Carbon Gap

CARBON LIMITS

perspectives climate research

DEVELOPING CDR AT SCALE AND SPEED

Roadmap for implementation of CDR in Norway

MAY 2024

Disclaimer

This document was developed to propose a roadmap for implementation of various Carbon Dioxide Removal (CDR) pathways in Norway. The Roadmap is based on the findings and analysis presented in the Background Report on Norway's potential for the deployment of CDR technologies and the results of the stakeholder engagement performed through a series of interviews and a one-day workshop addressing the main barriers and enablers for CDR deployment in Norway, as well as discussing necessary steps towards larger scale implementation of selected CDR pathways. This Roadmap presents an action plan which can be used as a reading material for policy makers and stakeholders involved in CDR development in Norway.

Carbon Limits AS and Perspectives Climate Research gGmbH accept no liability as a result of this roadmap and its contents being used, including any action or decision taken as a result of such use.

Acknowledgements

This Roadmap was prepared by Carbon Limits AS and Perspectives Climate Research gGmbH. The project team thanks Carbon Gap for their trust and participation in, and feedback on, the Roadmap for implementation of CDR in Norway. We wish to give special thanks to the stakeholders who were interviewed as part of the development of this Roadmap. The feedback and discussions with the stakeholders and Carbon Gap helped to pave the way for developing this Roadmap. The project team also extends its gratitude to the following workshop participants, for their invaluable contributions to the development of the Roadmap:

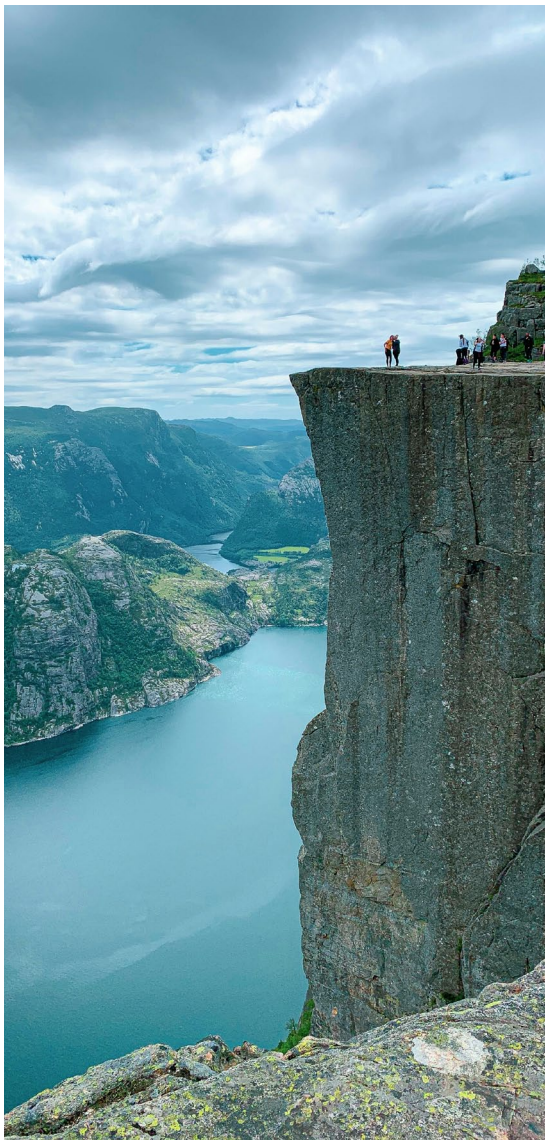
PARTICIPANT NAME	PARTICIPANT COMPANY
Asbjørn Torvanger	CICERO Center for International Climate Research
Bjørn Huso	Norwegian Agriculture Agency
Bjørnulf Tveit Benestad	Down to Earth
Carlos Dinamarca	SINTEF Industry
Christian Lindemann	Norwegian Institute for Water Research
Eirik Lilledahl	Carbon Removal
Eivind Berstad	The Bellona Foundation
Hans H. Kolshus	Norwegian Environment Agency
Hanne Rolén	Aker Carbon Capture
Helene Mørne	Carbonor AS
Helene Muri	Norwegian University of Science and Technology
Ingeborg O. Nordraak	Norwegian Forest Owners' Federation
Jannicke Gerner Bjerkås	Hafslund Oslo Celsio AS
Jon Bjartnes	World Wide Fund for Nature
Kaja Killingland	City of Oslo
Kaja Voss	Inherit Carbon Solutions
Lars Strøm	Ocean GeoLoop AS
Linn Viken Bøe	Skogkurs
Martine Mørk	Zero Emission Resource Organisation
Rahul Anantharaman	SINTEF Energy Research
Terje Kronen	Norwegian Society for the Conservation of Nature
Thomas Hartnik	Norwegian Institute of Bioeconomy Research

Cover image: © Anthony Tan - Unsplash

Table of Contents

List of Abbreviations

Bio-CCS	Biomass carbon capture and sequestration
CCfD	Carbon contracts for difference
CEW	Coastal enhanced weathering
CO_2	Carbon dioxide
CRCF	Carbon Removal Certification Framework
DAC	Direct air capture
DACCS	Direct air carbon capture and sequestration
GHG	Greenhouse gases
LULUCF	Land use, land use change, and forestry
MRV	Monitoring, reporting, and verification
NDC	Nationally determined contribution
O&G	Oil and gas
OAE	Ocean alkalinity enhancement
QGIS	Quantum Geographic Information System
R&D	Research and development
TEW	Terrestrial enhanced weathering
TRL	Technology readiness level
WtE	Waste-to-energy



© Karoline Vargdal - Unsplash

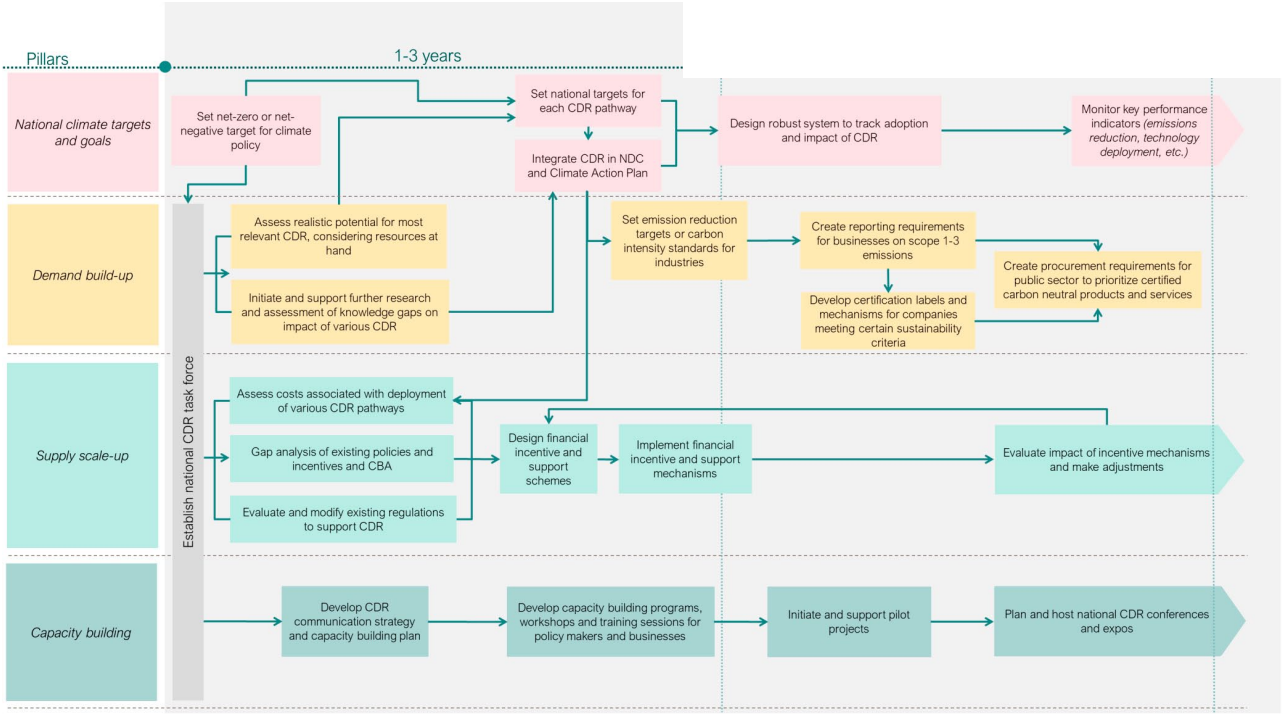


Figure 1 Roadmap for implementation of CDR in Norway

1. Executive summary

This Roadmap proposes actions to accelerate Carbon Dioxide Removal (CDR) deployment in Norway, highlighting key barriers and policies to enable wider adoption, without compromising societal imperatives.

Biomass (Bio-CCS) and Direct air carbon capture and sequestration (DACCS) are the most relevant CDR pathways for Norway, benefiting from technical advancement, substantial carbon dioxide (CO_2) storage potential, and strong state support. While **biochar, blue carbon (kelp farming) and afforestation/reforestation are also deemed highly relevant CDR pathways** for Norway, the level of their adoption will depend on prior experience and available area.

Setting a net-zero or net-negative target for Norway's climate policy should be a top government priority within 1-3 years. Clear regulations will enable investment in CDR, with resource availability shaping project scale. Informed by research and stakeholder input on five priority CDR pathways, policymakers should:

Bio-CCS – Address implementation challenges by improving Monitoring, Reporting, and Verification (MRV) processes, incentivizing the development of viable business models, and managing environmental concerns related to biomass sourcing.

Biochar – Allocate funds to address MRV issues, political resistance, and logistical challenges, while incentivizing farmer adoption and community engagement, to facilitate biochar's widespread deployment in agriculture and new business ventures.

Blue carbon – Issue regulatory guidance, integrating incentives like seaweed cultivation conditions for other types of licensing, and simplified permitting. Address persistent challenges, such as environmental risks, to realize benefits for biodiversity preservation and job creation.

DACCS – Harness Norway's renewable energy potential, CO_2 storage access, and technical expertise. Prioritize early stakeholder and community engagement to address societal concerns, while drawing on corporate demand and industry knowledge to overcome cost challenges.

Afforestation and reforestation – Utilize forestry as a crucial CDR pathway, leveraging the sector's profitability and existing government support schemes, while collaborating with the Norwegian Forest Owners' Federation to address commercial and durability risks.

Establishing a national CDR Task Force, led by the Ministry of Climate and Environment, is a crucial step to advance CDR implementation, with representatives from multiple sectors acting in four priority areas:

1. **National climate targets and goals** – Establish net-zero or net-negative emission targets, integrate CDR into national climate plans, set pathway-specific CO_2 removal targets, and implement comprehensive monitoring systems to track CDR technology adoption and performance.

2. **Demand build-up** – Evaluate CDR potential, fund research on knowledge gaps, and set emission targets for industries. Mandate carbon footprint reporting for businesses, create sustainable product labels, and prioritize carbon-neutral suppliers for government agencies.

3. **Supply scale-up** – Assess costs and incentive gaps, review existing support systems, conduct cost-benefit analyses, and tackle regulatory barriers for CDR pathways. Design financial incentives, set eligibility criteria, and monitor project success for funded initiatives.

4. **Capacity building** – Develop communication strategies, educational programs, and workshops for policymakers to promote CDR pathways. Implement pilot projects, offer financial support, and host conferences to showcase and scale innovative CDR

© Christiann Koepke - Unsplash

2. Introduction

This Roadmap is the final output of a broader project spearheaded by Carbon Gap, to determine the deployability of Carbon Dioxide Removal (CDR) techniques in three countries (France, Norway and the United Arab Emirates). The Roadmap (developed by the project team with inputs from key stakeholders in Norway) provides a series of actions required to accelerate the deployment of CDR in Norway.

The development of the CDR Roadmap for Norway was based on comprehensive background research on the CDR potential in Norway, provided in the Background Report to this Roadmap, as well as the results of the stakeholder engagement performed through a series of interviews and a one-day workshop.

- **CDR industry stakeholder interviews:** Semi-structured interviews with 20 stakeholders explored the feasibility of deploying CDR technologies at scale in Norway, covering topics such as research efforts, technology and resource availability, stakeholder identification, and barriers to implementation. The aim was to understand the potential, challenges, and necessary actions to facilitate the adoption of CDR technologies, including evaluating existing policies and incentives.

- **One-day stakeholder workshop:** The event gathered approximately 40 stakeholders in Norway to discuss the potential for large-scale CDR deployment in Norway, thereby laying the groundwork for the Roadmap. The aim was to assist decision-makers in understanding the feasibility of different CDR methods and identify necessary steps for their implementation. Discussions covered essential factors such as required resources and infrastructure, policy frameworks, incentives, and social geography considerations.

The discussions during the stakeholder engagement addressed key barriers to the implementation of each CDR method, as well as factors in place that can contribute to their implementation and the necessary steps to overcome any remaining barriers.

Actions outlined in the Roadmap are expected to reduce the barriers and strengthen the enabling factors associated with each CDR method in focus. Topics explored in collaboration with the key stakeholders include conflicts of interest with other societal imperatives (e.g., employment and environmental protection), competition with alternative resources utilization avenues (e.g., in relation to biomass and energy use), and potential synergies between various CDR strategies, and other industries. Additionally, the necessity of policies, incentives, and coordination efforts has been addressed.

© Johny Goerend - Unsplash

3. CDR pathways relevant for Norway[1]

Biomass carbon capture and storage (bio-CCS) and direct air carbon capture and storage (DACCS) rank highest on the list of the most relevant CDR pathways in Norway. This is because they are technologically more advanced that other CDR pathways in Norway, with a high theoretical CO_2 storage potential, several CO_2 storage sites being developed, and significant state support for CCS initiatives. Kelp farming is another CDR pathway that is highly relevant for Norway, due to the country's prior experience in kelp production and the availability of ocean area for kelp farming. Afforestation and reforestation also have a good potential in Norway, provided there is ample monitoring of the forest health. This ranking is in line with the findings from the stakeholder workshop, where participants placed priority on bio-CCS, DACCS, reforestation, improved forest management (IFM), biochar, and blue carbon (or kelp farming) as the most politically relevant CDR methods for Norway. Stakeholders raised however the issue of permanence when it comes to afforestation/reforestation and IFM, as well as identified the key areas where further research and assessment are required with regard to the potential of the most relevant CDR pathways for Norway (See Table 1 below).

CDR Pathway	Further assessment
Bio-CCS	Assess whether the additional capacity would be incorporated at existing facilities using biomass or if new facilities will have to be developed. Further assessment is required on land area and infrastructure requirements for BECCS.
DACCS	Monitoring of new electricity and thermal energy capacities is important to develop a more realistic potential. Pilot testing to assess suitable areas (based on climatic conditions) is required to find areas for DACCS deployment. Further analysis on electrochemical, mineral looping and humidity swing DACCS required once more testing is carried out on these technologies.
Biochar	As more information on land area and other infrastructure requirements for biochar is available, assess the suitable areas for establishing pyrolysis facilities.
Afforestation and Reforestation	Between 1,990 and 9,780 km2 of land could be available for afforestation or reforestation. This could be compared to the area receiving subsides for reforestation/afforestation to estimate further potential.
Kelp farming	More geographic research is required to assess what area could be dedicated to kelp farming, as well as possibility for restauration of kelp forests. More research required to assess sequestration using biochar and natural/forced storage of kelp on the ocean seabed.

Source: Carbon Limits

Table 1 Required further assessment with regard to the potential for the most relevant CDR pathways in Norway (more details provided in the Background Report)

Due to the multiple bio-CO_2 sources existing in Norway, bio-CCS is a "low-hanging" opportunity for Norway. If biomass production is optimized, bio-CCS potential and production of biochar can be improved significantly in the country. Collaboration on bio-CCS at the Nordic level also has a significant potential, considering Sweden and Finland both have ample sources of bio-CO_2. Storage sites in Norway could be used for storing bio-CO_2 from the Nordic region and North European countries.

Implementation of DACCS has a good potential in Norway, provided that Norway's potential to increase the country's renewable energy capacity is realized. However, DACCS, being a very energy-intensive technology, will only achieve substantial upscaling if electricity prices remain low and the carbon price is high enough to incentivize investments in this relatively expensive technology. Development of CDR pathways are highly dependent on the pace at which renewable energy capacities are developed in the country. Initiating pilot projects in areas with suitable weather conditions will help assess the potential for DACCS in the country.

1 More details are provided in the Background Report to this Roadmap

Kelp farming is a promising CDR pathway for Norway, offering potential for substantial upscaling. Northern Norway, with its cool seawater and long hours of daylight during summer, has a significant potential for kelp production.[2] While the country has significant ocean seabed for kelp farming, competitive uses of this seabed and waterway must be explored to estimate a realistic potential for CO_2 removal.

Afforestation and reforestation on the other hand have a high scope yet high uncertainty for CO_2 removal in Norway. The Norwegian government is currently preparing a subsidy plan aimed at reforestation and afforestation in overgrown and inactive agricultural land. In addition, a new support mechanism providing subsidies for afforestation of new areas is currently under consideration in Norway. The Norwegian Environment Agency and the Norwegian Agriculture Agency are working on a proposal for a subsidy scheme to support this measure, along with accompanying guidelines.[3] It is however uncertain to what extent the additional (to what is already under planning) reforestation and afforestation could be enacted in Norway, mainly due to potential goal conflicts at the intersection between forestry, agriculture and the environment.

It is important to highlight that even though the focus of this Roadmap is on the most relevant CDR pathways identified in this study, several actions can be initiated to gain more knowledge and understanding of the impact of other CDR solutions in Norway, as summarized in Table 2 below and further explained in the Background report to this Roadmap.

CDR Pathway	Further assessment
Coastal Enhanced Weathering (CEW)	Pilot projects are required to assess the pace of CO_2 removal from CEW process and suitability for Norwegian shoreline.
Terrestrial Enhanced Weathering (TEW)	Pilot projects are required to assess the pace of CO_2 removal from TEW process and suitability for Norwegian landscape.
Ocean liming	Pilot projects are required to assess the pace of CO_2 removal from ocean liming process.
Afforestation and Reforestation	Between 1,990 and 9,780 km^2 of land could be available for afforestation or reforestation. This could be compared to the area receiving subsides for reforestation/afforestation to estimate further potential.
Electrochemical CO_2 removal	Theoretical potential is immense, while using only electricity and sea water as the main resources. Norway with its large coastal area could prove to be an ideal test bed for electrochemical CO_2 removal.

Source: Carbon Limits

Table 2 Estimated theoretical potential of less relevant CDR pathways for Norway and required further assessment (more details provided in the Background report)

2 The Nofima notebook. (2020). *Kelp farming: a great opportunity for northern Norway and the world.* http://tiny.cc/j975yz
3 Landbruksdirektoratet. (2023). *Jord og jordhelse.* www.landbruksdirektoratet.no/nb/jordbruk/miljo-og-klima/jord-og-jordhelse

4. Enablers and barriers for the development of CDR in Norway

This section provides a summary of the main enablers and barriers for deployment of the selected CDR pathways in Norway. The findings in this section are mainly based on the results of the stakeholder engagement, including a series of interviews and a one-day workshop.

At the national level, the lack of a net-zero (or net-negative) target in Norway was highlighted as one of the key barriers for investing in various CDR solutions, while the absence of clear regulations and policy incentives created uncertainty and hesitation among potential stakeholders.

In general, it was acknowledged by the stakeholders that resource availability in terms of feedstock will be a sizing factor for removal methods in Norway. It will however not stand as a significant barrier. Projects can still be developed, but at a scale that is allowed by the availability of feedstock, energy, infrastructure and area. The infrastructure and biomass availability are not seen as a first problem. Questions pertaining to policies, incentives and finance are seen as more important, i.e., if the right framework is in place, the infrastructure development will most likely roll out naturally. It has also been highlighted that looking at the co-benefits of different CDR solutions (soil quality improvements, biodiversity, coastline protection, etc.) is key when prioritizing between various CDR pathways.

Bio-CCS/BECCS

There seems to be a general agreement among the key stakeholders in Norway that in terms of biomass for bio-CCS, the priority should be utilizing the preexisting available bio-waste.

Bio-CCS/BECCS benefits from its compatibility with existing waste and biomass value chains in Norway. It was, however, pointed out during the stakeholder workshop that in terms of **significant upscaling** of bio-CCS based on biogenic waste and resources, resource limitation can be a challenge, given competition with other domestic demand for biomass, in part high extraction cost, and increasing prices at the international market from growing demand and resource competition. Evolving policy and regulation at EU and national levels, popularity among citizens and municipalities, and growing market demand are key enabling factors for bio-CCS development. Municipalities are integral to the successful implementation of bio-CCS, as they can contribute to policy frameworks and provide the necessary infrastructure for these initiatives. For example, waste incineration plants in Oslo, Bergen and Trondheim municipalities have undertaken studies on the potential to implement bio-CCS. The technical feasibility of a value chain for capturing and storing CO_2 is reviewed, and investment support from the government is a possible instrument under consideration. In this respect, the bioenergy and waste management industries can facilitate bio-CCS, by providing a sustainable source of energy that can be harnessed and coupled with carbon capture and storage technologies.

Corporate demand for carbon removals is also an enabling factor for bio-CCS in Norway. Companies that subscribe to Science-Based Targets Initiative (SBTi) commit to reduce their Scope 1 and 2 emissions by 90-95% by 2050 and remove residual emissions, and bio-CCS is an increasingly popular option, with more project developers entering the market for removal credits. Industries with biogenic CO_2 emissions, and sectors allowed to have residual emissions, can contribute to drive demand for bio-CCS. Environmental claims and labelling schemes (i.e., certification that a product, process, or company complies with requirements for an environmental label) can contribute to enable bio CCS removals, drawing on experience from Nordic Ecolabelling (e.g., The Nordic Swan Ecolabel) and taking into consideration EU regulation on green claims.

Bio-CCS also faces various barriers to its wider implementation in Norway. Difficulty in Monitoring, Reporting, and Verification (MRV) – particularly for small and medium-sized enterprises (SMEs) in waste and biomass value chains – creates challenges in accurate measurement and reporting of the climate impact of this CDR solution. Currently, the lack of viable business models for bio-CCS also hinders widespread adoption, as uncertainties surrounding financial sustainability impede investment.

At the national level, the absence of a cohesive political vision or strategy constitutes a significant barrier to the successful integration of bio-CCS into national climate policies, impacting the development and implementation of supportive frameworks. Potential nature and biodiversity impacts, stemming from biomass supply chains, also poses a barrier, as concerns regarding the ecological consequences of sourcing biomass for bio-CCS may lead to resistance from environmental advocates and communities.

Biochar

The agricultural sector plays a key role in enabling biochar as a CDR pathway for Norway, by incorporating use of biochar in agricultural practices. Government subsidies for biochar production are already in place, and can significantly reduce the risk for new biochar producers to establish facilities in Norway. Several stakeholders, however, expressed their doubts regarding whether this support is sufficient to cover the cost of biochar production, pointing out that the lack of economic incentive remains the main challenge for many biochar producers.

On the commercial side, biochar provides new business opportunities for forest owners and biomass suppliers, encouraging sustainable practices and contributing to the circular economy, by utilizing biomass waste.

Biochar producers in Norway are typically SMEs with limited administrative capacity, while recipients tend to be smallholder farmers. As for bio-CCS, difficulty in MRV for small operators can present a significant barrier to widespread adoption of biochar as a CDR pathway. Generally, the Norwegian agricultural sector is conservative, and resistance to change from farmers can pose a barrier in the form of reluctance to adopt use of biochar in soil management practices.

The lack of community ownership, e.g., of biochar production facilities or private agricultural lands, presents a barrier, as community engagement and support are essential for the successful implementation of biochar initiatives, both in terms of adoption and land use practices. There are also instances of resistance from local communities to increased road traffic, associated with biomass transport and biochar distribution, which can pose a logistical barrier for widespread deployment of biochar.

Blue carbon

Regulatory guidance is a key enabler for blue carbon as a CDR method. The inclusion of seaweed cultivation as a condition for other types of licensing, e.g., salmon aquaculture or offshore wind facilities, can provide incentives for blue carbon and realize potential synergies with other marine industries. Likewise, CDR through seaweed cultivation could be encouraged by the development of more general guidelines on project design. In addition, the permitting process for new installations needs to be streamlined, and the fisheries sector needs to be systematically engaged in cross-sectoral marine spatial planning processes, from an early phase of project development, to avoid potential conflicts of interest, e.g., overlap with fishing and spawning areas.

While marine-based methods, such as protection of existing blue forests, restoration of degraded blue forests, and seaweed cultivation, contribute to both preserving and increasing CO_2 storage, they also have beneficial effects on biodiversity and other ecosystem services such as coastline protection and providing habitats for fish nurseries. Positive synergies between marine biomass cultivation and biodiversity are an enabling factor for the development of blue carbon as a CDR pathway in Norway, as this approach is less likely to meet opposition from environmental organisations and local communities than land-based biomass cultivation, e.g., large, monoculture forests. Moreover, Norway has a political interest in attracting labour to the marine sector, particularly to sustain populations in remote areas, e.g., in Northern Norway, where the fisheries and aquaculture sector is understaffed. Blue carbon activities can gain public support by contributing to employment in coastal communities.

For CO_2 captured through seaweed cultivation to be stored permanently, the biomass must be buried, or dumped to the ocean floor so that the CO_2 is bound in the sediment. This approach has been met with scepticism from scientists, emphasising the environmental risks associated with disturbing deep sea marine ecosystems, which have yet to be mapped or understood. An alternative and less controversial approach is to use marine-based biomass to produce biochar, or for BECCS. This approach is considered more socially acceptable and could enable blue carbon as a CDR pathway for Norway, in tandem with BECCS and biochar.

Other barriers for blue carbon as a CDR method relate to the lack of regulatory clarity and guidance at national or international levels, in addition to the lack of a robust MRV system, in part due to high uncertainties of actual sequestration potential of blue carbon. Blue carbon is currently not considered in the national GHG emission reporting according to UNFCCC GHG reporting via the IPCC Wetlands Supplement. The EU Carbon Removal Certification Framework should provide guidelines on how to calculate removals but does not explicitly include cultivation of seaweed as a CDR method.

DACCS

Norway has several comparative advantages for DACCS, notably its potential to increase production of renewable energy, as well as its access to CO_2 storage on the Norwegian continental shelf. Norway also has relevant technology environments, expertise, and capital that can be deployed to implement the technology. Several projects and companies are working on realizing DACCS in Norway. Corporate demand for removals can also contribute to enable DACCS in Norway, as large corporate offset buyers (e.g., Microsoft) increasingly demand carbon credits from such projects, to meet emission removal targets.

Norway's existing base of knowledge and expertise is a major enabling factor for DACCS. The oil and gas sector can provide technical competence, regarding CO_2 value chains, transport, and storage, e.g., in existing oil wells on the Norwegian continental shelf.

DACCS can face significant political and societal barriers in Norway. The technology is costly to implement and depends on government subsidies (i.e., taxpayer funding) to reach scale and profitability, raising concerns over its societal added value, e.g., in terms of employment and ownership. Moreover, if financial support schemes for DACCS preclude support for other climate solutions, e.g., subsidies to biochar producers or nature conservation efforts, the technology is more likely to face opposition, from farmers, the forestry sector, and environmental organisations.

DACCS is an energy-intensive technology, and access to affordable electricity is a key concern related to scaling this CDR pathway. While Norway's renewable electricity grid and generation capacity are expanding, there is increasing competition from other end-users due to increasing electrification of several sectors, as well as increasing competition from consumers in other European countries due to more high-capacity interconnectors. If DACCS projects secure access to affordable electricity (e.g., via power purchasing agreements), at the expense of other industries and consumers, these projects can face opposition. Technology development must be balanced by assessments of societal readiness, and involvement of relevant stakeholders (civil society, NGOs, and local associations), to understand and address their concerns. In this respect, it is critical for DACCS projects to account for their socioeconomic impacts and acceptability, generate community awareness and gain feedback, from an early phase of project development.

Afforestation / reforestation

Forests are a significant factor in the Norwegian greenhouse gas accounts. EU regulation and national-level subsidy schemes can play an important role in supporting the forestry sector as a CDR pathway in Norway, by providing regulatory frameworks and financial incentives for sustainable forest management.

While Norway's forests are mainly privately owned, many landowners voluntarily organize through strong and active trade associations, i.e., the Norwegian Forest Owners' Federation (Norges Skogeierforbund) and Norwegian Agrarian Association (Norges Bondelag). These associations can play a coordinating role in establishing standards and best practices for CDR. Active involvement of land and forest owners, via trade associations, is crucial for the success of forestry as a CDR strategy in Norway, which requires collaboration and collective efforts in land management practices.

The main barrier to reforestation and improved forest management (as CDR pathways) is that these activities are not commercially profitable for forest owners, who lack a clear value proposition. Timber remains the main source of revenue for forest owners, as the forestry sector supplies wood products to various industries, e.g., timber in construction and pulp and paper. However, if forest biomass is increasingly used for long-term CO_2 storage, rather than harvested for other applications, this could lead to a decrease in timber supplies, increased prices, and negative economic impacts for consumers and the forest products industry. The development of a viable forestry-based CDR industry must be balanced and managed in coordination with other forestry stakeholders.

Other key barriers for forestry as a CDR pathway in Norway relate to the risk of low durability storage, as the effectiveness of forests as a method for long-term CO_2 storage can vary according to local meteorological and soil conditions and management practices. This issue is salient in Norway, due to the high level of private forest ownership, which can potentially lead to heterogenous management practices and a lack of coordination around CDR approaches. Currently, Norway's national land management strategy is limited beyond its obligations in LULUCF, with little statistical data kept on land use for carbon removals. Here, national-level policy, and active involvement of forest and landowner associations is needed, to ensure that guidance and best practices for forestry-based CDR are followed.

Table 3 summarizes the key enablers and barriers for deployment of the most relevant CDR pathways in Norway. The following sections propose a series of actions that are expected to strengthen the most important enablers and reduce the barriers for CDR in the country.

Impacting factors / aspects	Bio-CCS	DACCS	Afforestation/ reforestation	Blue carbon	Biochar
Absence of a net-zero / net-negative target in Norway	✘	✘	✘	✘	✘
Absence of policy and tax incentives	✘	✘	✘	✘	✘
Absence of robust MRV systems for CDR	✘	✘	✘	✘	✘
Absence of clear political vision or strategy for CDR	✘	✘	✘	✘	✘
Growth in corporate commitments and pledges	✔	✔	✔	✔	✔
Labelling schemes / green certificates	✔	✔	✔	✔	✔
Existing value chains for bio-waste	✔				
Lack of viable business models	✘	✘	✘	✘	✘
Access to CO_2 storage	✔	✔			
Environmental impacts (e.g., biodiversity, soil quality, etc.)	✘			✔	✔
Transport and distribution	✘	✘			✘
Competition with other usage of biogenic feedstocks	✘		✘	✘	✘
Relevant technology environments, expertise, technical competence (O&G)	✔	✔	✔		
Competition with other usage of energy resources	✔	✘			
Risk of impermanent CO_2 storage			✘	✘	

✘ – indicates barriers
✔ – indicates enablers

Table 3 Summary of key enablers and barriers and their applicability to the assessed CDR pathways

5. Actions required to accelerate deployment of CDR in Norway

The key barriers and enablers for CDR deployment in Norway, highlighted in the previous section, will impact the CDR landscape in different ways. For example, the absence of a net-zero or net-negative target in the Norwegian climate policy reduces the need for CDR solutions thus presenting a significant barrier for building up demand for CDR. At the same time, lack of clear regulations and policy incentives have a large impact on scaling up the supply of CDR solutions. Some of the enablers and barriers are generic to all CDR pathways, whereas some are more specific to certain CDR pathways (e.g., growth in corporate climate commitments and pledges can boost the demand for any CDR method, while limited access to sustainable biomass has major impacts on supply of CO_2 removals from bio-CCS projects or biochar).

The proposed actions to address some of the key barriers and strengthen important enablers for CDR implementation in Norway are therefore divided into four strategic pillars, as shown in Figure 2:

1. Setting national climate targets and goals
2. Building up demand for CDR
3. Scaling up supply of CDR and reducing costs
4. Building up capacity and knowledge

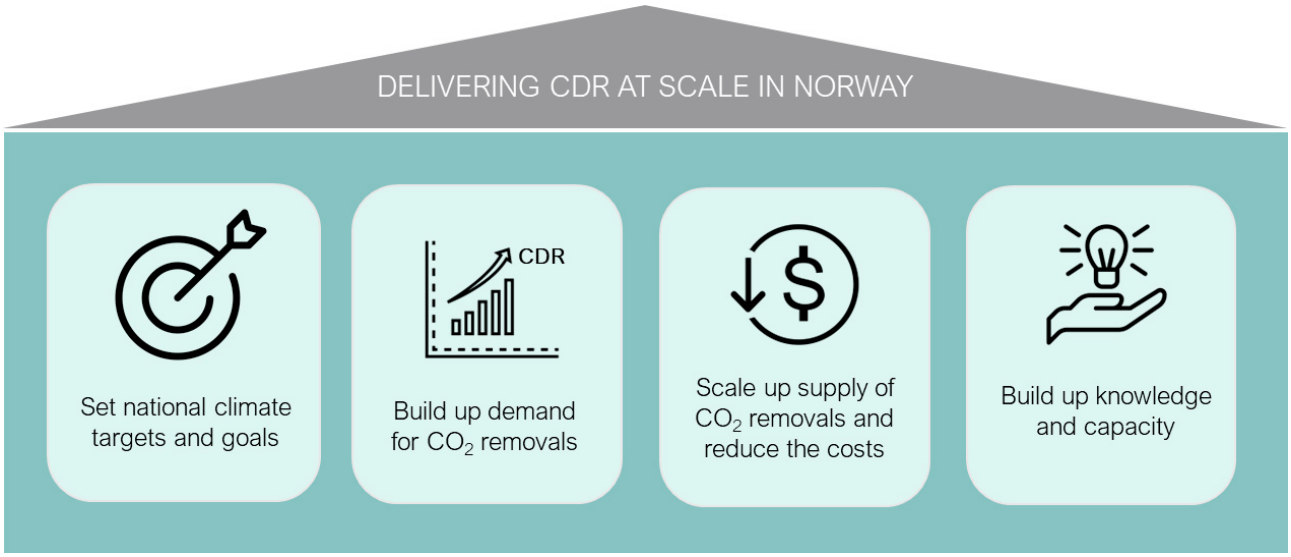


Figure 2 Four key pillars for accelerating deployment of CDR in Norway

Furthermore, some of the actions are expected to facilitate the deployment of any CDR pathway, whereas others will predominantly apply to a specific CDR method.

Setting a net-zero or net-negative target for the Norwegian Climate policy is the priority action that the Norwegian Government in collaboration with the relevant ministries and agencies should consider within the next 1-3 years.

The responsibility for the other actions proposed in this Roadmap could be divided between relevant ministries and their respective agencies, as well as municipal authorities and industry associations. The Roadmap proposes establishment of the **national CDR task force** as a second important step in scaling up CDR implementation in Norway. The CDR task force (CDRTF) could be led by the Norwegian Ministry of Climate and Environment and include representatives from other relevant ministries (e.g., Ministry of Finance, Ministry of Food and Agriculture, etc.), agencies, such as the Norwegian Environment Agency, the Norwegian Agriculture agency, etc., as well as representatives from environmental NGOs, industry associations and research centers (Figure 3).

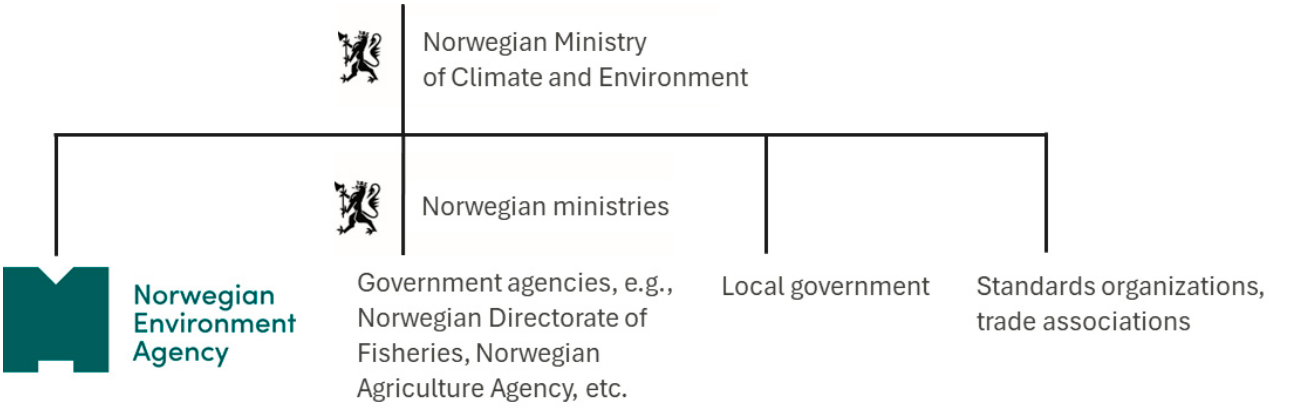
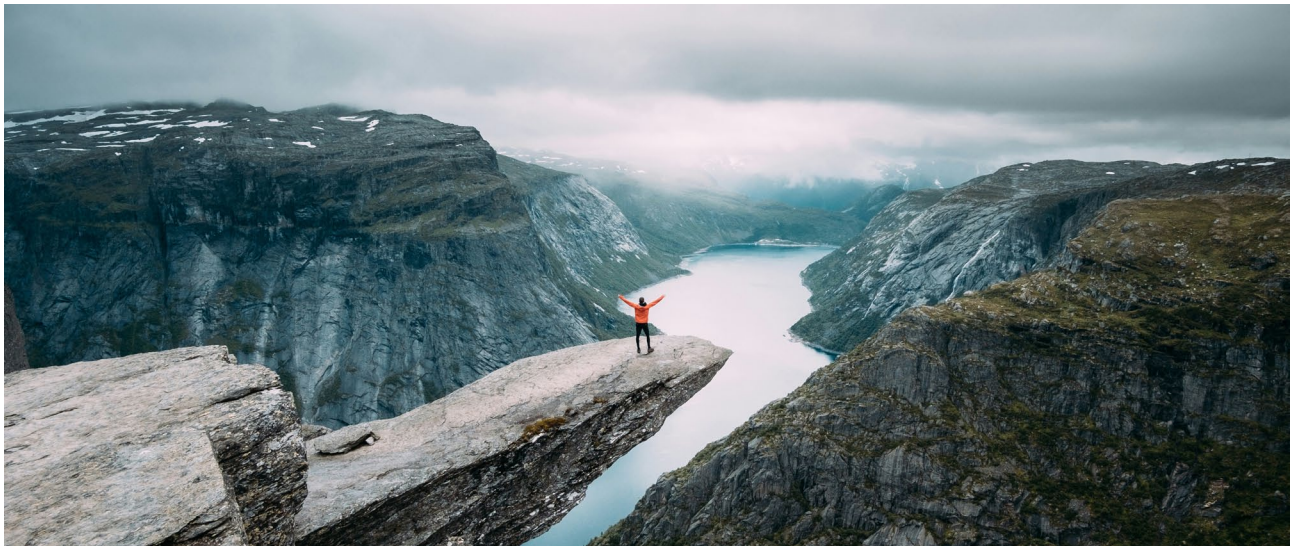


Figure 3 National CDR Task Force

The following tables provide more detail on the priority actions required for speeding up the deployment of the most relevant CDR pathways in Norway (Figure 1), where each table includes necessary actions within each of the key pillars (Figure 2).

Set up national climate targets and goals

Category of actions	Priority actions
Setting national climate targets facilitating CDR	• Set net-zero or net-negative target for national greenhouse gas emissions • **Establish a national CDR task force** • Integrate CDR into the National Determined Contribution (NDC, under the Paris Agreement, and the Climate Action Plan) • Set national targets for CO_2 removals (ideally **per type of CDR pathway**)
Monitoring and evaluation of CDR uptake	• Design a robust system to track the adoption and impact of CDR technologies, identify key performance indicators • Monitor key performance indicators, such as emissions reduction and technology deployment



© Benjamin Davies - Unsplash

Build-up demand for CO_2 removals

Category of actions	Priority actions
Research and development	• Assess the realistic potential for the most relevant CDR methods, considering resources availability • Initiate and support further research and assessment of knowledge gaps on the impact of various CDR pathways
	• Set emission reduction targets or carbon intensity standards for industries to encourage implementation of various CDR solutions
	• Introduce requirements for businesses to calculate, report and reduce the carbon footprint of their whole supply chain (i.e. including scope 3 emissions), to encourage them to select suppliers with lower emissions or invest in CDR projects to offset their emissions
Setting performance standards and sustainability requirements	• Develop certification labels that can be granted to products and services from companies that meet certain sustainability criteria, including adoption or investment in CDR solutions • Set requirements for government agencies to prioritizes suppliers with products and services from companies that meet certain sustainability criteria, including adoption or investment in CDR solutions

© Echo – Unsplash

Scale up supply of CO_2 removals and reduce costs

Category of actions	Priority actions
Assess regulatory framework and financial incentives for CDR implementation	**For all relevant CDR pathways:** • Assess costs associated with deployment of various CDR pathways • Identify gaps between the existing incentive mechanisms and costs associated with CDR deployment • Review existing support mechanisms and tax incentives for CDR implementation, analyse their impact • Evaluate existing and planned support and incentive mechanisms in other countries and their applicability to the Norwegian context • Conduct cost-benefit analyses of implementation of various support mechanisms • Review the existing environmental and climate regulations • Identify and address regulatory barriers hindering CDR project development • Consider amendments to support CDR initiatives (e.g., inclusion of seaweed cultivation as a condition for other types of licensing)
Develop financial incentives for CDR implementation	**For all relevant CDR pathways:** • Design financial incentive programs, such as grants, subsidies, low-interest loans, competitive grant programs for CDR research and development, inverse auctions, CCfDs (carbon contract for difference) • Establish criteria for eligibility and application processes • Develop clear guidelines for accessing funds, including reporting requirements **For bio-CCS and DACCS:** • Design tax incentive policies for implementation of industrial CDR • Establish support schemes / government guarantees or other risk-sharing mechanisms to attract private sector participation in infrastructure development
Evaluate the effectiveness of incentive programs	**For all relevant CDR pathways:** • Establish an evaluation framework to assess the impact of financial incentives • Monitor the number and success of CDR projects funded through incentive programs • Adjust incentive mechanisms based on evaluation results to optimize impact

© Lightscape - Unsplash

Build up knowledge and capacity

Category of actions	Priority actions
Develop CDR communication strategy and capacity building plan	**For all relevant CDR pathways:** • Define key messages, target audiences, and communication channels • Develop strategy's content, timeline and rollout plan • Identify areas requiring resource build up and areas with existing competence that can be further developed • Develop a plan to build up competence required for CDR deployment, including the timeline, rollout and responsibility for implementation
Capacity building for key stakeholders and public	**For all relevant CDR pathways:** • Develop educational programs, workshops and training sessions for policy makers • Integrate CDR topics into science and environmental curricula **For technology-based CDR (e.g., bio-CCS, DACCS)** • Develop workshops to address industry-specific challenges and opportunities, showcasing successful CDR case studies relevant to various sectors • Develop guidelines for businesses to integrate CDR technologies into their operations
Launch small-scale CDR pilot projects	**For DACCS, Blue carbon, ERW and biochar:** • Establish a competitive selection process for pilot projects • Provide financial support and regulatory assistance to selected projects • Monitor project performance and gather data for future scaling • Develop financial support mechanisms for scaling successful pilots
Organization of national CDR conferences and expos	**For technology-based CDR (e.g., bio-CCS, DACCS)** • Plan and host national conferences dedicated to CDR technologies to facilitate networking opportunities for stakeholders, businesses, and researchers and showcase innovative CDR technologies and projects through expos • Establish a platform for matchmaking between technology developers and potential CDR project investors

Credits

This report was prepared by **Carbon Limits AS** and **Perspectives Climate Research gGmbH** for **Carbon Gap**

Project leader: Irina Ålund (Carbon Limits)

QA: Gaëlle Cauchois (Carbon Limits)

Project members (Carbon Limits): Malavika Venugopal (Task Lead),
Anastasia Isaenko, **Irina Semykina**, **Lauren Selleck**, **Marton Volstad**, **Valentin Gentile**

Project Members (Perspectives Climate Research): Malte Winkler (PM),
Matthias Honegger (QC), **Olivia Wallis**, **Matthias Poralla**, **Paulien Veen**

About Us

Carbon Gap

Carbon Gap was created to be Europe's first philanthropically funded environmental advocacy organisation focused exclusively on Carbon Dioxide Removal (CDR). The mission is simple: do whatever it takes to ensure that Europe becomes a leader in developing and deploying CDR solutions at scale in a safe and equitable manner to preserve a stable climate. Carbon Gap coordinated the delivery of the project that produced this report.
www.carbongap.org

Carbon Limits AS

Carbon Limits works with public authorities, private companies, finance institutions and non-governmental organizations to reduce greenhouse gas emissions from a range of sectors. Our team supports clients in the identification, development, and financing of projects that mitigate climate change and generate economic value, in addition to providing advice on the design and implementation of climate and energy policies and regulations. Carbon Limits is a consultancy based in Oslo, Norway.
www.carbonlimits.no

Perspectives Climate Research gGmbH

Perspectives Climate Research gGmbH ("Perspectives") is supporting both private sector companies and the public sector in several topics related to climate change mitigation. Perspectives is internationally recognized for its innovative, high-quality outputs in many fields of international climate policy. Resulting from more than two decades of world-wide research and consultancy experience on various topics, the company can offer deep insights and profound political and economic knowledge in a very flexible, client-oriented manner.
https://perspectives.cc