceptually consistent; certain projections could be mutually antagonistic. Consequently, the aim was to identify **logically consistent scenario frameworks**. Given the relatively small size of the group and the number of projections involved, this was done via group discussion in plenary. To begin constructing each scenario framework, one participant was selected to pick a projection to start from in the above factor projection table. The moderator then went around the room allowing others to volunteer to pick the subsequent projections from different factors in turn, always having to explain

why and how their choice was consistent with the previously selected factor projections. If others in group disagreed with the consistency of the selected factor projection with those previously included in the framework, they were given the chance to suggest an alternative. However, if the participant who had originally selected the factor was not convinced by these arguments, s*he was free to stick with the original choice – provided s*he could justify the decision. Only one projection per factor was allowed to be used in each scenario framework. Once a factor projection had been used in one scenario framework, it could not be reused in another framework. Each participant was only allowed to pick one projection per scenario framework. Thus, each raw scenario framework was developed in as part of a participatory and communitive process. The factor projections that were grouped together to form the resulting three raw scenario frameworks (blue, green and red) are colour coded in the table below.

No.	Title & description	Projection A	Projection B	Projection C	Projection D	Projection E
KU1	**In other mitigation news**: level of success and failures of mitigation options affecting net emissions	**Focus on mCS for CDR**: marine geological storage as a key part of the overall mitigation puzzle. Focus on removal and geological storage of atmospheric carbon	**Focus on mCS for CCS:** mCS is taking place, but the majority of the CO_2 being stored is fossil or industrial carbon	**Focus on classic mitigation and non-mCS-based CDR measures**. We do not use mCS it is not needed due to success elsewhere	**The day NetZero died:** No mitigation is being actively being pursued, hence no need for mCS.	
KU2	**Financial Incentives – who pays for mCS?**	**No market for mCS**	**Compliance Market:** mCS/Sub-seabed CO_2 storage financed through the EU ETS. Both avoided emissions through CCS and removals through CDR	**Wild West:** Free-market removal& storage credits through voluntary carbon markets only	**EU/Government funded mCS** projects (storage for hard-to-abate and removals, governments decide which sectors are elligible)	**ETS and some government funding** (through removal credits)
KU3	**Storage & transport integrity**	**No leakage at all**	**Leakage, resolvable (at cost)** Leakages occur but there are solutions for it	**Leakage not resolvable** Leakages occur and there are no solutions for it	**Permanent (minor) leakage,** leakages occur, but it below the regulatory threshold	
KU4	**Political majorities on mCS in Germany and the EU**	EU pro, Germany pro EU pro, Germany pro	EU against, Germany pro	EU against, Germany against	EU pro, Germany against	

KU5	**Public perception of mCS within Germany:** Perception of the general and local publics about mCS	General public pro, local public against	General public against, local public pro	General public against, local public against	General public pro, local public pro	
KU6	**CO_2 storage location** Where Germany is storing its captured CO_2	**No offshore storage**, only terrestrial storage in Germany	**Storage in Germany only** (both onshore & offshore)	**No storage in Germany –** all CO_2 exported for storage elsewhere	**Offshore storage only –** in German & neighbouring countries EEZs **Offshore storage only –** in German & neighbouring countries EEZs	**No storage –** Germany is not storing any captured CO_2

Table 3: Scenario frameworks

Creating pictures and histories of the future

In breakout groups, the participants then fleshed out these scenario frameworks. They first described a coherent descriptive »picture« of the future, based on the projections in their respective scenario frameworks. They then created a corresponding narrative »history«, or trajectory that could plausibly lead to the situations they describe. They did this by conducting a backcasting exercise and creating timelines of key events that lead to their described pictures of the future. The additionally developed a ›theory‹ of each of their futures, mapping the core dynamics and underlying structures driving change in each scenario, and narrative graphs that show the phases and turning points of the scenarios. The result of such a process was thus set of qualitative scenarios that not only provided a range of detailed pictures of the future, but also included a rich ›history‹ of each future – a pathway which describes the key technological, economic, political and social changes that would have to happen between today and that imagined future. In a final step, the participants were asked to reflect upon which aspects of each scenario they as a group considered to be (in)feasible or (un)desirable.

Reporting back and group feedback

In plenary, each group was then asked to present their coherent descriptive »picture« of the future and the corresponding narrative »history«, or timeline of events that could plausibly lead to the situations they describe. In addition to asking questions to better understand the future worlds presented, the audience was invited to provide feedback on based on two questions; (1) *What would you like to hear more about?* (2) *How could this scenario be made more plausible?*

3. Scenario descriptions

The following section contains details of the three scenarios developed at the workshop. The material presented for each scenario includes: (1) the scenario frameworks each breakout group used, (2) the timelines and tables they used to explain their imagined pathway from today to that plausible future, (4) the ›theory of the future‹ maps showing the core dynamics/underlying structures of each scenario, narrative graphs that show the phases and turning points of the scenarios, (6) the narrative scenario texts themselves.[3], (7) an overview of the mCS activity taking place in each of the imagined futures, and the tables showing which aspects of each scenario the respective group considered to be (in)feasible or (un)desirable.

Yellow Scenario: »Export-Weltmeister« – Turning a blind eye

Picture of the future

No.	Title & description	Projection
KU1	**In other mitigation news: level of success and failures of mitigation options affecting net emissions**	**Focus on classic mitigation and non-mCS-based CDR measures.** Germany does not use (much) mCS – it is not needed due to success elsewhere
KU2	**Financial Incentives – who pays for mCS?**	**Wild West:** Free-market removal & storage credits through voluntary carbon markets only
KU3	**Storage & transport integrity**	**Permanent (minor) leakage:** leakages occur, but below the regulatory threshold
KU4	**Political majorities on mCS in Germany and the EU**	**EU pro, Germany against**
KU5	**Public perception of mCS within Germany:** Perception of the general and local publics about mCS	**General public pro, local public against**
KU6	**CO_2 storage location:** Where Germany is storing its captured CO_2	**No storage in Germany – all CO_2 exported for storage elsewhere**

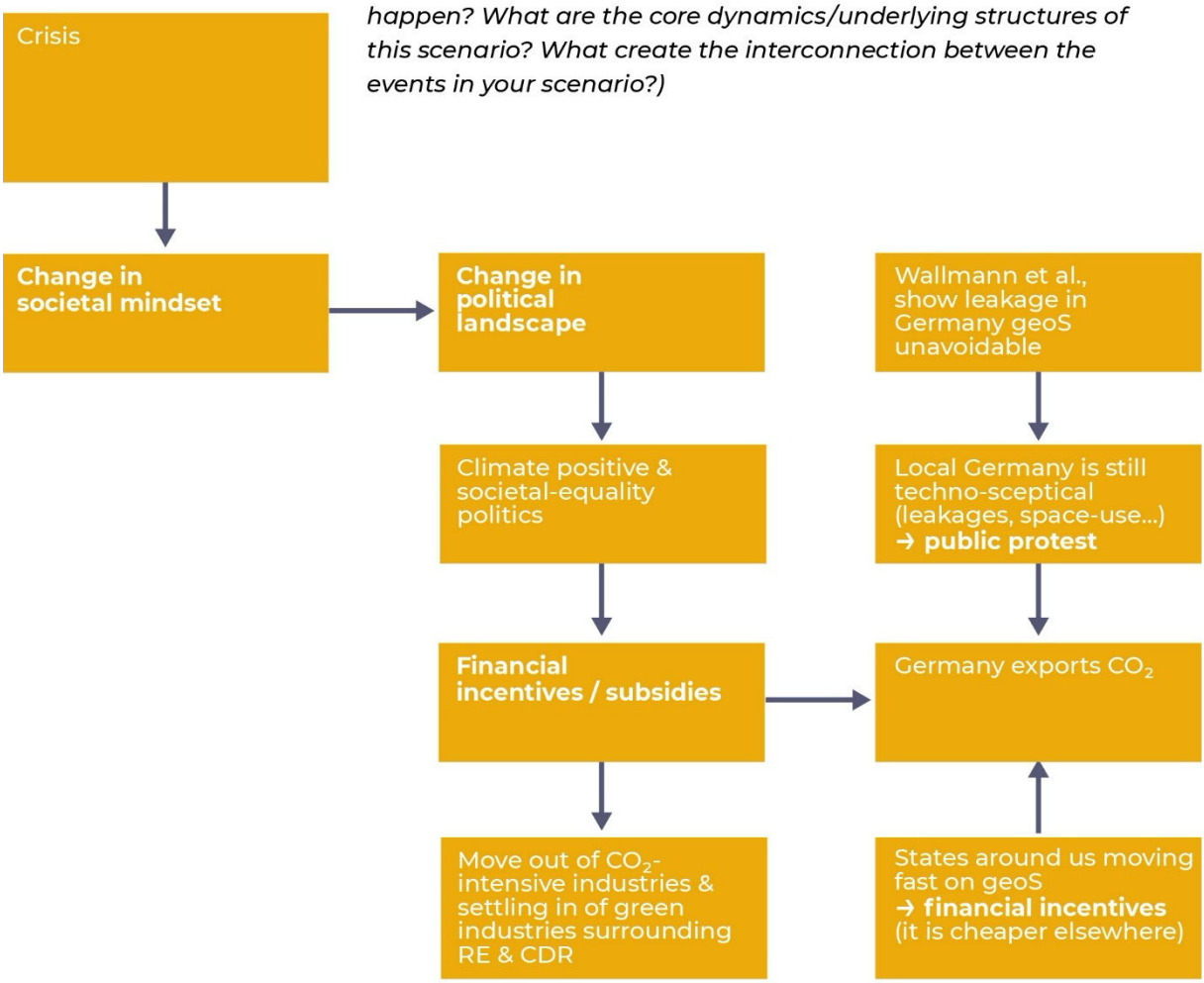
[3] The narrative scenario description texts included here are based on the material developed during the workshop, incorporate suggestions raised during the plenary feedback round, and were shared with the original group members for feedback prior to publication in this report, but were compiled by the report author(s). The scenario descriptions presented here thus represent the **author(s)'** summary of and reflection on the workshop discussions and does not necessarily reflect the views of all participants.

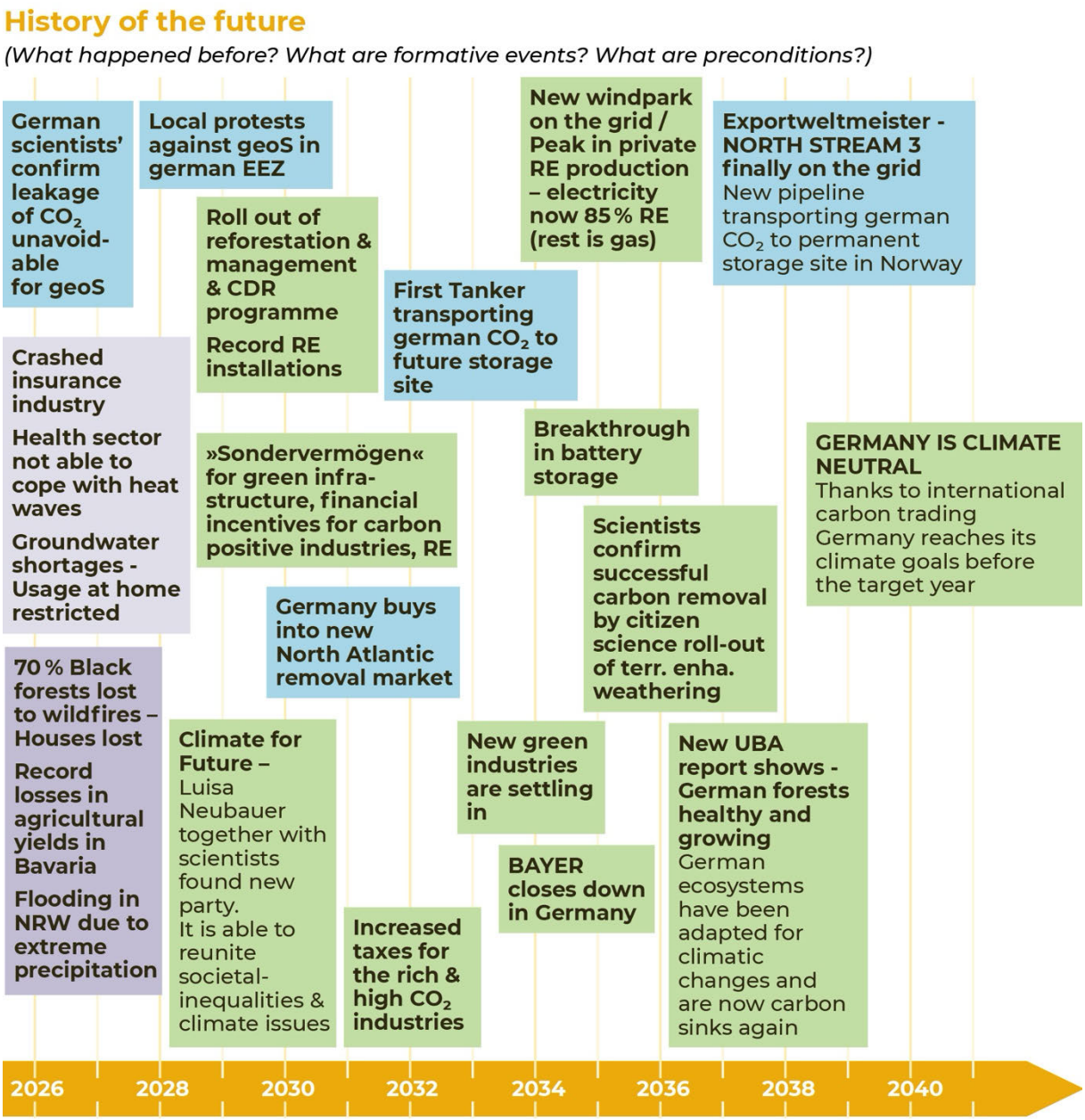
Key characteristics

Emissions reduction	**Substantially reduced, due to i) surging RE implementation including private producers, offshore wind energy (space conflict with mCS, increase in habitats), ii) reduction/export of CO_2-intensive industries (steel, chemical, cement), iii) climate positive societal transformation (transportation, food, heating)**
Other CDR approaches	Very successful: climate change resilient forests, peatland rewetting, CVE, enhanced weathering, etc. & bioenergy plants have been retrofitted with carbon capture (feedstock comes partly from managed forests)
CO_2 storage location	No domestic storage, geoS capacity in North Atlantic is much higher, space conflicts in Germany EEZ with windfarms, export of BECC and gas/industry + CC CO_2 to EU & Norway & UK (mostly by pipeline and ship)
Leakage	Research shows some leakage is to be expected -> local public not happy (nimby); Germany's position EU/internationally is demanding higher standards to regulate risk
Hard-to-abate emissions	Compensated for by investing in the international voluntary carbon removal credits

Theory of the future

(What drives/causes this scenario? What makes this scenario happen? What are the core dynamics/underlying structures of this scenario? What create the interconnection between the events in your scenario?)





History of the future in the Yellow Scenario. Colors indicate: green = positive developments; red/purple = negative developments; blue = mCS-specific developments.

Scenario description: mCS in 2040: Yellow Scenario – »Export-Weltmeister«

Summary

From the late 2020s, intensifying climate impacts in Germany coincided with rapid progress in mitigation, renewable expansion, and societal transformation, while research findings on unavoidable leakage reinforced local opposition to domestic mCS. Policy responses therefore prioritized offshore wind, industrial restructuring, forest management, and peatland rewetting, which substantially reduced residual emissions and the perceived need for CO_2 storage within Germany. From around 2028, Germany began exporting captured CO_2 for storage abroad, and during the 2030s this export-oriented model was consolidated as storage capacity expanded in other North Sea and North Atlantic countries and space conflicts intensive in the German EEZ. In parallel, Germany advocated for stricter international standards for carbon removal, storage and MRV, while relying on international voluntary

carbon markets and removal credits to counterbalance its remaining residual emissions. By 2040, Germany had achieved climate neutrality largely through classic mitigation and non-marine CDR, while positioning itself as an exporter of CO_2 as domestic mCS remains politically infeasible.

mCS in Germany in 2040: Picture of the Future

By 2040, Germany has largely achieved its climate targets through a combination of ambitious classic mitigation measures and the successful deployment of some non–marine carbon dioxide removal (CDR) approaches, primarily bioenergy with carbon capture and storage (BECCS). Emissions have declined substantially as a result of rapid renewable energy expansion in Germany – particularly offshore wind, along with deep societal transformations in transport, food systems, and heating, and the gradual relocation or downsizing of CO_2-intensive industries such as steel, cement, and chemicals. These developments have significantly lowered Germany's residual emissions, positioning the country as a high achiever within the EU. Other mitigation approaches, including climate-resilient forest management and peatland rewetting have been successful and reduced the perceived need for large-scale marine carbon storage (mCS) within German territory.

In this context, Germany has chosen to avoid domestic CO_2 storage entirely. Limited space in the German Exclusive Economic Zone due to offshore wind expansion, combined with persistent local coastal opposition to storage infrastructure and concerns about leakage risks, has made onshore and offshore storage politically controversial in Germany. Research acknowledging the inevitability of minor leakage – even if it is expected to remain below regulatory thresholds – has further reinforced local resistance. While the general public remains broadly supportive of CO_2 storage in the abstract, local communities oppose such sites, resulting in a strong »not in my backyard« dynamic in coastal areas. Consequently, all captured CO_2 from BECCS, industrial point sources, and gas processing in Germany is being exported for storage. Via pipelines and shipping, German CO_2 reaches primarily other EU countries, Norway, and the United Kingdom, all of which have greater geological storage capacity – particularly in the North Atlantic – than the German EEZ.

At the European level, many member states support mCS, while Germany maintains a cautious stance toward both mCS and carbon removal regulation more broadly, consistently citing environmental and political risks from weak oversight. Paradoxically, Germany benefits from today's loosely regulated »Wild West« voluntary carbon markets, investing in international removal credits to offset residual emissions while simultaneously advocating for stricter EU and international standards on monitoring, leakage, and environmental integrity. This creates tensions between Germany's regulatory ambitions and its practical reliance on CO_2-export for storage and international carbon removal credits to achieve its climate targets. By 2040, Germany has become known as an »export champion« – of not only of CO_2 itself, but also of CO_2-storage related technology, expertise and regulatory know-how. This means Germany is perceived as being a somewhat hypocritical actor on this issue: positioning itself as a leader in mitigation, innovation, and CDR governance debates, while at the same time ›outsourcing‹ its carbon storage and removal responsibilities.

History of the Future

Several dynamics combined to lead to this situation: Between 2026 and 2040, Germany's climate policy was shaped by the coexistence of accelerating climate impacts, rapid progress in mitigation and societal transformation, and persistent political resistance to mCS within the German EEZ. This combination put Germany on a pathway in which it achieved climate neutrality early while systematically externalising CO_2 storage to neighbouring countries.

The late 2020s was a period of intensifying climate impacts. Between 2026 and 2028, severe wildfires led to substantial forest and housing losses in the Black Forrest, while extreme precipitation caused major flooding in North Rhine–Westphalia and record agricultural yield losses in Bavaria. These events contributed to rising societal awareness of climate damages and fuelled public support for mitigation measures. The public mindset shifted and the political landscape in Germany became yet again increasingly open to trying to reconcile societal-equality and climate policy ambitions.

At the same time, German research institutions confirmed that some degree of CO_2 leakage from sub-seabed geological storage is unavoidable over long time horizons. Although leakage levels were assessed as manageable within regulatory thresholds, these findings triggered strong local opposition to mCS projects in the EEZ. As a result, public attitudes became increasingly differentiated: broad support for climate action and emissions reduction among the general public coexisted with firm rejection of domestic CO_2 storage infrastructure by local coastal communities.

From 2028 onwards, policy responses focused on accelerating alternatives. Early large-scale programmes for reforestation, ecosystem management, and peatland rewetting were rolled out, complemented by rapid expansion of offshore wind capacity. Renewable electricity generation increased sharply, and new wind parks were connected to the grid. At the same time, Germany began exporting captured CO_2 for storage abroad: the first tanker shipments transported industrial/gas power plant and biogenic CO_2 to sub-seabed storage sites in other European countries' EEZs. This marked a strategic turning point. Germany had significant amounts of captured CO_2, particularly from bioenergy and industrial sources, but domestic storage remained politically infeasible. As other countries were first-movers and positioned themselves strategically as CO_2 storage providers, ›outsourcing‹ storage to other countries emerged as a cost-effective compromise that reconciled ambitious climate targets with local opposition to carbon storage in Germany.

During the early 2030s, this export-oriented model was consolidated. A dedicated »Sondervermögen« for green infrastructure channelled public finance into renewable energy, grid expansion, and green industries. In parallel, Germany intensified its engagement at the European and international levels, advocating for stricter standards for geological CO_2 storage, monitoring, and leakage management. Expanded storage capacity in other countries in the North Atlantic, combined with increasing space conflicts in the German EEZ due to offshore wind deployment, further reduced incentives for domestic mCS development.

By the mid-to-late 2030s, Germany's electricity system reached approximately 85% renewable generation, supported by major breakthroughs in battery storage and a peak in private renewable energy production. Residual emissions in Germany were low, but not eliminated. International voluntary carbon markets expanded rapidly during this period, characterised by heterogeneous quality and governance gaps. Germany relied on international removal certificates to counterbalance its remaining residual emissions, while criticising the environmental integrity of a largely unregulated »Wild West« market. Germany achieved climate neutrality ahead of schedule, primarily through classic mitigation approaches, supplemented by terrestrial CDR and international removal credits.

In 2040, Germany has firmly positioned itself as an exporter of CO_2, rather than a host of sub-seabed storage sites. All CO_2 captured in Germany is transported to storage locations in EU partner countries, Norway, and the United Kingdom. Domestic opposition to mCS persists. The resulting situation is defined by a persistent tension: Germany claiming ethical climate leadership through mitigation, innovation, and standard-setting, while pragmatically relying on offshore storage solutions beyond its borders.

Overview of mCS activity taking place in 2040 in the yellow scenario

Type of activity	Export to Norwegian for mCS, Sandstone mostly and some basalt locations are coming up – they have it all, that is why they are so successful
Time frame/duration/rate	Full implementation of mCS; 50-100 Mt CO_2/year
Implementation location/ jurisdiction	Norway and other North Sea/Atlantic countries (UK, Norway, Iceland, Netherlands); partly national jurisdiction, partly international waters
Substance/ matter being introduced (origin, form, amount, persistence etc.)	Liquified, purified CO_2 from BECCS (~60-70%), hard-to-abate sectors' process emissions (such as cement, lime, or waste incineration; ~25-30%), some (limited) from natural Gas power plants (~5-10%; Luderer et al. 2021, Agora Think Tanks 2024)
Implementation scale (at introduction)	Full implementation of several CO_2 injection sites outside of Germany
Actors implementing	Private companies in Norway and other North Sea/Atlantic countries (UK, Norway, Iceland, Netherlands); reorientation from previous oil/gas industry
Funding	Removal credit markets
Delivery tech/ infrastructure involved	In Germany: capturing and purification tech+ pipelines & ships+harbours; mostly pipelines transporting CO_2 but also ships; all kinds of platform all over
MRV tech/ infrastructure involved	Outside of Germany: little to no eMRV happening; harbours being revived for CO_2 transport
Removal potential/duration	Long-term storage, with (minor) continuous leakage (which is not accounted for)
Costs (›best guess‹) (including planning, implementation, MRV)	Relatively low costs for Germany – little MRV, others have invested in infrastructures, we benefit from first movers that have experience
Anticipated ecological/ environmental impacts (positive & negative)	No impacts within Germany; unknown/un-monitored environmental impacts at the storage sites; thought to be local, not impacting ecosystems on a large-scale
Anticipated effects on other ocean uses in the area (fisheries, shipping, leisure etc.)	Mostly outside of Germany; new pipelines are built along existing pipelines
Affected stakeholders	CO_2 capturing industries (new commercial sector); local communities in Germany are not strongly affected because of the outsourced storage. Some negative reactions to pipeline construction due to fear of leakage. Local communities in the countries storing the CO_2 are affected – mix of positive (job creation) and negative (impacts on access for other marine uses)

Regulatory landscape – jurisdictional responsibility, decision-making authority, permitting & monitoring processes, consultation requirements	Marine spatial planning by BSH; export and transport of of CO_2 is permitted by Deutsche Emissionshandelsstelle of UBA; and regulated under the new change to the German CO_2 Storage and Transport Law; Monitoring & consultation regulations are the responsibility of the country hosting the storage site (e.g. Norway)
Social context conditions such as economic/ social vulnerabilities, economic structure, past experiences, environmental damage, and social-cultural relevance of the marine environment	Vocal locals afraid of leakages; good experiences outside of Germany (e.g. Norway); as of now no significant impact to marine environment.; Most impact outside of Germany.
Consultation/ engagement/ participation activities undertaken	Little to no public engagement is on geoS/mCS in Germany
Public perception of activity	General agreement that we need geoS but Nimby -> export it. General public much in favour of other climate solutions
Political contention about the activity	Some parties are pushing for higher eMRV standards, but we are still using the storage sites; some do not want to pay the price for geoS and carbon credits; some push for more involvement of government in geoS

Green scenario: Incremental continuity/Managed middle-ground

Picture of the future

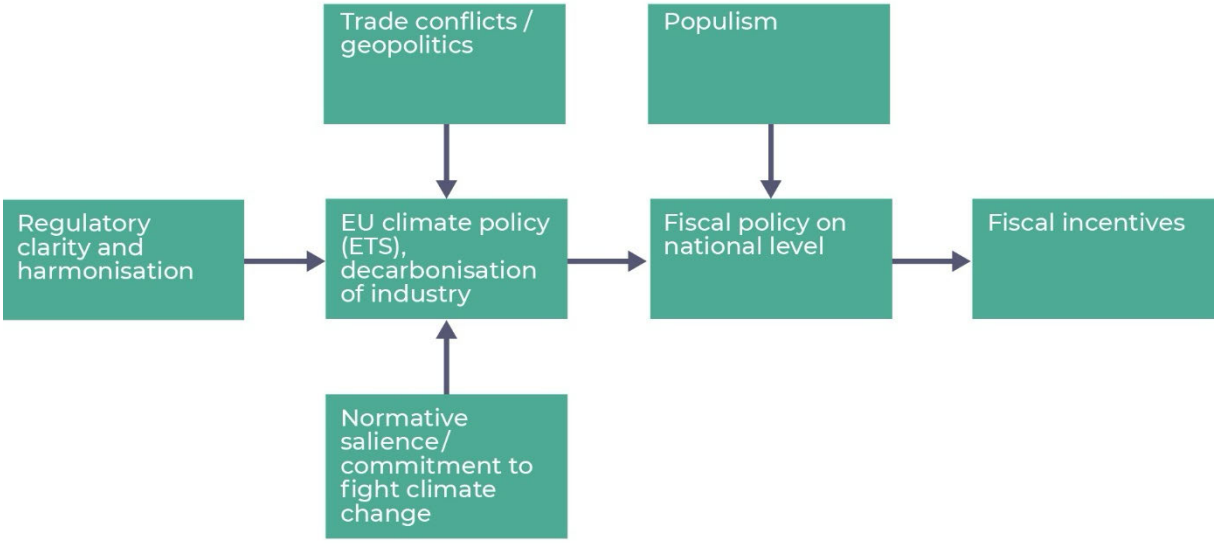
No.	Title & description	Projection
KU1	**In other mitigation news: level of success and failures of mitigation options affecting net emissions**	**Focus on mCS for CCS:** mCS is taking place, but the majority of the CO2 being stored is fossil or industrial carbon
KU2	**Financial Incentives – who pays for mCS?**	**Compliance Market:** mCS/Sub-seabed CO_2 storage financed through the EU ETS. Limited number of CCfDs (Klimaschutzverträge) starting in 2027. Both avoided emissions through CCS and removals through CDR
KU3	**Storage & transport integrity**	**Leakage, resolvable (at cost)** Leakages occur but there are solutions for it
KU4	**Political majorities on mCS in Germany and the EU**	**EU pro, Germany pro**
KU5	**Public perception of mCS within Germany:** Perception of the general and local publics about mCS	**General public against, local public pro**
KU6	**CO_2 storage location:** Where Germany is storing its captured CO_2	**Offshore storage only –** in German & neighbouring countries EEZs

Key characteristics

Storage projects	5-10 projects underway (hard-to-abate sectors: cement, waste incinerators, lime industry), CCS for industry only partly implemented
Energy mix	largely renewables, some blue hydrogen in the energy mix (competition for subsidies)
CO_2 storage location	German EEZ & export to Scandinavia, UK and Poland
Transport infrastructure	CO_2 carriers, pipelines emerging at a later stage
Financing	Weakening of ETS timeline
Leakage	Leakage along the process chain: CO_2 has to be closely monitored
Public acceptance	»Local vocals« are in favour because of jobs/benefits

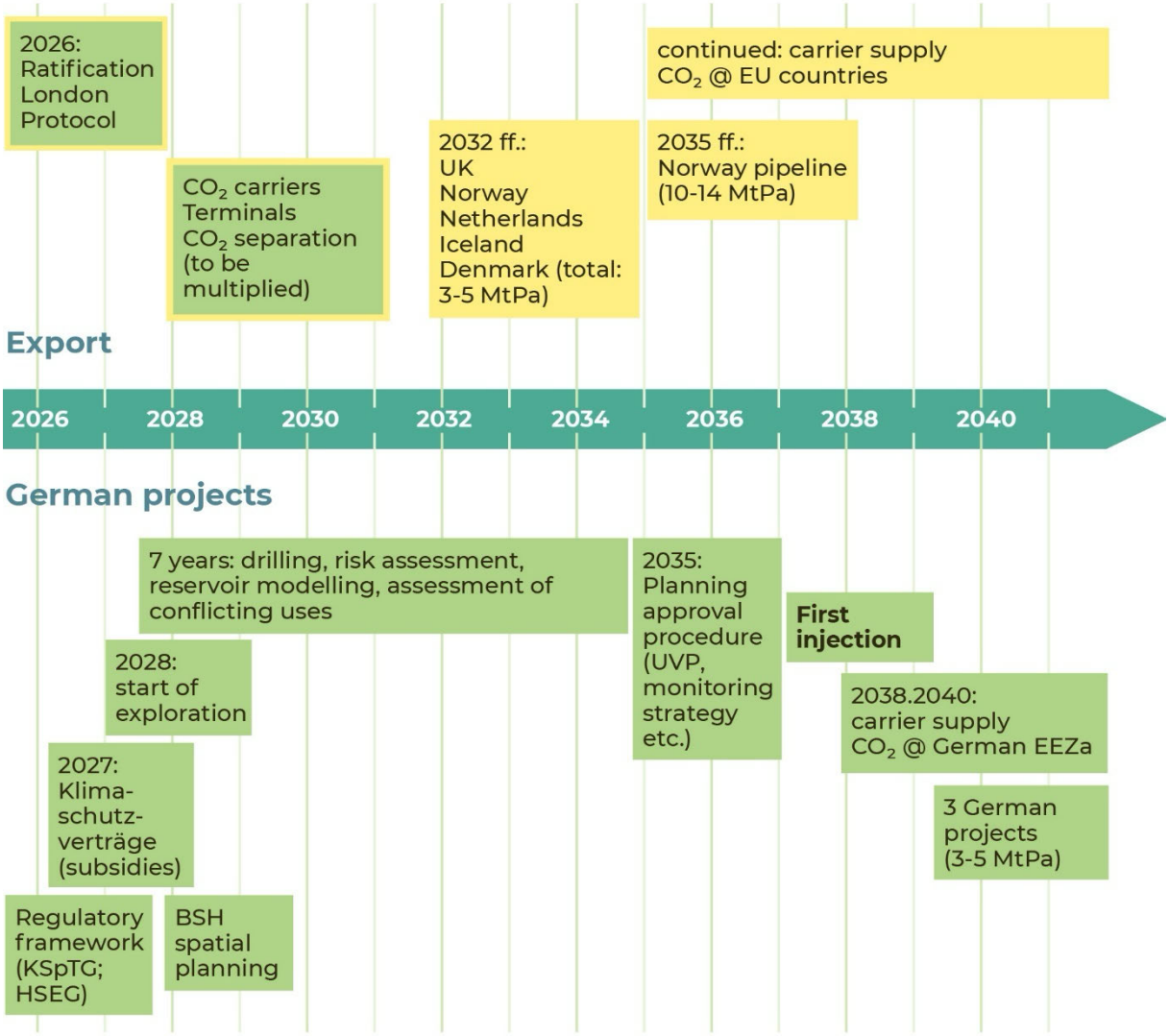
Theory of the future

(What drives/causes this scenario? What makes this scenario happen?
What are the core dynamics/underlying structures of this scenario?
What create the interconnection between the events in your scenario?)



History of the future

(What happened before? What are formative events? What are preconditions?)



Scenario description, mCS in 2040: Green Scenario: Incremental Continuity/Managed Middle-Ground

Summary

From the early to mid-2020s, Germany and the EU reaffirmed industrial decarbonisation under the EU ETS, while regulatory debates, costs and accounting practices channelled mCS primarily toward CCS for industrial point sources rather than for atmospheric CDR. Legal revisions and international agreements in the mid-2020s created a framework for offshore and transboundary CO_2 storage, but persistent opposition to onshore storage, uncertainty about ETS prices, and limited use of contracts for difference constrained early investment. From around 2028, a small number of projects entered long planning, exploration, and permitting phases in the German EEZ, while shipping-based exports to Norwegian, Danish, British, and Dutch storage sites expanded from the early 2030s. Throughout the 2030s, technological learning improved capture, transport, and MRV, but did not fundamentally reduce costs, and intermittent leakage events reinforced the need for continuous (expensive) monitoring. By 2040, these cumulative dynamics resulted in a small, but well-established offshore-focused German mCS sector embedded in the ETS and supplemented by international storage cooperation.

mCS in Germany in 2040: Picture of the Future

By 2040, marine geological CO_2 storage (mCS) in Germany has become an established but limited element of the national climate policy strategy. It operates primarily as component of industrial carbon capture and storage (CCS), rather than as a part of atmospheric carbon dioxide removal (CDR). Marine (sub-seabed) activities are concentrated within the German Exclusive Economic Zone (EEZ) and selected neighbouring EEZs, reflecting persistent political and societal resistance to onshore storage as well as regulatory pragmatism. Between five and ten storage projects are operational or in advanced ramp-up, together handling approximately 10–20 Mt CO_2 per year. The stored CO_2 originates predominantly from hard-to-abate industrial process emissions, primarily from cement, lime, and waste incineration, as well as a small amount from blue hydrogen production.

The European Union Emissions Trading System (EU ETS) remains the central financial driver of these activities. Both avoided emissions through industrial point-source CCS and limited removals associated with biogenic waste incineration coupled with carbon capture and geological storage are recognised within the compliance market, although price signals remain insufficiently strong to enable a rapid scale-up. Fiscal support instruments such as Contracts for Difference (CfD) exist but are applied sparingly, resulting in constrained investment across the value chain. Germany relies substantially on CO_2 exports to established storage hubs in Norway, Denmark, the United Kingdom, and other North Sea countries, supplementing its comparatively modest domestic storage capacity.

Technically, the mCS landscape is characterised by a mix of ship-based transport, coastal hubs, and emerging pipeline infrastructure, supported by increasingly sophisticated (and expensive) monitoring, reporting, and verification (MRV) systems. Leakage occurs intermittently along the capture, transport, and injection chain, but is considered manageable and reversible at additional cost. Ecological impacts are assessed as small to moderate, and are mitigated through strict permitting. Marine spatial planning strategies have been implemented that seek to balance use of marine spaces for CO_2 storage, fisheries, offshore wind, shipping, military uses and marine protection. Although some spaces can be used for multiple purposes, some cannot, and this restricts the area available for mCS, and not all areas that could theoretically be used for mCS in the German EEZ are actually used for this purpose.

Societal acceptance remains divided. While the general public in Germany is skeptical or ambivalent about marine geological CO_2 storage due to reports about intermittent leakage (even though it is deemed manageable by experts), local stakeholders in some coastal regions have expressed support for mCS, motivated primarily by perceived employment opportunities, infrastructure investment, and regional economic benefits. Politically, both Germany and the EU maintain a broadly supportive stance toward mCS as part of an industrial decarbonisation strategy, even as it becomes increasingly evident that the scale achieved by 2040 is insufficient to close the remaining emissions gap.

History of the future

The situation in 2040 is the outcome of a gradual, path-dependent evolution rather than a decisive policy shift. In the mid-2020s, Germany and the EU reaffirmed their commitment to industrial decarbonisation under the EU ETS, while remaining cautious about large-scale public investment in CCS infrastructure. Early debates focused on whether mCS should primarily serve removals or emission reductions; in practice, regulatory and financial incentives converged on CCS for industrial point sources, where accounting rules, compliance mechanisms, and political justification were more straightforward.

During the mid-2020s, regulatory groundwork was laid through revisions of the German Carbon Storage Act & High Seas Dumping Act, and the ratification of international frameworks such as the London Protocol amendment enabling transboundary transport of CO_2. These steps provided legal clarity but did not resolve underlying distributional and societal conflicts. Public opposition to onshore storage in Germany remained strong due to NIMBY-ism and mobilisation by environmental NGOs around issues of potential leakage from onshore storage sites, reinforcing a strategic pivot toward

offshore-only solutions and external storage partnerships. At the same time, uncertainty about long-term ETS prices, the persistence of free allowances, and limited uptake of climate contracts for difference (CCfDs) constrained early investment decisions.

From around 2028 onward, a small number of industrial CCS projects began to receive approvals and conditional funding, initiating lengthy planning, exploration, and permitting processes for offshore saline aquifer storage in the German EEZ. Given development timelines of seven to eight years post project-approval, the first injection within German waters did not occur until 2038. To avoid further delay in emissions abatement, industry and government simultaneously pursued export-oriented solutions, leveraging shipping-based transport to Norwegian, Danish, British, and Dutch storage sites from as early as 2032.

Throughout the 2030s, technological learning improved capture efficiencies, transport logistics, and MRV systems, but did not fundamentally lower the costs. Leakage events along the CO_2 chain, while technically resolvable, reinforced the need for continuous monitoring and further added to operational costs. Meanwhile, broader energy system and industrial developments which included CO_2 point-source-capture increased competition for scarce storage capacity and subsidies.

Politically and socially, the period was marked by ambivalence rather than backlash. Climate targets were increasingly missed, yet responses remained incremental. Populist pressures and fiscal constraints limited large-scale public spending, while normative commitment to climate mitigation persisted at the rhetorical level. Localised support for mCS emerged in specific coastal regions where economic benefits were tangible, even as national public opinion remained largely disengaged or skeptical.

By 2040, this trajectory has produced a »middle-of-the-road« outcome: mCS is neither marginal nor transformative. It functions as a necessary but insufficient complement to broader decarbonisation efforts, embedded in a weakened yet still operative ETS framework and reliant on international cooperation for storage capacity. The history of this future is thus defined less by decisive turning points than by the cumulative effects of regulatory caution, limited fiscal ambition, and the gradual normalisation of offshore CO_2 storage as an industrial risk-management practice.

Overview of mCS activity taking place in 2040 in the green scenario

Type of activity	CO_2 storage primarily in saline aquifers (Germany); depleted oil and gas fields (for ex. DK); possibly basalt storage (Norway)
Time frame/duration/rate	8 years for storage in GER to become operational, starting 2038, Export starts 2032
Implementation location/ jurisdiction	3 locations in German EEZ; export to NOR, DK, UK, NL, Iceland, Poland
Substance/ matter being introduced (origin, form, amount, persistence etc.)	Gaseous and (predominantly liquid transport; source of CO_2: hardest-to-abate (i.e. lime, cement, waste incineration) + blue H2; 10 – 20 Mt/a (storage in GER + export); 99% permanency of CO_2 stored
Implementation scale	5-10 storage projects underway in 2040, – 10 – 20 Mt/a, (including storage in GER + export)
Actors implementing	Industry; regulators are regulating (LBEG; BSH; BGR; UBA; BfN)
Funding	ETS prices level in comparison to CCS costs unclear (+ still free allowances present); CCfDs (or equivalent); BIK (or similar smaller funding sources);

	penalty regime (injection capacity obligated entities); funding of BECCS-based removals through ETS is likely
Delivery tech/ infrastructure involved	Initial transport means: CO_2 ships / carriers; floating turrets; multiple CO_2 hubs (coast); 2035 onwards: pipelines; infrastructure onshore: train / ship / barges -> pipeline
MRV tech/ infrastructure involved	See above; + special monitoring platform
Removal potential/duration	Removals are only occurring in connection with (biogenic) waste incineration coupled with point source capture and storage of resulting CO_2.
Costs (›best guess‹) (including planning, implementation, MRV)	Offshore GER: hub + 100 km transport + storage = 50 €/t ship transport; Exports options: NOR 100 €/t transport + storage; DK: 50-80 €/t (depending on onshore/offshore) Capture costs for hardest to abate industry (i.e., cement): ca. 100 €/t Transport: 20 – 50 €/t (capture cost blue H2: 10 €/t) MRV: 5 – 10 €/t
Anticipated ecological/ environmental impacts (positive & negative)	Small to moderate (negative) ecological impact (strict regulations for seismic and environmental monitoring etc.; leakage resolvable). Some localized, short-term negative effects due to pipeline construction. Leakage, when it occurs, has short term, localised effects, but as clear regulatory requirements are in place for monitoring for leakage, and practices in place for rapid resolution of suck leakage, ecological impacts are small.
Anticipated effects on other ocean uses in the area (fisheries, shipping, leisure etc.)	Multi-use- marine spatial plans are in effect and functioning to avoid use-conflicts, these are effective, but limit the area available for mCS infrastructure.
Affected stakeholders	Fisheries; military; offshore windfarms; local people at the coastline. As marine spatial planning is effective, most impacts on other ocean uses are minimised. Some local coastal communities at the coast gain economic benefits (job creation in construction and monitoring etc.)
Regulatory landscape – jurisdictional responsibility, decision-making authority, permitting & monitoring processes, consultation requirements	KSpTG provides a sufficient regulatory regime; Ratification of relevant amendment to London-Protocol to allow the transboundary transportation of CO_2 for storage; EU level regulations for harmonization of transport & storage standards are in effect.
Social context conditions such as economic/ social vulnerabilities, economic structure, past experiences, environmental damage, and social-cultural relevance of the marine environment	Less energy intensive industry in GER; some coastal communities initially still resisted the development of mCS infrastructure, but provision of local economic benefits (hub locations, job creation) counterbalances this
Consultation/ engagement/ participation activities undertaken	Extensive stakeholder engagement – including fisheries, military, offshore wind, local community members etc. in planning for coastal hub locations, marine spatial planning, developing monitoring plans, ensuring job

	creation, local benefits etc. Town halls, citizen assembles as well as more focused expert-stakeholder planning workshops fed into decision making.
Public perception of activity	Disinterest of the majority of Germany regarding mCS per se; but some local vocals (minority) in favour due to economic benefits.
Political contention about the activity	Political majorities in both Germany and the EU maintain a broadly supportive stance toward mCS as part of an industrial decarbonisation strategy

Red Scenario: The Burning yet Hopeful World

Picture of the future

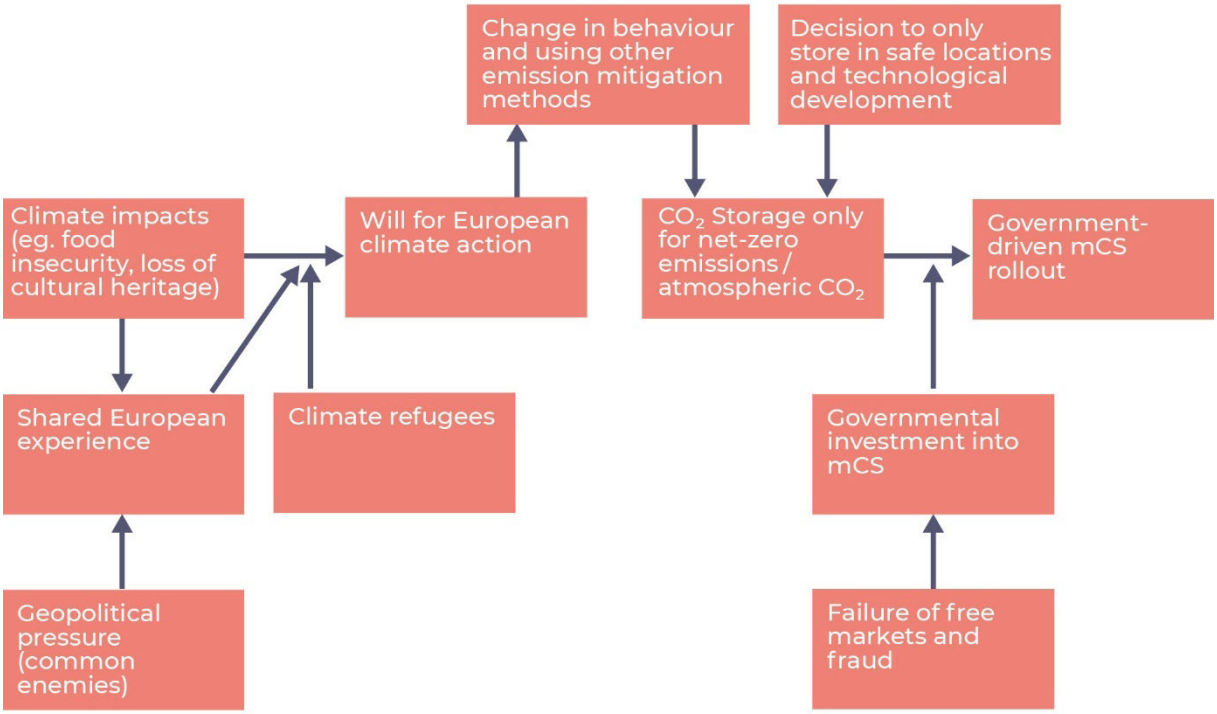
No.	Title & description	Projection
KU1	**In other mitigation news: level of success and failures of mitigation options affecting net emissions**	**Focus on mCS for CDR:** marine geological storage as a key part of the overall mitigation puzzle. Focus on removal and geological storage of atmospheric carbon
KU2	**Financial Incentives – who pays for mCS?**	**EU/Government funded mCS projects** (storage for hard-to-abate and removals, governments decide which sectors are eligible)
KU3	**Storage & transport integrity**	**No leakage at all**
KU4	**Political majorities on mCS in Germany and the EU**	**EU pro, Germany pro**
KU5	**Public perception of mCS within Germany:** Perception of the general and local publics about mCS	**General public pro, local public pro**
KU6	**CO_2 storage location:** Where Germany is storing its captured CO_2	**Offshore storage only –** in German & neighbouring countries EEZs

Key characteristics

Why do people and governments support mCS?	Frequent droughts in Germany combined with heavy floodings, climate migration from Global South leads to climate action, EU came back together due to the pressure of Climate Change
Why marine CS?	Terrestrial storage capacities are lower than expected and more leakage, thus more expensive, emission reductions not sufficient (despite no fossil fuels)
Why government-funded mCS?	ETS money used by government to finance mCDR projects, EU had to act quickly, thus EU directly funds mCDR, keep companies in EU and make EU competitive, scandals around private actors doing ETS-funded mCDR
Why is the EU successful in scaling mCS?	EU conditionality for climate measures and high funding for research and development of climate technologies thus no leakage and more trust

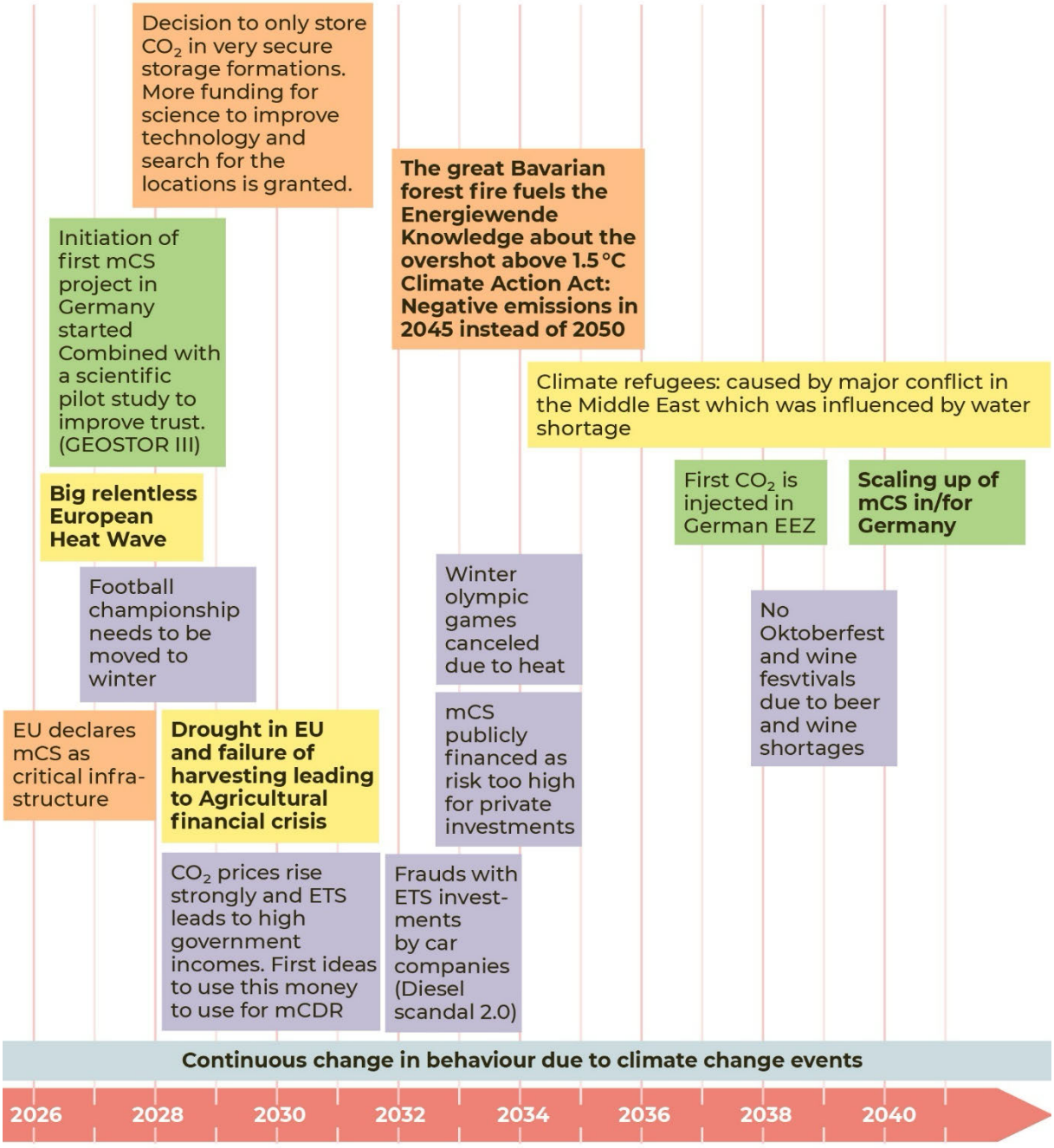
Theory of the future

(What drives/causes this scenario? What makes this scenario happen?
What are the core dynamics/underlying structures of this scenario?
What create the interconnection between the events in your scenario?)



History of the future

(What happened before? What are formative events? What are preconditions?)



History of the future in the Red Scenario. Colours indicate: green = physical development of mCS in Germany; yellow = climate change impacts; purple = broader societal and political developments indirectly enabling mCS deployment; orange = policies directly impacting deployment scale-up.

Scenario description: Red scenario: The burning yet hopeful world

Summary

From the late 2020s, a sequence of extreme climate events and rising climate damages made climate change a shared European condition, while scandals around ETS-funded projects weakened confidence

in purely market-based mitigation and removal. In the early 2030s, evidence from offshore storage in other North Sea countries and growing concerns about climate-induced migration broadened political support for more coordinated, state-led climate infrastructures. Germany began planning publicly funded pilot projects framed as science-based, transparent, and participatory, with accelerated licensing and EU coordination shortening development timelines. As mitigation and industrial decarbonisation progressed more successfully than expected, policymakers stipulated that mCS should primarily be used for atmospheric CO_2 removal and its use was only allowed in the safest offshore sites. Terrestrial geological storage was not permitted, and CCS for ongoing fossil and industrial emissions was minimized. By 2040, this trajectory resulted in a publicly financed, offshore geological storage of atmospheric CO_2, with broad political and societal acceptance.

mCS in Germany in 2040: Picture of the Future

By 2040, Germany and the European Union are simultaneously stabilising and deeply scarred by the impacts of climate change. Overall mitigation progress has been substantial: fossil fuel use has largely been phased out, industrial decarbonisation has advanced, and emissions trajectories are trending downward. Recurrent droughts, intense flooding, and large-scale wildfires – including memorable events such as the Bavarian forest-fires of the mid-2030s – have entrenched the societal understanding that climate action is urgently needed to come back from the dangerous ›overshoot‹ of the Paris temperature target. Against this backdrop, marine geological carbon storage (mCS) has become a central, widely accepted component of the German and wider European climate policy portfolio.

In this future, mCS is primarily used for carbon dioxide removal rather than the management of industrial or fossil emissions. The focus lies on the geological storage of atmospheric CO_2 captured through bioenergy with carbon capture and storage, direct air capture, direct ocean removal and ocean alkalinity enhancement. Storage takes place exclusively offshore, within German and neighbouring countries' exclusive economic zones (EEZs). Terrestrial storage projects have largely been discontinued due to lower-than-expected capacities, threat of potential leakage (i.e. due to high number of pre-existing man-made wells, mines and drilling sites, shallower depth of storage sites) public resistance, and escalating costs.

A defining feature of the 2040 landscape is the finance model underpinning mCS. Storage infrastructure is publicly funded. While private actors design and operate projects, the state retains strategic control through financing, eligibility rules, and stringent safety standards. This arrangement emerged from a loss of trust in purely market-driven approaches following high-profile scandals involving misallocated ETS funds – it was revealed that several large projects credited under ETS-linked schemes systematically overestimated net removals due to flawed baseline assumptions and unaccounted lifecycle emissions. In contrast, publicly backed mCS megaprojects, embedded in EU-wide cooperation frameworks, are perceived as credible, transparent, and accountable.

Public and political support for mCS is broad and stable. Both general and local public's view offshore storage as a necessary and prudent response to ongoing climate risks, particularly given the demonstrated absence – or extremely low risk – of leakage. This trust is underpinned by extensive public investment in research, monitoring, and site selection, allowing authorities to restrict storage to the safest geological formations. Politically, strong pro-mCS majorities exist at both German and EU levels, reinforced by a shared European experience of climate damage impacts and by concerns over climate-induced migration from neighbouring regions. The result is a future that is not free of climate harm, but one in which collective action, state capacity, and technological maturity have converged to make mCS a legitimate pillar of long-term climate stabilization.

History of the Future

The trajectory that led to this mCS future in 2040 began in the late 2020s, amid growing dissonance between climate action and lived experience. Although emissions reductions accelerated during this period, Europe was hit by a sequence of extreme events that challenged prevailing assumptions about climate risk. Prolonged heatwaves, water scarcity in Southern Europe, and escalating wildfires culminated in what many later described as a continental turning point: climate change was no longer a distant or abstract problem but a shared European condition.

At the same time, political confidence in market-based climate governance eroded. While carbon prices rose sharply under the EU ETS – generating substantial revenue – several scandals revealed that ETS-funded mitigation and removal projects had failed to deliver credible outcomes. These controversies did not discredit climate policy as such; rather, they shifted attention toward the institutional design of implementation. Governments concluded that critical infrastructures, particularly those involving long-term geological risk, could not be left solely to market incentives and voluntary corporate action.

By the early 2030s, this reassessment coincided with two reinforcing dynamics. First, evidence from early offshore storage projects in countries such as Norway demonstrated that marine geological storage could be operated safely under stringent regulatory oversight. Second, climate-induced migration pressures – driven in part by water scarcity that exacerbated conflict in the Middle East – reshaped political coalitions within Europe. Concerns about social stability and migration did not initiate climate action, but they broadened support for decisive, state-led interventions, including among more conservative constituencies.

Germany's decision to pursue mCS emerged from this convergence. Planning for the first publicly funded pilot projects began in the early-2030s, with licensing and site assessment processes explicitly framed as science-driven, transparent, and participatory. These early projects functioned as trust-building exercises, involving researchers, regulators, civil society organisations, and coastal stakeholders. Although infrastructure development was initially thought to take roughly a decade, accelerated funding, regulatory streamlining, and EU coordination prevented major delay and, in some cases, projects were up and running within seven to eight years.

Crucially, the scope of mCS was deliberately constrained. As mitigation and industrial decarbonisation progressed more successfully than expected, Germany did not require the use of large amounts of CCS storage capacities to abate ongoing fossil and industrial emissions. Instead, mCS was used primarily for atmospheric CO_2 obtained through CDR. This limitation allowed policymakers to prioritise only the most secure offshore sites, accepting higher costs in exchange for near-zero leakage risk. The political narrative emphasised that mCS was not a substitute for emissions reductions but a necessary response to overshoot and a prerequisite for achieving net-negative emissions after mid-century.

By the late 2030s, mCS had been scaled as a dedicated public infrastructure for carbon dioxide removal. EU-level conditionality mechanisms ensured alignment across member states, while generous funding for research and monitoring sustained public confidence. The resulting system was neither utopian nor fully stabilised: Europe continued to experience significant climate impacts. Yet the history of this future is defined by a shift in governance logic – away from fragmented, market-led experimentation towards coordinated, state-backed responsibility for long-term climate action. This shift meant that marine geological storage became both politically and socially supported in Germany and Europe more broadly.

Overview of mCS activity taking place in 2040 in the red scenario

Type of activity	Offshore marine carbon storage
Time frame/duration/rate	2026 – 2039 run-up, 2039 first injection, scaling-up from 2040
Implementation location/ jurisdiction	German EEZ and neighbouring countries
Substance/ matter being introduced (origin, form, amount, persistence etc.)	Substance: Primarily atmospheric CO_2 from BECCS, DACCS, OAE etc, along with some (limited) point source process emissions from a few ›hard to abate‹ sectors deemed ›critical‹ (i.e. cement production & waste incineration). Origin: both marine-based and terrestrial CDR Persistence: as good as permanent (no leakage) Amount: small amount, because of limited storage sites due to »no leakage security«
Implementation scale (at introduction)	Moderate, part of an overall mitigation strategy with mCDR as one component, strict security guidelines limit scope; ~1–5 Mt/a (Northern Lights Phase 1 as reference: 1.5 Mt/a, TotalEnergies 2025)
Actors implementing	private actors
Funding	EU and Member state-funded
Delivery tech/ infrastructure involved	Combination of pipelines, floating injection sites or ships, a mixed approach, cased on whatever is best suited to guarantee maximum safety/low risk of leakage in a given location
MRV tech/ infrastructure involved	High effort of MRV, sensor developing in the years before scaling up, private actors execute MRV, state controls MRV, EIA as part of the MRV
Removal [storage] potential/duration	Removal n.a. because activity is only storage, limited storage potential due to high security standards, very high storage duration, storage process itself is ongoing
Costs (›best guess‹) (including planning, implementation, MRV)	>200 € / t CO_2, some hope of lower costs due to technological progress, funding source ETS may make storage cost-efficient
Anticipated ecological/ environmental impacts (positive & negative)	low negative impact, some demand on land, some possible local disturbance through MRV, ships etc, but still overall very low negative impact, no leakages remove major worry -> but includes only storage and transport, not original CDR Generally positive impact through contribution to climate change mitigation but naturally hard to quantify
Anticipated effects on other ocean uses in the area (fisheries, shipping, leisure etc.)	Deployment and MRV conflict with other uses (offshore wind energy; military zones, etc) and environment; impact might be reduced by new technologies Leisure & Tourism: low because offshore

Affected stakeholders	Marine users: negative due to use conflict (fisheries, military, environmental groups) Companies executing the storage (primarily [ex] fossil fuel companies) Employees: positive due to some job creation (especially off-shore since maybe hard to fully automate), plus their communities, also in trade networks (European countries cooperating) Governments: Need to provide funding [open question just how many jobs are created by this???] -> both only concern storage, open question about who is affected by CDR itself
Regulatory landscape – jurisdictional responsibility, decision-making authority, permitting & monitoring processes, consultation requirements	Responsibility: private actors are generally responsible (liable); state responsibility is the last resort decision-making: International law, EU, national level permitting process: federal level (Umweltbehörden) in cooperation with other authorities (national and federal level) monitoring process (EIA, operation monitoring, post-closure monitoring): private actors; regulated by the state
Social context conditions such as economic/ social vulnerabilities, economic structure, past experiences, environmental damage, and social-cultural relevance of the marine environment	Massive climate impacts on Europe as a whole plus »threat« of climate migration have caused widespread willingness to a renewed push for mitigation across (most) of the political spectrum -> people are hurting because of CC Positive experiences from other EU countries Renewed sense of »Europeanness« in opposition to threats from Russia & US
Consultation/ engagement/ participation activities undertaken	As required by law change in 2026, low to moderate consultation with wider public, public is generally convinced of need to mitigate including storage, offshore remains path of least resistance due to continued resistance to land-based storage. Decisions around siting of storage sites framed as ›as science-based, transparent, and participatory‹ involving town halls and participatory planning workshops.
Public perception of activity	Very positive because of low risks, participatory involvement in project planning etc.
Political contention about the activity	Consensus across all German parties because of urgent need to fight climate change

4. Comparative reflections and conclusions

When asked to reflect on their key take-aways from the scenario workshop, the participants highlighted **the complex relationships between public perception, political will, and the scientific evidence**. In all three scenarios, scientific evidence alone did not drive decision-making on mCS; equity considerations, as well and (public & political) perceptions of environmental and economic risk also played key roles in shaping mCS trajectories in the scenarios. The discussions repeatedly returned to the question of **how public perception of mCS and climate action more broadly may evolve**, often concluding (somewhat reluctantly) that significant external shocks (e.g. escalating climate impacts and

associated economic costs) might be required to shift public and political attitudes on climate action. This points to a broader structural challenge that emerged across the scenarios: responsible development of mCS depended heavily on **politically supported policy instruments** (e.g. emissions trading systems), making this sort of climate action especially vulnerable to fluctuations in public trust and political will. In this context, the **role of science emerged as both stabilizing and reactive**: building trust through pilot projects, providing evidence on safety (e.g. leakage risks), and responding to growing public concern as climate impacts become more tangible. However, the implicit assumption that »things must get worse before they get better« suggests that the workshop group may have found it hard to plausibility imagine how public perception about and support for mCS may emerge organically without external shocks.

At the same time, the discussions highlighted that **political dynamics were crucial** to the scenarios. While participants acknowledged the rise of populism and right-wing skepticism toward climate policy in Germany and the EU in recent years, these dynamics were not fully reflected in the scenarios – rather it was assumed that progressive and/or Green parties were primarily responsible for action on mCS. This raised important questions about whether future pathways for mCS could also be driven by other types of political coalitions, including conservative or even right-wing actors, rather than by »green« majorities. Overall, the reflections on the scenario development process underscored that **societal and political conditions played a key role in shaping mCS futures** in all the scenarios.

The reflections on the workshop also highlighted the **limits and opportunities of this method of foresight scenario** development itself. Participants agreed that these types of scenarios can help **open up and structure thinking about a wider range of plausible futures**, but they only ever capture a sub-set of possible futures, and are **only as diverse as the group developing them**. In addition to having diverse perspectives, disciplines and expertise involved, making the assumptions that feed into the scenario development process explicit was seen as essential, since unclear or hidden assumptions can distort how the scenarios are interpreted or perceived by external readers. Designing complex but still plausible scenarios that integrate plausible ecological impacts, political dynamics, and social context conditions was seen as both necessary and challenging. Finally, the participants emphasized that the workshop made the value of **collaboration across disciplines and perspectives** when thinking through plausible future developments very clear, even if it can be (and was) challenging.

This report has outlined the process and key insights from a single participatory foresight exercise. It is important to emphasize that the OAE scenarios developed during these processes are **exploratory** in nature. They are designed as **thought experiments** to stimulate structured dialogue about possible mCS futures in the German context among a specific group of participants. The resulting scenarios are context-specific and **should not be interpreted as forecasts of probable or desirable futures**. Instead, they serve as a starting point for further forward-looking discussions and highlight the value of such approaches for examining the complexity of mCS development pathways.

As the reflections in this report illustrate, such participatory foresight processes can be a valuable means to (1) expand our understanding of possible mCS developments and (2) encourage more critical reflection on the assumptions shaping how we think about mCS and wider climate futures.

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Annex

Anonymized participant list

No.	Affiliation	Expertise
1	Academia	Ocean biogeochemistry
2	Academia	Ocean biogeochemistry
3	Academia	Geochemistry
4	Academia	Earth system modelling
5	Academia	Material Chemistry
6	Academia	Geohydromodelling
7	Academia	Ocean biogeochemistry
8	Academia	CDR Policy & Politics
9	Academia	CDR Policy & Politics
10	Academia	Law
11	Academia	Law
12	Academia	Integrated Assessment modelling
13	Academia	Marine Geotechnic
14	Academia	Climate ethics/philosophy
15	Academia	Biodiversity Economics,
16	Administration/regulatory bodies	Nature protection/regulation of human activities
17	Administration/regulatory bodies	Nature protection/regulation of human activities
18	Civil society	Marine environmental protection
19	Civil society	Industrial carbon management

Full Factor List and Uncertainty-Impact Ratings

No	Factor	Uncertainty	Impact	Varianz-Score	Varianz		U	I
1	Change in general (What can we rely on?) [18]	3.23	1.79	14.48	0.95	0.95	3.23	1.79
2	Humanity (honesty, greed, exploitation,.. I know, a bit more overarching) (Will there be humanitarian development and will it gain more importance?) [18]	2.80	1.72	17.69	1.40	0.76	2.80	1.72
3	Changes in behavior (e.g. using wood rather than concrete for constructions) (How much concrete and waste incineration will be needed in the future?) [19]	2.89	2.07	8.06	0.77	0.61	2.89	2.07
4	Geopolitical dynamics in the Baltic/North Sea (Will the North Sea region stay politically and militarily stable so that pipelines and offshore CO2 sites can operate safely?) [20]	2.95	3.19	12.31	0.83	0.92	2.95	3.19
5	International cooperation (functional and effective or not?)	2.67	2.41	16.25	1.00	1.02	2.67	2.41
6	Trade and tariffs (Will trade relations support or hinder EU climate action?)	2.73	2.74	6.37	0.53	0.65	2.73	2.74
7	Economic abilities (When will the next global financial crisis hit us?) [17]	2.85	2.95	7.41	0.58	0.72	2.85	2.95
8	Infrastructure Development (Will the global economy invest enough in offshore CCS infrastructure before climate tipping points are breached?) [3]	2.79	3.45	8.45	0.84	0.58	2.79	3.45
9	EU political landscape (Will there be a trading system for CO2 removal ? / Do we have all right wing climate deniers in power?) [17]	2.96	3.34	9.12	0.94	0.56	2.96	3.34
10	EU cross-border CO2 transport and storage infrastructure (sufficient or not?)	2.17	2.68	10.30	0.81	0.78	2.17	2.68
11	Actors that implement CCS in the North Sea (who will be the first to implement?)	1.45	2.18	5.30	0.36	0.69	1.45	2.18
12	Offshore storage development in other EU countries (how will that influence Germany?)	2.24	2.63	10.06	1.17	0.46	2.24	2.63
13	Regulatory clarity (will regulations be clear and harmonized?)	2.51	3.06	8.49	0.69	0.72	2.51	3.06
14	Focus of regulation (prioritising economic or ecological considerations?)	2.41	2.39	6.85	0.46	0.79	2.41	2.39
15	Legal framework ((when) will sub-seabed carbon storage be legal in Germany?)	1.67	3.51	5.24	0.56	0.47	1.67	3.51
16	Populism (will it derail climate action in Germany and the EU?)	2.73	2.84	6.78	0.65	0.58	2.73	2.84
17	Strategic orientation of the Green party (Fundis vs. Realos) (Will the Green party consistently support CDR?) [2]	2.51	1.46	6.39	1.03	0.25	2.51	1.46
18	Society (including basic needs, trust, etc) (Will society "stay together" and benefit from the storage method?) [18]	2.86	1.78	8.58	0.69	0.73	2.86	1.78
19	Distribution of newly created wealth (How unequal will wealth be distributed by 2030 (e.g. measured by Gini Coefficient)) [10]	2.17	1.40	3.32	0.47	0.24	2.17	1.40
20	Political salience and perceived urgency of climate change (high or low?)	2.96	3.29	10.30	0.72	0.87	2.96	3.29
21	Dominant framing of CDR among different societal and political circles (which framing dominates?)	2.56	2.90	7.83	0.69	0.65	2.56	2.90
22	General public's acceptance of CO2 storage (acceptance or rejection?)	2.96	2.95	9.90	0.72	0.83	2.96	2.95
23	Coastal regions' acceptance of CO2 storage (acceptance or rejection?)	2.62	2.73	5.81	0.57	0.53	2.62	2.73
24	Funding for CO2 storage projects (Will there be an increase in (public) funding for CO2 storage projects?) [8]	2.46	2.96	15.45	1.02	0.94	2.46	2.96

No	Factor	Uncertainty	Impact	Varianz-Score	Varianz		U	I
25	Financial incentives (Will they be sufficient for offshore carbon storage infrastructure development?)	2.90	3.52	6.76	0.77	0.47	2.90	3.52
26	Economic feasibility (given or not?)	2.56	3.12	10.13	0.80	0.77	2.56	3.12
27	Private sector involvement () [21]	1.85	2.96	6.41	0.47	0.72	1.85	2.96
28	Technological innovation in injection techniques (how will the technology develop?)	2.24	2.24	5.81	0.40	0.73	2.24	2.24
29	Progress of climate change adaptation (Which measures have been taken to adapt to climate change) [10]	2.58	1.79	8.55	0.69	0.73	2.58	1.79
30	Scientific and technological developments limiting CO2-emissions (how successful and effective?)	2.47	2.29	12.72	0.80	0.98	2.47	2.29
31	Alternative climate change mitigation strategies (substitutes) (How cost-efficient are other climate change mitigation strategies) [10]	2.83	2.56	8.21	0.69	0.69	2.83	2.56
32	How will monitoring technology develop? (how fast, reliable and supportive of CCS?)	2.51	2.18	7.20	0.58	0.69	2.51	2.18
33	Applying CCU rather than CCS (Is CCU viable and useful?) [19]	2.40	1.67	5.16	0.46	0.56	2.40	1.67
34	Perceived fossil lock-in (Will we succeed in ensuring that CO2 storage solutions are only used by the sectors that really need them?) [12]	2.90	1.95	5.30	0.43	0.61	2.90	1.95
35	Protected areas (will marine ecosystem restoration mandate limit locations for CCS?)	1.96	2.02	5.33	0.39	0.67	1.96	2.02
36	Marine spatial planning conflicts with other activities (how much and what space is dedicated to which activities?)	2.39	2.91	16.05	1.02	0.99	2.39	2.91
37	Environmental, Ecosystem & Disturbance Factors () [3]	2.41	2.22	10.88	0.79	0.84	2.41	2.22
38	Biodiversity concerns (will they hinder geological storage?)	2.18	2.28	5.90	0.58	0.53	2.18	2.28
39	Ecological conditions of the Seas (What is the status of the Sea ecology (good, bad, medium) compared to today by 2030) [10]	2.29	1.89	5.60	0.53	0.54	2.29	1.89
40	Sea level rise (Will rising sea levels and stronger storms require the redesign or closure of offshore CO_2 storage facilities?) [20]	2.23	1.89	8.15	0.62	0.77	2.23	1.89
41	Unknown environmental and ecosystem risks and impacts (what do we not yet foresee?)	2.90	1.94	10.44	0.77	0.83	2.90	1.94
42	Geological Suitability of storage sites () [3]	2.02	3.19	9.07	0.78	0.69	2.02	3.19
43	Quantity of storage capacity / availability of storage sites (How much storage capacity will be detected?) [8]	2.25	2.64	8.35	0.84	0.57	2.25	2.64
44	Safety and leakage (what will field tests and deployments in other countries show?)	2.57	3.29	5.79	0.69	0.42	2.57	3.29
45	Long-Term liability (who is liable for future damages?)	2.52	2.52	20.48	1.36	0.92	2.52	2.52
46	Legacy infrastructure (i.e. abandoned wells) (What is the scale of the issue surrounding the critical state of abandoned wells?) [12]	2.08	2.07	6.62	0.50	0.72	2.08	2.07

Sub-seabed carbon dioxide storage 2040

- change in general (What can we rely on?) [18]
- humanity (honesty, greed, exploitation,.. I know, a bit more overarcing) (Will there be humanitarian development and will it gain more importance?) [18]
- Changes in behavior (e.g. using wood rather than concret for constructions) (How much concrete and waste inceneration willl be needed in the future?) [19]
- Geopolitical dynamics in the Baltic/North Sea (Will the North Sea region stay politically and militarily stable so that pipelines and offshore CO2 sites can operate safely?) [20]
- International cooperation (functional and effective or not?)
  - Desintegration of EU (How can be help the EU to maintain its integrity?) [19]
  - cooperation between states () [21]
  - Ratification of London Protocol (Will the amendment of the London Protocol be ratified?) [8]
  - international agreements (What is the world order by 2030) [10]
- Trade and tariffs (Will trade relations support or hinder EU climate action?)
  - EU tariffs on cement imports (Is the EU really committed to introduce CO2 tariffs on e.g. cement and steel imports?) [19]
  - International policy (Will climate policy still have a high priority in the future?) [19]
  - Pessure from US government to revise EU climate policy (Will the EU be forced to import large amounts of fossil fuels from the US and soften regulations?) [19]
- economic abilities (When will the next global financial crisis hit us?) [17]
- Infrastructure Development (Will the global economy invest enough in offshore CCS infrastructure before climate tipping points are breached?) [3]
  - Infrastructure development () [21]
  - infrastructure (is it worth it to invest that much to build the necessary infrastructure for the respective outcome?) [18]
  - infrastructure funding (Will there be enough political will to finance the infrastructure build-up adequately?) [12]
  - technilogical development (Will the effect be great enough that it will be worth the effort?) [16]
- EU political land scape (Will there be a trading system for CO2 removal ? / Do we have all right wing climate deniers at power?) [17]
- EU cross-border CO2 transport and storage infrastructure (sufficient or not?)
  - Availability of cross-border transport and storage infrastructure (pipelines, hubs, shipping) (By 2040, will Germany be physically connected to at a large-scale CO_2 transport and storage network capable of handling large quantities of CO2?) [20]
  - Trans-European CO2 transport infrastructure (How effective will cross-border cooperation be in building CO2 transport and storage infrastructure?) [8]
- Actors that implement CCS in the North Sea (who will be the first to implement?)
  - first experiences (Who will be the first to implement at scale CCS in the German North Sea?) [17]
  - driving forces behind implementations (Who is going to implement CCS, and why (emissions avoidance or CDR)?) [17]
- Offshore storage development in other EU countries (how will that influence Germany?)
  - uptake of similar options by neighbouring countries (Will neighbouring countries create a trend towards sub-seabed storage?) [2]
  - cross-country border complications (Will there be differences in how CO2 storage is handled in the future across different countries, or will there be a streamlining effect?) [12]
  - Offshore storage developments in other EU countries (Will neighbouring countries such as Norway, Denmark, and the Netherlands still allow/encourage Germany to store its CO2 in their reservoirs?) [20]
- Regulatory clarity (will regulations be clear and harmonized?)
  - Unclear regulatory framework (How will this framework evolve after the KSpTG is implemented) [19]
  - regulatory clarity (Will the regulatory environment suffice?) [12]
  - State of German regulatory/premitting landscape (Will Germany have fully enabled offshore CO_2 storage through a clear and streamlined permitting regime that allows injection in its own waters?) [20]
  - State of EU regulatory regime on CCS (Will the EU have adopted a harmonised and binding regulatory framework for CO_2 transport and storage (including cross-border liability rules)?) [20]
- Focus of regulation (prioritising economic or ecological considerations?)
  - resources (Is there a benefit considering resource exploitation vs positive environmental effects?) [18]
  - politics / regulations (internationally and nationally) (Will the politicians decide/put regulations in favor of ecology and societies (particularly "weaker" ones) or rather based on economy and power?) [18]
- Legal framework ((when) will sub-seabed carbon storage be legal in Germany?)
  - legal framework (When will it become legal to store CO2 in sub-seabed storage sites?) [17]
  - legal framework () [21]
  - legal framework (Is there any hope with political decision makers? :-)) [15]
  - legal authorisation (Will CCS in large scale and not just for research purposes be legally authorized?) [16]
  - Regulation of CO2 storage in the sea (KSpTG) (Will the bill for commercial carbon capture and storage be adopted?) [8]
- Populism (will it derail climate action in Germany and the EU?)
  - geopolitical situation may affect local implementation (see last point) [15]
  - attitudes towards climate action in German conservatism (Söder vs. Günther) (Will German conservatism go fully populist on climate action?) [2]
  - Right-wing populism (Are hard enviromental regulations a factor that favors right-wing populism and how do we deal with this?) [19]
- strategic orientation of the Green party (Fundis vs. Realos) (Will the Green party consistently support CDR?) [2]
- society (including basic needs, trust, etc) (Will society "stay together" and benefit from the storage method?) [18]
- Distribution of newly created wealth (How unequal will wealth be distributed by 2030 (e.g. measured by Gini Coefficient)) [10]
- Political salience and perceived of climate change (high or low?)
  - extreme weather events in Germany (How will they shape the public discussion?) [2]
  - perception of urgency (What will the climate state be in 2030? Will the consensus be that we have breached 1.5?) [17]
  - Rate of climate change (independent of mitigation and adaptation) (What is the total damage of catastrophies directly caused by climate change) [10]
  - Political interest and ambition (How high are interest and ambition in climate targets?)
    - ambition in climate targets () [21]
    - political interest (Will political support remain regardless of future changes in government?) [16]
  - public interest (How will the public interest develop?) [16]
- Dominant framing of CDR among different societal and political circles (which framing dominates?)
  - dominant framing of CDR in wider society: dangerous distraction vs. necessary part of the puzzle (Which framing wins out?) [2]
  - dominant framing in environmentalist circles: forbidden climate engineering vs. unpleasant but justified (Which framing wins out?) [2]
  - dominant framing of CDR in conservative & far-right circles: technological openness vs. climate nonsense (Which framing wins out?) [2]
- General public's acceptance of CO2 storage (acceptance or rejection?)
  - General public acceptance of CDR (How volatile will public acceptance of CDR be?) [8]
  - public acceptance () [21]
  - environmentally friendly technology, risk, former accidents, etc. (How long does such a track record have to be to convince many people?) [15]
  - public interest (How will the public interest develop?) [16]
  - achievement in emission reduction (When will society accept that even when reaching strictest reduction goals there is a need for CDR?) [15]
  - Public Perception and Social License to Operate (Will the public trust sub-seabed storage as a climate solution—or reject it as another form of environmental risk?) [3]
  - public opinion (How can we convince people that CCS is part of the solution space without it solving the climate crisis altogether?) [17]
  - origin of CO2 (own vs. imported) influences social acceptance (When will wider parts of society accept CO2 as a waste product with economic value?) [15]
- Coastal regions' acceptance of CO2 storage (acceptance or rejection?)
  - Fisheries and coastal community opposition (Will CO2 storage be accepted by the coastal communities?) [12]
  - Perception/acceptance of coastal populations (How will the perception of coastal populations change over time?) [8]
  - Stakeholder preceptions/public opinion (Will the majority of German coastal communities and national publics/ key NGOs actively support/oppose offshore CO_2 storage in german waters?) [20]
- private sector involvement () [21]
- Economic feasibility (given or not?)
  - incentives to foster innovation (and revenues?) (Will feasibility rule in teh future, and where?) [15]
  - Energy availablity/price (will clean electricity in Germany be cheap enough that the extra energy needed for capturing CO_2 (i.e. through DACCS) no longer makes carbon capture prohibitvely expensive?) [20]
  - economics (What/Where are the penalties of making it economically feasible?) [18]
- Financial incentives (Will they be sufficient for offshore carbon storage infrastructure development?)
  - Financing and carbon-pricing context (Will there be sufficent financial incentive for the development of offshore carbon storage infrastucture?) [20]
  - Ecosystem Resilience and Impact Management (Will governments align economic incentives with ocean carbon storage strongly enough to drive mass deployment by 2040?) [3]
  - CO2 price as governing factor (Where does the major move has to be done to provide incentives, on national or international level?) [15]
  - financial incentives () [21]
- Funding for CO2 storage projects (Will there be an increase in (public) funding for CO2 storage projects?) [8]
  - High costs of CCS (What cost level will be accepted by society?) [19]
  - Economic development (Which share of their economic growth will governments be willing to invest in climate change mitigation) [10]
- Technological innovation in injection techniques (how will the technology develop?)
  - technology readiness level of injection eqipment (How will technology develop?) [12]
  - Technical, Regulatory & Infrastructure (Will a breakthrough emerge that makes deep-sea CO_2 injection safer, cheaper, and more scalable than today?) [3]
  - Technological Innovation in Injection Techniques () [3]
  - technological development (How much will it improve?) [18]
- Progress of climate change adaptation (Which measures have been taken to adapt to climate change) [10]
- Scientific and technological developments limiting CO2-emissions (how successful and effective?)
  - Future technology developments (e.g. climate-neutral cement without CCS) (Can we avoid hard-to-abate CO2 emissions without CCS) [19]
  - Alternative climate change mitigation strategies (substitutes) (How cost-efficient are other climate change mitigation strategies) [10]
  - economic development in comparison to other methods (land vs. sea) (Will there be a mix between terrestrial and marine methods soon?) [15]
  - Scientific and technological developments (Did science have a breakthrough to solve the issue of global warming) [10]
  - technological development (How much will it improve?) [18]
- How will monitoring technology develop? (how fast, reliable and supportive of CCS?)
  - scientific findings supporting safety & monitoring (Will studies continue to support CCS as a low-risk carbon storage option?) [17]
  - CO_2 Leakage Risk & Monitoring Technology (Will our monitoring technologies evolve fast enough to detect and prevent deep-sea carbon leaks before they cause ecological harm?) [3]
  - Development of technologies for environmental monitoring (How fast will improved technologies for environmental monitoring be developed?) [8]
  - AI developments (i.e. for monitoring) (Will AI tools for detecting leaks and monitoring geological movement CO2 be trusted enough by regulators to prove that stored CO2 is staying safely stored?) [20]
- Applying CCU rather than CCS (Is CCU viable and useful?) [19]
- perceived fossil lock-in (Will we succeed in ensuring that CO2 storage solutions are only used by the sectors that really need them?) [12]
- Protected areas (will marine ecosystem restoration mandate limit locations for CCS?)
  - protected areas (Is there a way to protect our MPAs from CCS in or beneath them, regardless of the political pressure and the spatial conflict?) [16]
  - Operationalisation Article 5 of the EU Nature Restoration Directive in Germany (Will Germany's (Eu-mandated) plans to restore marine ecosystems end up limiting where/how many offshore CO2 storage sites can be built?) [20]
- marine spatial planning conflicts with other activities (how much and what space is dedicated to which activities?)
  - renewable energy expansions / space conflicts (How much offshore wind will be build by 2030?) [17]
  - Competing offshore uses (To what extent will offshore wind, shipping lanes, fisheries, military zones, marine protected areas etc. restrict the number of sub-seabed storage sites in the German EEZ?) [20]
  - Conflicts with other users in the AWZ (military, offshore wind) (Is it possible to solve these conflicts?) [19]
  - marine spatial planning / area conflicts (Will there be changes in the MSP in favour of CCS?) [16]
  - conflicts of interest (Which conflicts are there and who will decide in the end?) [18]
  - Alternative uses of the seas (e.g. fisheries) (How will the demand for fish products change until 2030) [10]
  - Marine spatial planning; conflicts with other uses (How strongly will conflicting uses of the sea affect stakeholder support?) [8]
  - renewable energy space competition (i.e. offshore wind farms) (Will we manage the different usage needs of the sea efficiently?) [12]
  - development in other sectors of marine activities (Is Germany holding on to the 70 GW offshore wind target?) [16]
- Environmental, Ecosystem & Disturbance Factors () [3]
- Biodiversity concerns (will they hinder geological storage?)
  - biodiversity movements/considerations (Have biodiversity concerns overtaken climate?) [17]
  - biodiversity conflicts (How do populations of for example the harbor porpoise react?) [12]
- Ecological conditions of the Seas (What is the status of the Sea ecology (good, bad, medium) compared to today by 2030) [10]
- Sea level rise (Will rising sea levels and stronger storms require the redesign or closure of offshore CO_2 storage facilities?) [20]
- Unknown environmental and ecosystem risks and impacts (what do we not yet foresee?)
  - ecological impact (Which ecological impacts didnt we consider at the current state of knowledge?) [18]
  - research of the effects on the ecosystem (How big are the influences on the marine ecosystem?) [16]
  - Environmental risks of CO2 storage and tranport (Are their any risks that we do not foresee?) [19]
- Geological Suitability of storage sites () [3]
  - location of storage site / environmental conditions at storage site (Do we understand the system enough to not make it worse and destroy a lot?) [18]
  - site specific geological constraints (How many of the potential restrictions occur regularly at the site level?) [12]
- Quantity of storage capacity / availability of storage sites (How much storage capacity will be detected?) [8]
  - actual annual CO2 injection rate for storage sites (How much CO2 per year are we actually able to inject/store?) [17]
  - identification of geological storage reservoirs () [21]
  - Reservoir characteristics (Will humanity discover enough geologically secure seabed formations to meet the world's net-zero targets by 2040?) [3]
- Safety and leakage (what will field tests and deployments in other countries show?)
  - Field study findings regarding CO2 leakage (Will there be new findings on CO2 leakage?) [8]
  - (lack of) notable accidents with sub-seabed storage in other countries (Norway) (Will there be major accidents?) [2]
  - results of previous experiments (indoor and outdoor) (Is storage likely to be permanent and safe?) [2]
- Long-Term liability (who is liable for future damages?)
  - RRules on post-closure responsibility (transfer to state after a monitoring period vs. perpetual operator liability) (Will German/EU law stipulate that companies can hand over long-term responsibility for a CO_2 storage site to the government after a set period?) [20]
  - Long-Term Liability and Storage Integrity (Who will bear responsibility for the CO_2 stored today if it leaks a century from now—and will they be prepared?) [3]
- legacy infrastructure (i.e. abandoned wells) (What is the scale of the issue surrounding the critical state of abandoned wells?) [12]

Presented with xmind