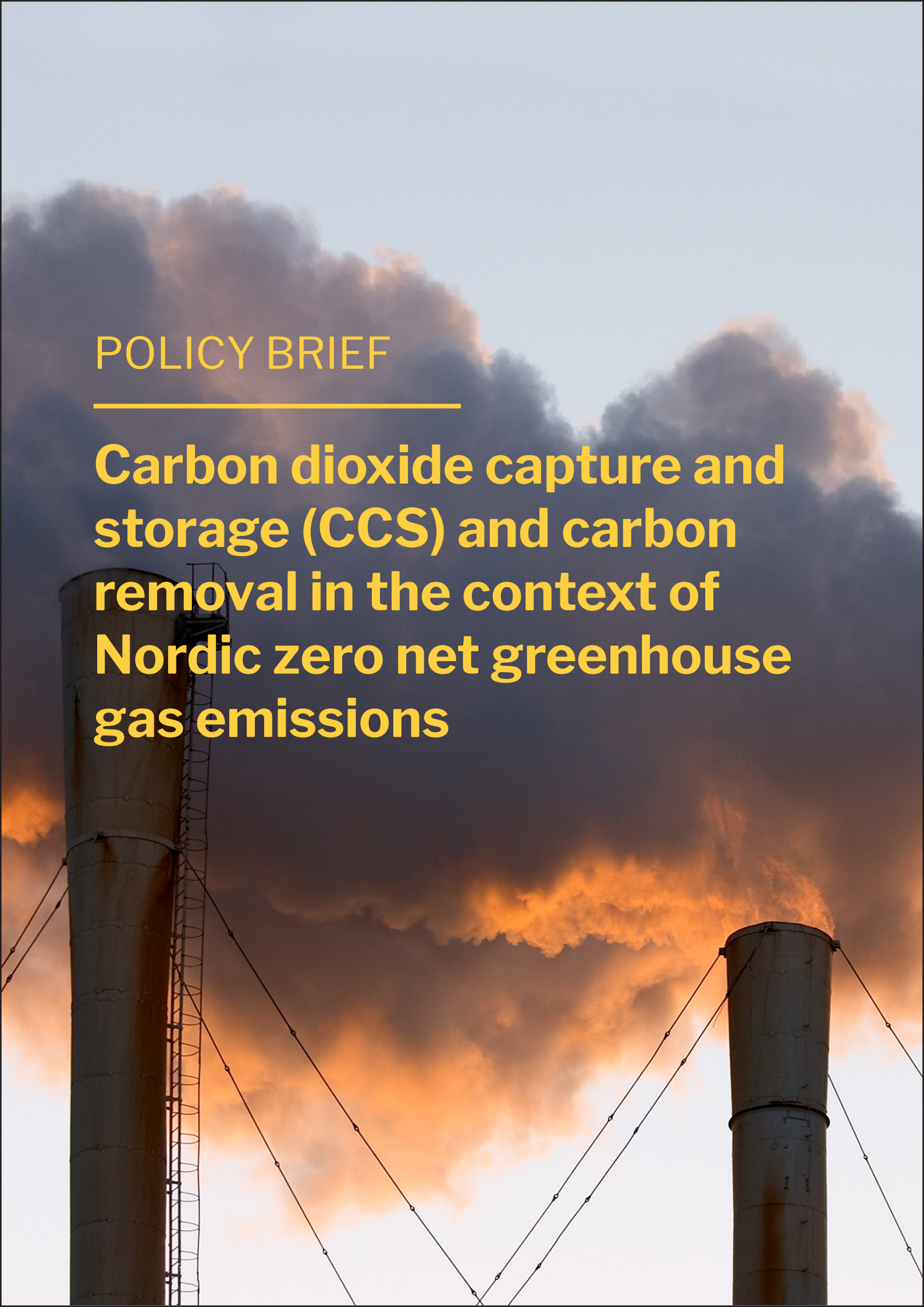

POLICY BRIEF

Carbon dioxide capture and storage (CCS) and carbon removal in the context of Nordic zero net greenhouse gas emissions

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Kenneth Möllersten, IVL, with contributions from Lars Zetterberg, IVL, and Oras Tynkynen, Tyrsky Consulting.

Introduction

How can CCS and carbon removal contribute to achieving zero net emissions of greenhouse gases in the Nordic countries? Why is a cross-Nordic perspective relevant?

All Nordic countries have set ambitious targets to achieve net-zero and even net-negative greenhouse gas emissions in line with a (global) 1.5-degree pathway, both individually through various national goals and legislation as well as jointly through the 2019 Helsinki Declaration on Nordic Carbon Neutrality[1] ("the Declaration"). In the Declaration, the Prime Ministers declare that the Nordic countries want to lead by example and intensify cooperation. The Declaration underlines the important role of carbon capture and storage (often just called "CCS") and bioenergy with CCS (BECCS). BECCS is the technology that is considered most promising in terms of achieving permanent removal of carbon dioxide from the atmosphere ("carbon removal") in the Nordics. Furthermore, the EU has the ambition to achieve zero net emissions within the Union by 2050 and, as appropriate, achieve net-negative emissions thereafter.[2]

CCS applied to carbon dioxide emissions from fossil sources enables deep emission cuts where alternative mitigation solutions are not feasible for technical and/or economic reasons. The applicability of CCS is limited to larger point emission sources. However, it is only realistic to capture up to about 90 percent of the carbon dioxide in a gas stream. This means that CCS applied to fossil emission sources will lead to so-called 'residual emissions' that will need to be counterbalanced in order to attain zero net emissions.

Carbon removal can be achieved through various so-called Carbon Dioxide Removal (CDR) methods that remove carbon dioxide from the atmosphere on a net basis. Carbon removal has two crucial roles to play. Firstly, carbon removal will be required to counterbalance some 'residual emissions' that are extremely challenging to fully mitigate, for instance from aviation, shipping, agriculture, and fossil CCS. Without carbon removal, zero net emissions cannot be achieved.

1 The Helsingfors Declaration, a declaration from the meeting between the Nordic Prime Ministers and the Ministers of Environment, 25 January 2019. Available at: https://www.norden.org/en/declaration/declaration-nordic-carbon-neutrality

2 European Climate Law. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32021R1119

Secondly, carbon removal, if in the long-term deployed at levels exceeding residual emissions globally, enables bringing down atmospheric carbon dioxide levels from an 'overspent emissions budget'. This may be used to 'force' a decline in carbon dioxide-induced warming from an 'overshoot' level to the Paris Agreement target level. BECCS and direct air carbon capture and storage (DACCS) are CDR methods that rely on CCS technology. A fundamental difference is that in contrast to fossil CCS, BECCS and DACCS can achieve net carbon removal. Each Nordic country, and the Nordic region as a whole, will need carbon removal to counteract residual emissions.

Box 1: Fossil CCS and carbon removals have different roles.

Whenever discussing fossil CCS it is important to bear in mind that it should primarily be seen as a tool to manage emissions in sectors where full decarbonisation is very challenging. A third role of carbon removal can be to get down to zero net emissions faster. However, the capacity of BECCS and DACCS (and other CDR methods) to remove carbon dioxide from the atmosphere should not be seen as a tool to allow for continued emissions, but only as a complement to very aggressive emission reductions.
The Nordic countries' individual and joint ambitions to reach zero net emissions will likely require very significant CCS deployment within a couple of decades. Storage sites and sources where carbon dioxide can be captured are unevenly distributed throughout the Nordic countries which means that cross-border carbon dioxide transportation will be required. Since infrastructure across the value chain will include multiple actors across the Nordics, the Nordic governments can play a crucial facilitation and coordination role.

Context of this policy paper

The organizations CONCITO, CICERO, IVL Swedish Environmental Research Institute (IVL), Tyrsky Consulting and University of Iceland and Reykjavik University, have carried out the project "Nordic Stocktake and Visions – Pathways to climate neutrality" for the Nordic Council of Ministers. The project is intended as a regional tool to support the Global Stocktake process and spur further climate action, both within the Nordics and beyond. The main results are described in the report "Nordic Stocktake".

As a part of the project, the consortium held five webinars on topics of special relevance for reaching climate neutrality in the Nordic region. The webinars can be viewed on Norden.org.

This policy paper builds on the analysis carried out in the project as well as on the webinar "CCS and CDR in the context of Nordic carbon neutrality" held on 3rd October 2023. The paper was written by Kenneth Möllersten, IVL, with contributions from Lars Zetterberg, IVL, and Oras Tynkynen, Tyrsky Consulting.

Status of CCS and carbon removal across the Nordic countries

The regulatory environment that applies to CCS activities in the Nordic countries has developed significantly over the past decade or so. All Nordic countries have transposed the EU CCS Directive into national legislation. The International Maritime Organization IMO has adopted a resolution allowing the export of carbon dioxide for storage below the seabed, the IPCC has clarified that BECCS can and should be recorded as a “negative emission”. The trend in EU and Nordic politics is to develop the regulatory system in a more permissive direction, in support of CCS and carbon removal. Regulators are working to remove remaining regulatory gaps and lower barriers.

It should also be noted that, in addition to an enabling regulatory environment, sufficient financial incentives must be in place for investments in CCS to actually happen. This is also largely up to regulators. The current regulatory design of the EU ETS, the union’s flagship economic instrument to incentivise climate change mitigation, has included CCS applied to carbon emissions from fossil fuels and industrial processes among technologies that can be rewarded.

The EU has so far, however, not introduced any policy instrument that drives investments into carbon removals through BECCS or DACCS. Some national initiatives in Nordic countries, such as Norway, Denmark and Sweden have been implemented, or are being prepared, to enable investments in CCS and carbon removals, which will be outlined in more detail below. Carbon removal potentials are unevenly distributed. For example, in the Nordics, the large point sources of biogenic carbon dioxide needed to deploy BECCS are to be found primarily in Sweden and Finland. This gives reason to consider enabling international trading of removals-based mitigation outcomes. Trading would broaden the demand base for carbon removal mitigation outcomes and countries with surplus potential could export carbon removal to countries with more limited potential.

Denmark

According to a climate agreement for energy and industry of 2020, CCS constitutes an essential element in achieving the climate policy objectives enshrined in the Danish Climate Act. In 2021 a roadmap for CCS was agreed upon, which includes several initiatives, including an agreement to enable storage of carbon dioxide in Danish subsoil. The political ambition in Denmark is to build an entire CCS value chain and that Denmark should become a European hub for the storage of carbon dioxide. Agreements regarding subsidy schemes for CCUS have been made with a total budget of 38 billion DKK (in 2023 prices) and a target of reductions and removals of 3.2 million tonnes of carbon dioxide per year in 2030. The subsidies are structured under three separate funds. Eligible technologies include CCS applied to fossil and biogenic carbon dioxide as well as DACCS, depending on the specific fund. Subsidy periods span over 2024-2044 and contract periods are between 8 to 20 years. First tranche bids were evaluated and subsequently resulted in a contract concerning state aid for Denmark's first project: Ørsted Bioenergy & Thermal Power A/S will capture and store 430,000 tonnes of carbon dioxide of biogenic origin annually from 2026. Further tenders are expected to be rolled out in the coming years.
Denmark has ample space for storage. However, many of the potential storage sites are not thoroughly examined and mature for injection. Investigation and licensing processes for both offshore and onshore storage have been initiated and are being intensified.

Finland

Finland has historically assumed a cautious position in relation to CCS. Sectoral low-carbon roadmaps, produced by business organisations with the support of the government, have included CCS as a tool to address industrial emissions. In terms of funding tools for new technology development, the Sustainable Growth Programme for Finland allocated EUR 150 million to hydrogen and carbon capture and utilisation projects and carbon capture and utilisation technologies to reduce carbon emissions caused by waste incineration will be piloted. However, in the programme of the current Finnish government, it is highlighted that Finland has a natural competitive advantage when it comes to capturing and utilising wood-based carbon dioxide. The government aims to introduce policy instruments that would end both fossil and biogenic carbon dioxide emissions from large industrial sources. If implemented, this would be the first measure of its kind internationally. Finland is to explore funding through reverse auctions and similar mechanisms, for the incentivisation of the capture of carbon dioxide.

Iceland

CCS using the Carbfix method of underground mineralization of carbon dioxide is part of the Icelandic government's climate action plan, to be applied to reduce emissions from geothermal power plants as well as heavy industries. Since 2012, Carbfix has captured and stored over 90 thousand tons of carbon dioxide from the country's largest geothermal power plant, using a technology the company developed to achieve underground mineralization of carbon dioxide.

The method involves dissolving carbon dioxide in water and the subsequent injection into basaltic layers, where it solidifies through mineralisation in less than two years. In 2019 a declaration of intent was signed between the Icelandic government, Carbfix and local heavy industries to investigate if the Carbfix method can be applied to reduce carbon dioxide emissions from domestic heavy industry.

The Swiss company Climeworks operates the world's largest Direct Air Capture plant, Orca in Iceland with a capacity of 4 000 tonnes of carbon dioxide per year. The heat and electricity required to run the direct air capture process is supplied by the Hellisheidi Geothermal Power Plant and the captured carbon dioxide is mineralised by Carbfix. Construction of the next, roughly ten times bigger, plant, called Mammoth, has been initiated at the same location.

Carbfix is planning to build a storage hub for carbon dioxide with a terminal that would enable the import of carbon dioxide to Iceland via ships, e.g., from European industry. The project, called 'Coda Terminal', recently received a large grant from the EU Innovation Fund.
Storage activities so far have been onshore making use of fresh water, but there are plans to start investigating mineralisation at coastal locations, then using salt water.

Figure 1: To achieve permanent mineralization of carbon dioxide – turning carbon dioxide into stone – Carbfix uses three injection wells near the Hellisheiði geothermal power plant in Iceland to inject carbonated water into underground rock formations, where it mineralises in less than two years. The stored carbon dioxide is captured from two sources: the emissions of the geothermal power plant, and the atmosphere through direct air capture. Photo from Carbfix.

Norway

Norway has been an early mover in using carbon pricing and regulatory instruments for the deployment of CCS. Today, over 25 years of experience in CCS has been accumulated, including geological storage of carbon dioxide under the seabed in the Sleipner and Snøhvit fields outside its coast. There is a great potential for carbon dioxide storage beneath the seabed in the North Sea. National targets for CCS in Norway are closely linked to targets for the so-called Longship project. In this project, carbon dioxide will be captured in two facilities, a waste incineration plant and a cement plant, transported by ship to a terminal, and then transported in a pipeline to the injection site. The carbon dioxide will be injected into geological formations 2600 meters below the seabed. The transport and storage component of the Longship project is called Northern Lights. Two-thirds of the cost of the first phase is covered by the Norwegian state.

Norway's aims with this project include facilitating learning and cost reduction in subsequent projects and developing infrastructure with additional capacity that other project developers can utilise, hence lowering the threshold for establishing new CCS projects. At the time of writing this report, the project in the waste incineration plant has been temporarily paused due to significantly increasing costs. The first commercial agreement has been signed regarding the storage of carbon dioxide at Northern Lights. It involves the transportation of carbon dioxide from the Netherlands.

Northern Lights is planning the next phase which involves expanding the capacity with 5 million tonnes of carbon dioxide stored annually. Two more storage licenses have been awarded and one more is in the pipeline. Equinor and Wintershall Dea announced a cooperation including a 900 km long pipeline for carbon dioxide transport which will provide European emitters with access to offshore storage sites on the Norwegian Continental Shelf.

The government of Norway expects that additional storage will be developed by third parties that are not funded by the Norwegian state.

Sweden

Sweden has no formal CCS strategy. However, BECCS is recognised as a so-called supplementary measure that can be utilised to counterbalance residual emissions to attain zero net emissions. Sweden is currently preparing a support scheme for BECCS in the form of reverse auctions (see below). Other ongoing efforts aimed at facilitating BECCS deployment, and CCS more broadly, include the preparation of a treaty with Norway to enable the Swedish export of carbon dioxide for storage and the establishment of a national centre for CCS which is part of the Swedish Energy Agency.

In terms of support for research, development and demonstration, the "Industrial Leap Programme", running from 2018 through 2030 with a total budget of 1,4 billion SEK, provides support for CCS, including carbon removal applications. Moreover, the Swedish 'Fossil Free Sweden Initiative' is preparing a cross-sectoral strategy for Swedish BECCS.

The Swedish Energy Agency has been assigned to develop the abovementioned support scheme for BECCS and is currently developing the design of the planned reverse auctions. In a reverse auction, actors can submit bids on how much carbon dioxide they can capture and store, and at what cost. A winning bid will be the best solution at the lowest cost. The carbon dioxide must be captured at facilities in Sweden, but the geological storage will take place outside Swedish borders. Winners will be paid support based on verified geologically stored tonnes of biogenic carbon dioxide. The government has promised 36 billion SEK for the programme for the years 2026-2046. The level of ambition for the support system is based on the targets stipulated in the Swedish Government Official Report 2020:4 – The road to a carbon-neutral future.

The goal, according to the governmental report, is to capture and store two million tonnes of biogenic carbon dioxide per year by 2030. 1 to 3 reverse auctions are to be held between 2024 and 2026. The support period per project should be up to 15 years.

Opportunities for Nordic collaboration on CCS and carbon removal

The Nordic countries have somewhat different entry points in CCS. However, there are several shared interests. It may be useful for the Nordic countries to coordinate positions to have a stronger impact on policy development, not least in the EU. Potential current issues include Industrial Carbon Management Policy, EU 2040 targets (including the role of carbon removals in the EU ETS), and the Carbon Removal Certification Framework.

The Nordic countries could jointly explore opportunities for market-based solutions involving international transfers of mitigation outcomes from BECCS and DACCS activities (between the Nordics and beyond) to further enhance the deployment of carbon removal projects in the region.

Strengthen the ability to strategically plan for the coordinated development and optimisation of infrastructure along the CCS value chain, including for cross-border transport of carbon dioxide.

The Nordic countries should take initiatives to intensify their cooperation and dialogue, building on existing structures, providing for joint efforts to build knowledge and sharing of Nordic experience and lessons learned. Regular Nordic-level sessions could be arranged for the exchange of information between governments and other stakeholders, including special sessions dedicated to specific themes, dedicated brainstorming sessions etc.