Nordic Council of Ministers

# Nordic Stocktake
## Pathways to Climate Neutrality

# Contents

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# 1. Preface

The world is taking stock of global climate action and the Nordic countries are moreover doing a regional stock take of their own.

This year world leaders will conclude the political phase of the Global Stocktake. This will give a status of the world's joint efforts to deliver collectively on the long-term goals of the Paris Agreement.

The message from science is clear. The IPCC AR6 states that the trajectory for keeping 1.5 °C within reach requires global peaking of GHG emissions immediately and by 2025 at the latest.

Rapid emissions reductions are needed within every sector of our economies and options are available.

The Nordic Stocktake report gives us the opportunity to further support the overall objective of the Global Stocktake process from a regional perspective. It reveals that the Nordic region must intensify the efforts and demonstrate that there are mitigation options available in all sectors. The early start of the Nordic energy transition has paid well off and spurred the development of green solutions and industries. However, many sectors are still lagging, and further initiatives are needed. The Nordic countries have the tools, know-how and institutional and financial capacity to step up and lead by example towards systemic change. The co-operation in the Nordic Council of Ministers must serve this purpose and support the Nordic path towards climate neutrality.

A crucial part of the Nordic Stocktake and Visions project is to create new visions and narratives for what a climate neutral region could look like. The green transition is a great opportunity to create a society in balance, both socially and environmentally. A climate neutral society could provide us with both healthier lives and stronger local communities with inclusive democracy and long-term policies.

It is my hope that this first Nordic Stocktake can give us a sense of where we are on a collective Nordic path towards a net-zero climate-resilient future and inspire us to support and learn from each other on the way.

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*This project was carried out in 2023 and has been undertaken by a Nordic consortium consisting of the organizations CONCITO (DK), CICERO (NO), IVL Swedish Environmental Research Institute (SWE), University of Iceland and Reykjavik University (IS), and Tyrsky Consulting (FI). The project has resulted in two reports: Nordic Stocktake – Pathways to climate neutrality, and Nordic Visions of Climate Neutrality, five webinars and five policy papers, and the results will be spread globally through international dissemination and communication activities at the New York Climate Week (2023) and at COP28 in the Nordic Pavilion.*

*The project was commissioned by the Swedish EPA on behalf of the Nordic steering group for Climate Transition in the Nordics and the Nordic working group for Climate and Air. However, the content does not necessarily reflect the Nordic Council of Ministers' views, opinions, attitudes or recommendations. The Nordic Council of Ministers will assess the report's recommendations and discuss how they could be addressed going forward towards a climate neutral Nordic region, contributing to the Nordic Vision 2030.*

# 2. Executive summary

## Taking stock of the Nordic countries' pathways to climate neutrality

With global greenhouse gas (GHG) emissions at their highest levels in human history, the need for rapid transformation of societies is immense. Science calls for immediate and deep emission reductions across all sectors to avoid accelerating climate change. Hence, countries that have the tools, know-how and institutional and financial capacity must step up and lead by example.

The Nordic region is well prepared to take on this responsibility and has a strong track record of leading by example. In accomplishment of the Helsinki Declaration on Carbon Neutrality[1], the Nordic countries have committed themselves to assess the scenarios for how to achieve climate neutrality. Furthermore, the Nordic region aims to be the world's most sustainable and integrated region by 2030 (Our Vision 2030[2]). The most recent status report[3] (2023) shows that Nordic green ambitions are challenged and points to a need for greatly accelerated efforts.

This report, *Nordic Stocktake*, reaches a similar conclusion. Due to the Nordics being early starters within the green energy transition, there have been tangible emissions reductions within the energy sector. However, other sectors are lagging behind, and the Nordic region needs to increase the pace of transition to continue leading by example.

Reaching climate neutrality is a massive task, and there are many challenges to overcome. Most of these challenges are not unique to the Nordic countries and solving these in the Nordic region – in countries well-positioned to do so – would prove valuable for global climate action.

1. Nordic Co-operation (2020, November 4). *Declaration on Nordic Carbon Neutrality*. Retrieved from, https://www.norden.org/en/declaration/declaration-nordic-carbon-neutrality
2. Nordic Council of Minister (2020). *The Nordic Region – towards being the most sustainable and integrated region in the world: Action Plan for 2021 to 2024*. Retrieved from, https://norden.diva-portal.org/smash/get/diva2:1508295/FULLTEXT01.pdf
3. Nordic Council of Ministers (2023). *Norden – en bæredygtig og integreret region? Statusrapport for Vores Vision 2030*. Retrieved from, https://norden.diva-portal.org/smash/get/diva2:1760998/FULLTEXT02.pdf

## To stay well below 2 °C, pursuing 1.5 °C, we need ambitious climate neutrality targets and immediate climate action.

The messages in the latest IPCC assessment report are clear: immediate and deep emission reductions are necessary in order to stay well below 2 degrees, pursuing 1.5 °C. The latest UNEP Emission Gap Report (2022) reaches the same conclusion and calls for transformative action[4].

This is further underscored by the scenarios in the recently released report from the EU Climate Advisory Board. The Advisory Board recommends keeping the EU's GHG emissions budget within a limit of 11 to 14 gigaton $CO_2e$ between 2030 and 2050. This requires emission reductions of 90–95% by 2040, relative to 1990.

All the Nordic countries have set targets for climate neutrality, the target year varying from 2030 to 2050. The targets differ with respect to what the target encompasses and how it can be reached. With the exception of Sweden, the Nordic countries include the land use, land-use change and forestry sector (LULUCF) when aiming for net-zero emissions – with the caveat that the role of LULUCF in reaching climate neutrality in Norway and Iceland is yet to be determined. Currently, only Norway and Sweden allow removals and reductions in emissions outside national borders to count towards achieving climate neutrality, and in Sweden, only as so-called supplementary measures that may be used for the remaining 15% of emissions.

## Emissions have been reduced significantly since 1990 in the energy and waste management sectors – deep decarbonization is needed in all remaining sectors.

Net GHG emissions in the Nordic countries, including emissions/removals from the LULUCF sector, have been reduced from 203 million tonnes of $CO_2e$ in 1990 to 150 million tonnes of $CO_2e$ in 2021, corresponding to a reduction of 26%. This reduction is almost exclusively achieved through large emissions reductions in the energy sector.

The energy sector accounts for 55% of total net GHG emissions in the Nordic region. From 1990 to 2021, the GHG emissions in this sector were reduced by 54 million tonnes of $CO_2e$ (40%) across the Nordic countries.

In waste management, emissions have been reduced by 8 million tonnes of $CO_2e$ (a 59% reduction).

4. UNEP (2022, October 27). *The Closing Window Climate crisis calls for rapid transformation of societies. Emissions Gap Report 2022*. United Nations Environment Programme. Retrieved from, https://www.unep.org/resources/emissions-gap-report-2022

For domestic transport, industrial processes, and agriculture, forestry and land-use, emission reductions have been smaller. Reaching climate neutrality rests on the achievement of deep decarbonization within these sectors in the coming years.

From 1990 to 2021, the GHG emissions from the Nordic domestic transport sector were reduced by only 3 million tonnes of $CO_2e$, corresponding to 5%. In the industry sector, emissions have been reduced by 5 million tonnes of $CO_2e$ (a 17% reduction). In agriculture, forestry and land-use, the LULUCF-sink has shrunk by 20 million tonnes of $CO_2e$ (a 31% reduction in the amount of carbon stored in the forest and soil sinks) while emissions from agriculture have been reduced by 4 million tonnes of $CO_2e$, corresponding to a 12% reduction.

## Reaching climate neutrality is a massive task, but there are multiple pathways to climate neutrality in the Nordic countries.

Leading by example and achieving climate neutrality requires the Nordic countries to accelerate their decarbonisation efforts in all sectors. This is a massive task. However, we can learn from previous experiences and intensify the planned efforts, initiatives and policies that form multiple pathways across the Nordic region.

The **energy** sector plays a key role in the green transition and all Nordic pathways to climate neutrality rely on decarbonization of energy production. Current development has focused on the expansion of green power production, particularly with respect to bioenergy, wind and solar. Favourable conditions, such as high potential for bioenergy, geothermal and hydro power in some of the Nordic countries, have also helped the transition towards a low-carbon energy sector. Pathways to climate neutrality include further massive expansion of renewable energy production to decarbonize the power sector as well as other sectors and to provide renewable energy for mitigation initiatives in hard to abate sectors, supplemented by improvements in energy efficiency.

In the **domestic transport** sector, emissions have been addressed with a range of initiatives focused primarily on road transport and passenger cars. Electrification of the car fleet has accelerated across the Nordic region in recent years with Norway as a frontrunner. Biofuels and blending requirements, partly driven by EU regulation, have also played a large role. Despite previous efforts, emissions in the transport sector remain high across the Nordic region, with almost no real GHG reductions compared to 1990. There are large differences in the development across the Nordic countries in this sector, with three countries seeing increases in emissions from 1990 to 2021. Further electrification of the private car fleet, enhanced public and multi-modal transportation and plans to decarbonise heavy transport are part of the Nordic countries' plans and strategies for the domestic transport sector.

The emissions from **industrial processes** in the Nordic countries have primarily been regulated through the EU Emissions Trading System (EU ETS) and different national carbon pricing mechanisms. The sector is largely dependent on developments in the energy sector with respect to the access to dependable green power to electrify industrial processes without losing international competitiveness. Carbon Capture and Storage (CCS), Carbon Capture and Utilization (CCU) and similar technologies are expected to play a large role in achieving net-zero emissions in this sector and the Nordic countries are piloting different initiatives such as government support for CCS on point-sources and prioritizing R&D for CCS-technologies.

In **waste management**, previous policies across the Nordics have focused on reducing the emissions from landfill and increasing the level of recycling, especially in households. Plans include reducing the total amount of waste, increasing the recycling rate and fostering circularity.

Across the Nordic countries, not nearly enough has been done to reduce the GHG emissions from **agriculture**. Most initiatives have focused on reducing emissions from agriculture by targeting the activities on the farm and despite talk about more demand-side initiatives, they still need to be implemented. For **forestry and land-use**, initiatives have been targeted at rewetting and/or afforestation of wetlands and peatlands, but progress is slow. Pathways to climate neutrality in the Nordic countries involve large emissions reduction in agriculture in particular, but more specific initiatives and strategies are needed.

## The main challenges are the same across the Nordic countries.

There are still many challenges and barriers to reaching climate neutrality in the Nordic region. Many of these are the same across the Nordic countries (and beyond).

Across the Nordic countries, in the **energy** sector, a combination of scepticism towards energy production facilities due to negative impacts on local populations and nature, as well as a slow review and permit processes, risk halting the planned expansion of green power. At the same time, increasing the share of renewables in the energy mix creates intermittency issues regarding a sufficient expansion of supplementary power production that can be regulated.

For **domestic transport**, the main challenges are in the road transport sub-sector. Firstly, the future role of biofuels as a mitigation instrument is unclear. The production of biofuels is limited by land resources, competing with food production and ecosystems services, and limited availability of a waste feed-stock for production of advanced biofuels. Secondly, and despite positive developments in electric vehicle uptake, internal combustion engine cars (ICE) still have a dominant presence on the roads. Phasing out ICE cars and trucks is a major challenge.

Regarding the **industry sector and emissions from industrial processes**, the main cross-Nordic challenges are incentivising emission reductions in an internationally competitive sector – while avoiding carbon leakage - and scaling up and providing incentives for carbon removal technologies. The attainment of Nordic countries' individual and joint ambitions to reach net-zero GHG emissions may require very significant CCS deployment within a couple of decades, but that will require significant efforts and cross-Nordic collaboration on capture, transport and geological storage of $CO_2$.

In **waste management**, reducing emissions is not the major challenge. Instead, issues such as reducing the amount of waste generated, increasing recycling rates of sorted waste and, in general, the broader transition to a circular economy is lacking across the Nordic region.

In **agriculture, forestry and land-use**, strategies and initiatives are hard to implement due to political concerns such as carbon leakage, regressive effects on income distribution, food security and rural development. This is a major challenge in decarbonising and transforming the agricultural sector in all the Nordic countries. Across the Nordic countries, strengthening carbon storage in sinks and reducing emissions from forestry and land-use also proves difficult. This is especially true regarding emissions from degraded wetlands, such as cultivated peatlands. The Nordic forest sink is strained by climate change and increased demand for biomass.

## The challenges can be overcome – especially through cross-Nordic collaboration.

As stated by the IPCC, *"There are options available now in every sector*". This is also true in the Nordic region. Since many of the challenges, as outlined above, are the same or similar across the Nordic countries, there is ample opportunity for Nordic collaboration on the path towards climate neutrality.

In the **energy** sector, we recommend the next steps for Nordic collaboration:

- knowledge-sharing on increasing acceptability - and reducing potential negative impacts on nature and local populations - for renewable energy installations
- cross-Nordic analysis/overview on future energy supply and demand, especially regarding balancing power capacity by supplementing increasing renewable power
- knowledge-sharing on energy efficiency policies.

In the **domestic transport** sector**,** we see a need for Nordic collaboration on:

- developing a Nordic roadmap for the sustainable development, production and use of biofuels and synthetic fuels

- developing a strategy for how to reallocate ICE cars to those users and uses that would have the lowest travel needs and a supporting assessment framework to identify the GHG trade-offs of different policies.
- supporting urban action plans for zero emission passenger and freight transport.
- knowledge-sharing on promoting public transport across the Nordic countries to further lower emissions from the use of ICE cars and coordination of rail transport systems across the Nordics.

To address emissions from **industrial processes,** Nordic collaboration could focus on:

- piloting public procurement for low-carbon industrial products
- knowledge-sharing on best practices in incentivising direct electrification of suitable industrial processes across the Nordic countries.
- intensifying collaboration on the value chain of Carbon Capture and Storage across the Nordic countries.
- developing a joint Nordic CCS strategy to increase the potential to realise economies of scale in transportation and storage infrastructure for captured carbon dioxide.
- Nordic research on governance and business models for generating $CO_2$ removal (negative emissions).

For **waste management**, emissions are low and declining and Nordic collaboration efforts should thus focus on governance of waste more generally – and not just on territorial emissions from the waste management sector. There are options and a need for more Nordic collaboration in improving conditions for the circular economy.

**Agriculture, forestry and other land-use** is a challenging sector for all the Nordic countries and the potential for valuable Nordic collaboration is high. We recommend that Nordic collaboration focuses on:

- knowledge sharing and research co-operation on addressing emissions from organic soils.
- knowledge sharing on carbon pricing in agriculture – risks and incentive structures.
- Nordic research on climate accounting on farms and improving knowledge on ways to reduce emissions on the farm from livestock, such as manure management – including biogas production, crop cultivation and fodder additives to reduce methane releases from ruminants.
- studies on examples of how to improve the conditions for producers of plant-based proteins, both in terms of research, education and regulatory frameworks.
- Nordic research and innovation funds targeted towards plant-based production.

In addition to the opportunities from Nordic collaboration that arise directly from the shared challenges in the different sectors, we see **further opportunities** for Nordic collaboration:

- a study on Nordic scenarios for climate neutrality (at the Nordic level)
- knowledge-sharing on efficient climate policy collaboration between government levels
- coordination and transparency on assumptions for climate neutrality strategies and pathways in the Nordic countries
- coordination of value chains on waste, CCS and bioenergy across the Nordics to enhance efficiency and economies of scale effects in terms of money, energy and GHG emissions
- increased knowledge-sharing ("best practices") and collaboration on addressing consumption-based emissions in the Nordic countries
- collaboration on a just and fair transition, incl. more research on making carbon taxes and pricing fair.

# 3. Reader's guide to the stocktake report

The report describes and assesses emissions from the five countries in the Nordic region: Denmark, Finland, Iceland, Norway, and Sweden. Emissions and removals from Greenland, Faroe Islands and Aaland are included in the emissions statistics from Denmark and Finland, respectively.

For the Nordic Council of Ministers, the organizations CONCITO, CICERO, IVL Swedish Environmental Research Institute, University of Iceland and Reykjavik University, and Tyrsky Consulting have carried out this assessment. The consortium has taken stock of GHG emissions in the Nordic countries, described and assessed the national pathways towards climate neutrality in the Nordic region. The report also addresses issues of timing and adequacy of the pathways and strategies for reaching climate neutrality in the Nordic countries and opportunities for further Nordic collaboration.

This project is a part of the initiative "Climate transition in the Nordics" to support the Nordic Vision 2030. The overall aim of the Nordic Vision is to become the most sustainable and integrated region in the world by 2030. All co-operation in the Nordic Council of Ministers must serve this purpose. The objectives of the vision include to strengthen research and development and the promotion of solutions that support climate neutrality and climate adaptation. The work of the Nordic Council of Ministers should also contribute to the positive development of international co-operation on the environment and climate, such as by promoting Nordic green solutions to the rest of the world.

The Nordic Stocktake is intended as a regional tool to support the Global Stocktake process and spur to further climate action, both within the Nordics and beyond. The political phase of the UNFCCC Global Stocktake (GST) will be conducted during COP28 in December 2023. The Paris Agreement's Global Stocktake process is designed to assess the global response to the climate crisis every five years, with this year's stocktake being the first ever. The GST will illustrate how we make progress toward the goals of the Paris Agreement globally, and the gaps in meeting them.

## 3.1. Report structure

In the first chapter (Climate neutrality targets in the Nordic countries), we give an overview of the countries' climate neutrality targets and the development in emissions/removals from 1990 to 2021 across the Nordic region.

In the chapters following, we describe each country's climate neutrality target, the status of GHG emissions in that country and – where possible – an assessment of how adequate and timely the pathways are towards achieving climate neutrality. Countries are described in alphabetical order.

After the country chapters, five chapters are dedicated to exploring status, development, pathways, challenges and opportunities in the given sector. The five sectors are:

- Energy
- Domestic transport
- Industrial processes
- Waste management
- Agriculture, forestry and land-use

The sectors are delimited according to the IPCC Guidelines for emission statistics and might not align with national sector delimitations and categories.

Finally, the last chapter in this report (Further opportunities for Nordic collaboration) describes further opportunities for Nordic collaboration not covered in the sector chapters.

# 4. Climate neutrality targets and emissions in the Nordic countries

## 4.1 Climate neutrality targets

Each of the five Nordic countries have set a target for climate neutrality and some of them are among the most ambitious targets in the world. Despite the specific definition and wording of the targets in the different countries, they will all be referred to in this report as "climate neutrality targets".

Across the Nordic countries, climate neutrality targets differ with respect to what the targets encompass and how they can be reached. With the exception of Sweden, the Nordic countries include the land use, land-use change and forestry sector (LULUCF) when aiming for net-zero emissions – albeit with the caveat that the role of LULUCF in reaching climate neutrality in Iceland and Norway is yet to be determined. In Sweden, LULUCF can only be used as a supplementary measure (as described in the country chapter on Sweden).

In Norway, GHG removals outside national borders can be counted towards the target. In Denmark, Finland and Iceland, reductions and removals must currently take place within the national territory. In Sweden, similarly to how LULUCF is treated, supplementary measures allow for a certain percentage of the target to be achieved with reductions and removals outside national borders[5].

Table 1 below, summarises the targets of the Nordic countries and what the targets encompass. These are explained further in the country chapters.

5. Article 6 ITMOs

**Table 1:** Climate neutrality targets in the different Nordic countries

| Country | Target | Coverage | Inclusion of international actions |
|---|---|---|---|
| Denmark | Climate neutrality by 2050 | Target includes all GHG emissions and LULUCF | Target must be reached with domestic actions |
| Finland | Climate neutrality by 2035 | Target includes all GHG emissions and LULUCF | Target must be reached with domestic actions |
| Iceland | Climate neutrality by 2040 | Target includes all GHG emissions (accounting LULUCF[(i)] undecided) | At this point, the target must be reached with domestic actions |
| Norway | Climate neutrality by 2030 and low emission society from 2050 (90-95% emission cuts) | Target includes all GHG emissions (accounting LULUCF[(ii)] undecided) | The climate neutrality target is focused on contributions at the international level and can be reached with a combination of domestic and international actions. The low emission society target must be reached with domestic actions, while the 90-95% can account for cooperation within the EU ETS. |
| Sweden | Zero net greenhouse gas emissions by 2045[(iii)] | National target does not include LULUCF (except as a possible supplementary measure) | Target must be reached with domestic actions (except the option to counterbalance residual emissions using ITMOs[(iv)]) |

[(i)] It is stipulated that the exact inclusion of the LULUCF sector and its contribution to carbon neutrality must be elaborated further due to need to improve the data and unusually high share in total emissions.
[(ii)] The exact role of the LULUCF sector has yet to be determined
[(iii)] Swedish territorial GHG emissions must be at least 85 percent lower by 2045 at the latest in comparison with 1990. So-called supplementary measures may be used for the remaining 15 percent of emissions.
[(iv)] ITMO = Internationally Transferred Mitigation Outcomes.

## 4.2. Status of GHG emissions across the Nordic countries

Net GHG emissions in the Nordic countries, including emissions/removals from the LULUCF sector, have been reduced from 203 million tonnes of $CO_2e$ in 1990 to 150 million tonnes of $CO_2e$ in 2021, corresponding to a reduction of 26%.

Figure 1, below, illustrates the total Nordic territorial GHG emissions and net emissions from 1990-2021 with GHG emissions above 0 and removals below 0. The total net territorial Nordic GHG emissions are shown with a black line.

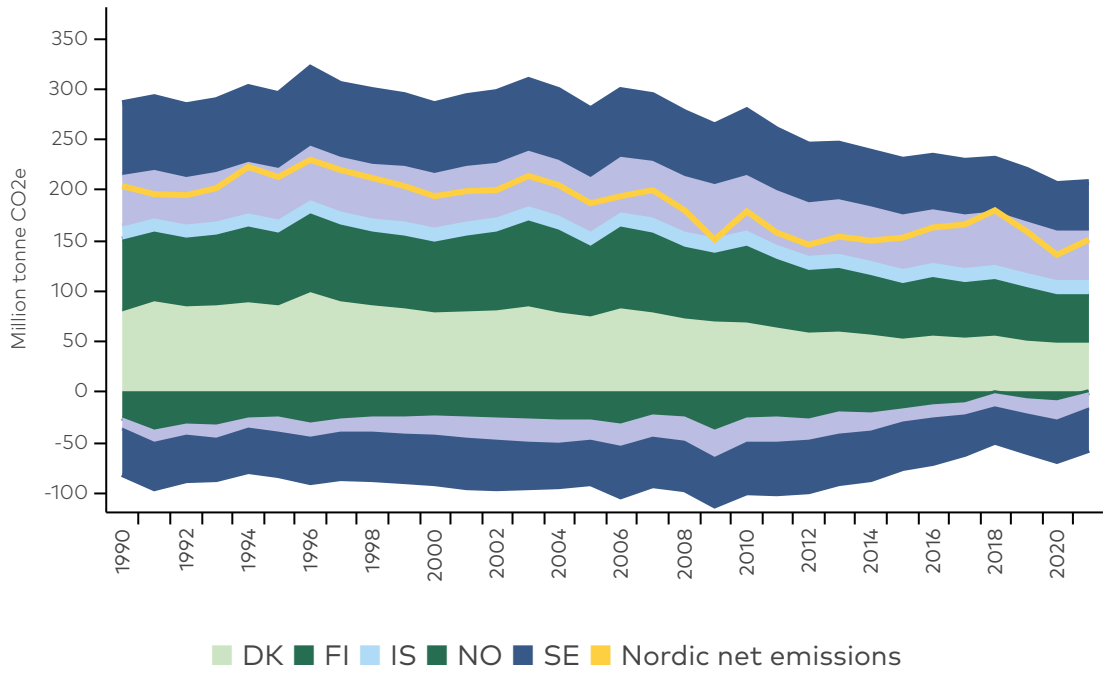



**Figure 1:** Development of territorial GHG emissions and removal across the Nordic countries (incl. LULUCF), 1990-2021

*Source: UNFCCC https://unfccc.int/topics/mitigation/resources/registry-and-data/ghg-data-from-unfccc).*

Emissions and removals from the LULUCF-sector varies significantly across the Nordic region. Thus, Figure 2 below shows the net emissions from the Nordic countries without LULUCF. The emissions/removals from the LULUCF-sector in the Nordic countries is covered in more detail in the sector-chapter on "Agriculture, forestry and land-use".

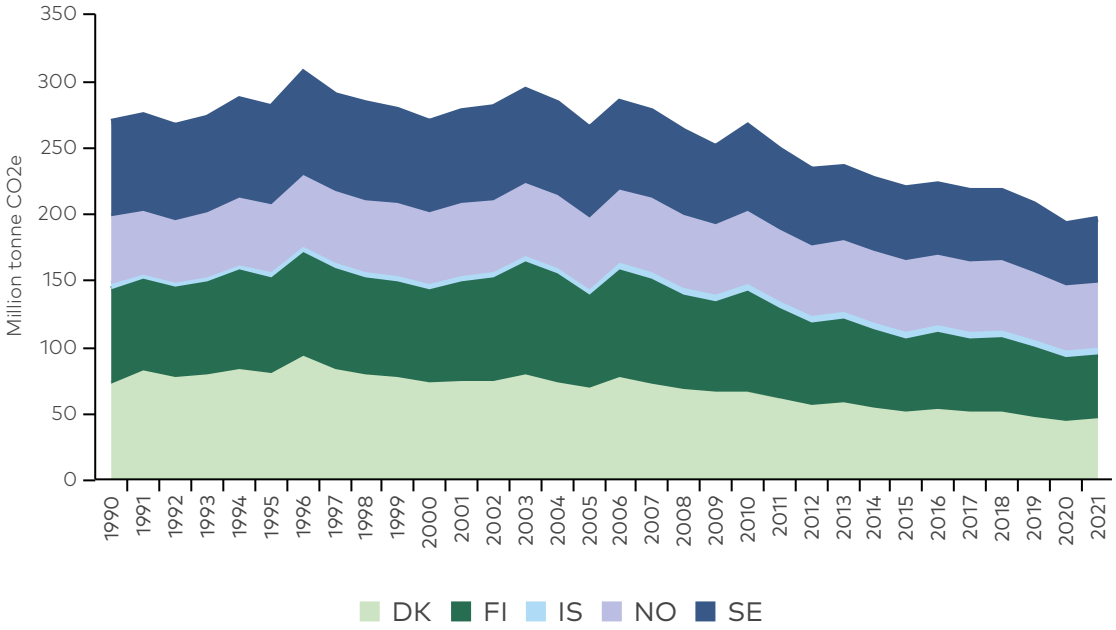



**Figure 2:** Development of net territorial GHG emissions (excluding the LULUCF-sector) across the Nordic countries, 1990-2021

*Source: UNFCCC. GHG data from UNFCCC*
*https://unfccc.int/topics/mitigation/resources/registry-and-data/ghg-data-from-unfccc*

# 5. Denmark

## 5.1. Climate neutrality target

Denmark has a climate neutrality target in 2050 and two interim targets of 50-54% in 2025 and 70% in 2030, compared to 1990. The targets include all greenhouse gases and LULUCF emissions. GHG emissions areas are calculated according to UN accounting rules. The targets are enshrined into the legally binding Danish Climate Act. The Danish government has proposed to move the climate neutrality target forward to 2045 and set a new net-negative target of 110% in 2050[6]. These proposals have still to be turned into law.

## 5.2. Status of GHG emissions

Denmark has reduced emissions from 78.8 million tonnes of $CO_2e$ in 1990 to 48 million tonnes in 2021, a reduction of 39%. Another 8.6 million tonnes of $CO_2e$ must be reduced between 2021 and 2025 to reach the low end of climate target of 50-54% in 2025. As Figure 3 shows, the latest projection from the Danish Energy Agency[7] (DEA) assesses that the target is within reach based on existing policies. However, according to assessments by the Danish Climate Council and CONCITO there is high uncertainty regarding the projection in 2025. CONCITO estimates that new policies must deliver another 2.4 million tonnes in reductions before 2025 just to reach the lower (50%) end of the target range[8].

6. Statsministeriet (14. december 2022). *Regeringsgrundlag 2022: Ansvar for Danmark*. Retrieved from, https://www.stm.dk/statsministeriet/publikationer/regeringsgrundlag-2022/
7. Energistyrelsen (April 2023). *Klimastatus og -fremskrivning, 2023*. Retrieved from https://ens.dk/service/fremskrivninger-analyser-modeller/klimastatus-og-fremskrivning-2023
8. Capion, K. & Hasforth, T. (May 2023). *Sidste udkald for at nå klimamålet for 2025.* CONCITO. Retrieved from, https://concito.dk/udgivelser/sidste-udkald-naa-klimamaalet-2025

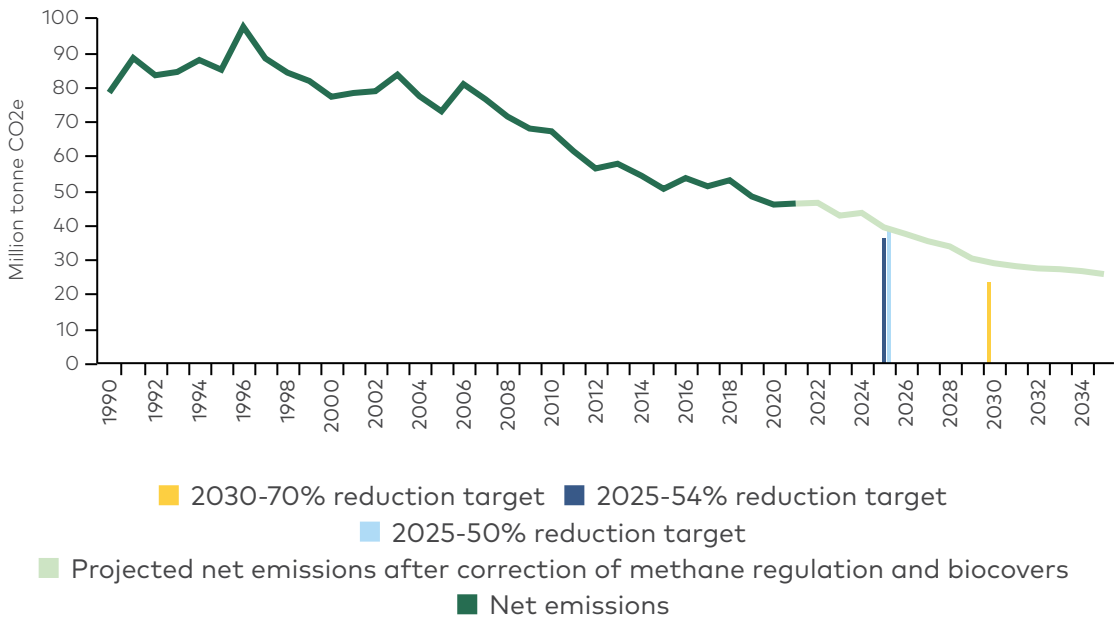



**Figure 3:** Denmark's total net emissions as well as 2025 and 2030 targets

*Source: Own figure based on DEA (2023). Klimastatus og -fremskrivning, 2023*
*https://ens.dk/sites/ens.dk/files/Basisfremskrivning/kf23_hovedrapport.pdf*

To reach the 2030 target of 70%, Denmark must reduce emissions by 24.3 million tonnes of $CO_2e$ between 2021-2030. The latest projection by the DEA estimates that a further 5.4 million tonnes of reductions must be achieved to reach the target[9].

The Parliament has agreed on a separate reduction target for agriculture and land-use that demands a further 5 million tonnes of GHG-emissions reduction in the sector. The government will propose a tax on GHG-emission on agriculture and land-use pending the recommendations from an expert committee. The expert committee shall put forth recommendations on how to tax and support the transition in the agricultural sector.

The electricity and district heating sector (excluding waste incineration) has historically accounted for up to 40% of the total Danish emissions. However, this share has decreased significantly since 2010 and in 2021, the sector accounted for only 11% of total emissions. In 2025, this share is expected to have dropped to 3%, and by 2030, electricity and district heating (excluding waste incineration) are expected to constitute less than 1% of total net emissions[10].

9. Energistyrelsen (April 2023). *Klimastatus og -fremskrivning, 2023*. Retrieved from, https://ens.dk/sites/ens.dk/files/Basisfremskrivning/kf23_hovedrapport.pdf#page=11
10. Energistyrelsen (April 2023). *Klimastatus og -fremskrivning, 2023*. Retrieved from, https://ens.dk/sites/ens.dk/files/Basisfremskrivning/kf23_hovedrapport.pdf

There have been significant fluctuations in emissions from the electricity and district heating sector. These fluctuations are driven by fluctuating weather conditions, such as cold winters or varying precipitation levels in the Nordic region (which affect Nordic hydropower production). These fluctuations are expected to decrease in the future as total emissions from the electricity and district heating sector are reduced due to the phasing out of fossil-fired power plants and the transition to electricity production primarily based on wind, solar and biomass.

As emissions from **electricity and district heat production** decrease, the share of emissions from other sectors in the total emissions increase, as they are not reduced to the same extent. This is based on current predictions in the absence of new climate policy to reduce emissions in these other sectors.

Emissions from **agriculture, forestry, horticulture and fisheries** (including emissions from agricultural processes, agricultural areas and forests, as well as the sector's energy consumption) have thus gone from representing about 25% of the total emissions historically to constituting 34% of the total emissions in 2021. In 2025, this sector is expected to constitute 44% of net emissions, and by 2030, the sector's share of the total emissions is projected to rise further to 52%.

Similarly, the share of total net emissions from **the transportation sector** has grown from 15% in 1990 to 27% in 2021, and in 2025 and 2030 it is expected to account for 31% and 35% of net emissions, respectively.

The distribution of the total emissions in 2030 across sectors illustrates that emissions in 2030 will be concentrated in relatively few sectors. Nearly 90% of the total net emissions of 29.0 million tons of $CO_2$e are expected to originate from either agriculture, land use or the transportation sector.

Carbon capture and storage (CCS) is expected to play a significant role in Danish emission reductions towards 2030. State subsidy schemes are targeting fossil, process and biogenic emissions which are expected to result in a total reduction of 3.2 million tonnes of $CO_2$ pr. Year by 2030. This requires tendering and supporting policies in line with established climate goals.

Gross emissions (i.e. emissions before accounting for CCS), the emissions from agriculture, forestry, horticulture and fisheries, as well as the transportation sector, will constitute about 80% of total emissions in 2030.

## 5.3. Assessment of timing and adequacy

The DEA has outlined four scenarios for climate neutrality in Denmark in 2050[11]. These show several possible pathways for Denmark. These pathways are dependent on assumptions regarding technological development and behavioural changes. The scenarios are shown in the graph below:

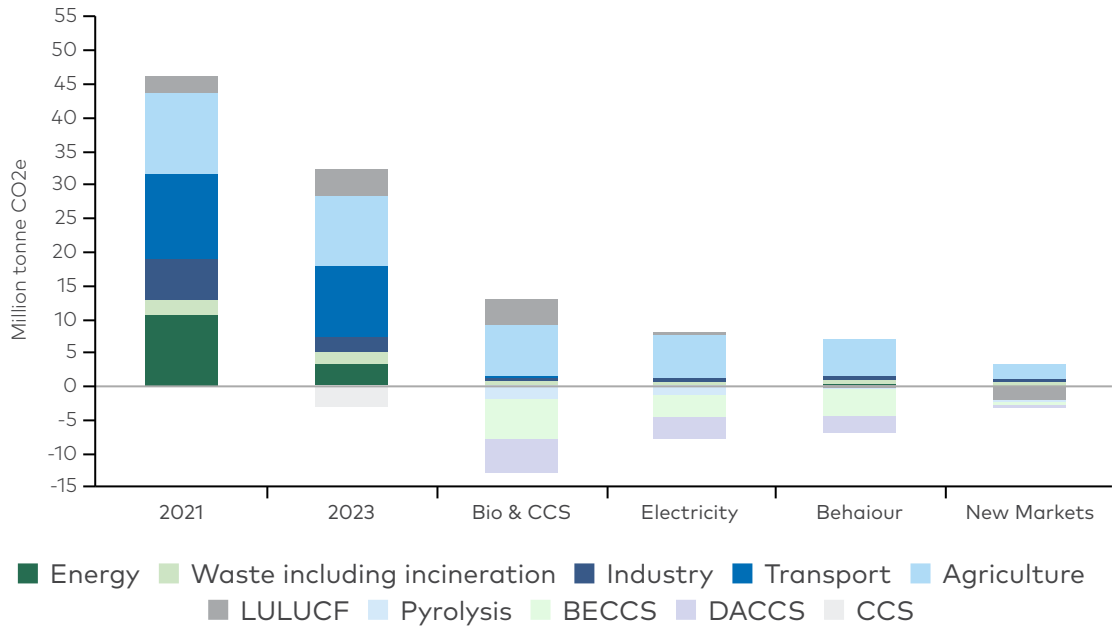



**Figure 4:** Scenarios for reaching net-zero in Denmark in 2050

*Source: DEA (2023). Klimastatus og -fremskrivning, 2023*
*https://ens.dk/sites/ens.dk/files/Basisfremskrivning/kf23_hovedrapport.pdf*

In the DEA's scenarios, the majority of residual emissions in 2030 will be from transport and agriculture. With continued electrification of road transport, after 2030 the remaining emissions will largely stem from agriculture and land-use towards 2040. Targeting technological development towards less GHG-intensive agricultural production and promoting dietary changes is thus key to achieving the long-term targets. Moreover, carbon dioxide removal (CDR) from the atmosphere, biologically and technologically, is also necessary to achieve GHG-neutrality since agricultural production will lead to emissions of GHG.

11. Energistyrelsen (2022, September 23). *Resultater for KP22-scenarier*. Retrieved from,https://ens.dk/sites/ens.dk/files/Basisfremskrivning/resultater_for_kp22-scenarier_23-09-2022.pdf

Looking further ahead, the proposed climate target of 110% in 2050[12] demands 8 million tonnes net-negative emissions. If residual emissions in 2050 are, for example, 6 million tonnes, 14 million tonnes CDR (8+6) will be needed to reach 110%. Moreover, there might be a demand for CO2, for example, for e-fuels and products. Thus, the net-negative target in 2050 emphasises that CDR must play an important role long-term. But the scale of CDR in climate politics will be very closely linked to residual emissions from the agricultural sector in particular, and the historical emissions that CDR must compensate for.

12. Statsministeriet (14. december 2022). *Regeringsgrundlag 2022*, *Ansvar for Danmark*. Statsministeriet. Retrieved from, https://www.stm.dk/statsministeriet/publikationer/regeringsgrundlag-2022/

# 6. Finland

## 6.1. Climate neutrality target

Finland has adopted a target of reaching carbon neutrality by 2035 and becoming carbon negative thereafter. The target was first set in the government programme in 2019[13] and later codified in law in the Climate Act[14]. Despite what the term suggests, "carbon neutrality" covers all greenhouse gases and is defined as removals by sinks being as large as emissions. As the target takes into account LULUCF sinks, the target year of 2035 is not directly comparable to those of other countries which do not factor in all sinks. Finland does not have separate targets for carbon dioxide removal. On the other hand, buying offsets from abroad is not included as a mechanism to reach the target.

Choosing 2035 as the target year was informed by the work of the independent advisory Finnish Climate Change Panel[15]. An earlier study commissioned by the Finnish Innovation Fund, Sitra, came to a similar conclusion[16]. While defining a country's share of emission reductions compatible with globally reaching the temperature goals set in the Paris Agreement depends on various factors, not least the equity criteria used for distributing the effort between countries, the Finnish target can be considered to meet its fair share of global efforts.

Carbon neutrality by 2035 is complemented by targets for different years. The Climate Act sets targets for the combined emissions from emissions trading and effort-sharing sectors to be reduced by at least 60% by 2030, 80% by 2040 and 90-95% by 2050, compared to 1990 levels. Sectoral targets will be discussed in the respective sections later in the report.

13. Finnish Government (6. June 2019). *Inclusive and competent Finland – a socially, economically and ecologically sustainable society.* Retrieved from, https://julkaisut.valtioneuvosto.fi/handle/10024/161664
14. Ympäristöministeriö (2022, July 1). *Ilmastolaki.* Finlex. Retrieved from, https://finlex.fi/fi/laki/ajantasa/2022/20220423
15. Ollikainen, M., Weaver, S. & Seppälä, J. (July 2019). *An approach to nationally determined contributions consistent with the Paris climate agreement and climate science: application to Finland and the EU.* The Finnish Climate Change Panel. Retrieved from, https://www.ilmastopaneeli.fi/wp-content/uploads/2019/10/Finlands-globally-responsible-contribution_final.pdf
16. Rocha, M., Sferra, F., Schaeffer, M., Roming, N., Ancygier, A., Parra, P., Cantzler, J., Coimbra, A.& Hare, B. (June 2016). *What does the Paris climate agreement mean for Finland and the European Union?* Climate Analytics. Retrieved from, https://www.sitra.fi/en/publications/what-does-paris-climate-agreement-mean-finland-and-european-union/

## 6.2. Status of GHG emissions

Finland has reduced emissions relatively consistently over the past 20 years. From a high of 85.5 million tonnes of $CO_2e$ in 2003, total emissions (excluding LULUCF) have declined by 44% to 47.8 million tonnes in 2021. Compared to the 1990 levels of 71.0 million tonnes, the reduction has been a more modest 33%. As Finland's emissions have, until recently, been dominated by the energy sector, interannual variation has been relatively large, owing to big fluctuations in, for example, heating demand and electricity imports depending on the weather. It is noteworthy that the declining long-term trend in emissions has not been significantly affected by disturbances such as the post-pandemic recovery and the energy crisis triggered by Russia's war of aggression against Ukraine.

However, progress has been highly uneven across sectors. The waste and construction and housing sectors have reduced their emissions by 65% and 53%, respectively, compared to 1990 levels. Emission reductions in transport and mineral and metal industry, on the other hand, have been relatively modest, at 18% and 3%, respectively. The energy industry has successfully cut emissions by no less than 64% from the peak in 2003 but compared to 1990 levels the reduction has been less than half of that. While agricultural emissions declined by 12% in the 1990s, they have since remained essentially unchanged. Emissions from the emissions trading sector have declined much more than in the effort-sharing sector.

Whereas total emissions (excluding LULUCF) have been declining, the development in the LULUCF sector has seen the opposite. In 2021, for the first time, the sector turned from a net sink into a net source of emissions. While the net sink has been declining from a high of more than -30 million tonnes in 2009 for a long time, the recent collapse from -17 million tonnes in 2020 to +2 million tonnes in 2021 is unprecedented.[17]

Owing to this, net emissions (including LULUCF) in 2021 were actually 7% higher than in 1990, despite success in cutting emissions. This development jeopardises the carbon neutrality goal which was originally based on the assumption of a -21 million tonne net LULUCF sink in 2035. The Finnish Climate Change Panel estimates that the LULUCF gap in 2035 could now be as large as 19 million tonnes. Taking into account already announced measures, there would be a need to increase the LULUCF sink – or compensate it with alternative measures – by an additional 14 million tonnes.[18]

17. Ministry of the Environment Finland. (2030). *Annual Climate Report 2022*. Retrieved from, https://julkaisut.valtioneuvosto.fi/handle/10024/164392
18. The Finnish Climate Change Panel. (2023). *Suuntaviivoja Suomen ilmastotoimien Tehostamiseen [Guidelines for enhancing climate action in Finland].* Retrieved from, https://www.ilmastopaneeli.fi/wp-content/uploads/2023/02/ilmastopaneelin-julkaisuja-1-2023-suuntaviivoja-ilmastotoimien-tehostamiseen.pdf

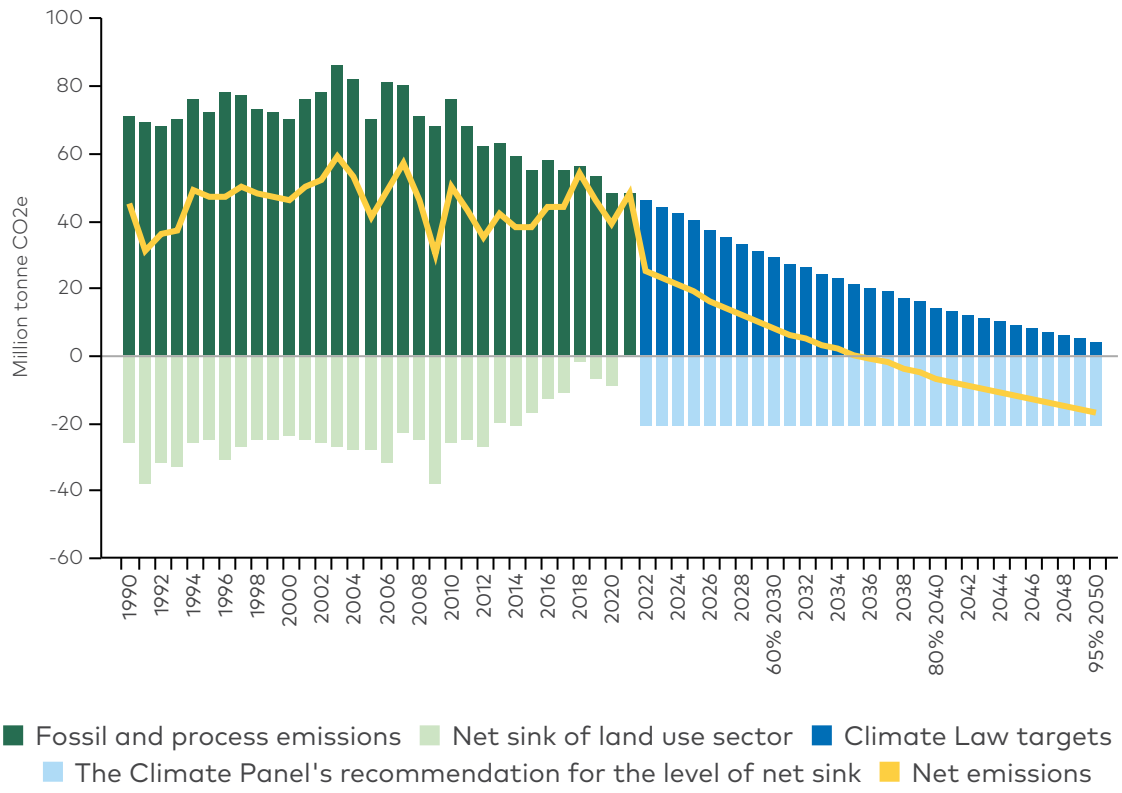



**Figure 5:** The past development of total emissions and sinks in Finland and the required trajectory to reach national emissions targets

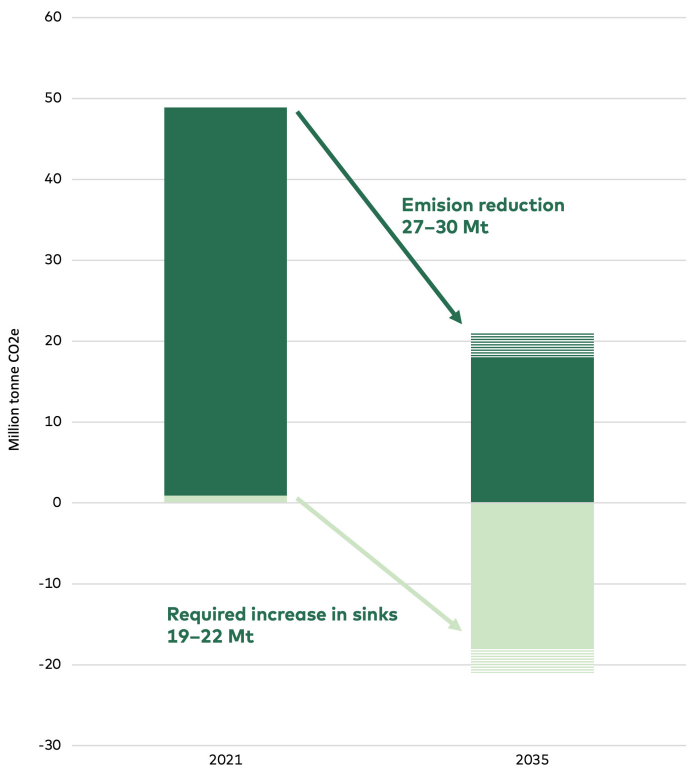
*Source: Ollikainen, M. (2023). Ilmastopaneelin yleiskatsaus: tilanne ja haasteet. The Finnish Climate Change Panel. https://www.ilmastopaneeli.fi/wp-content/uploads/2023/05/Ilmastotyon-tilanne-Suomessa_8.5.2023_Ollikainen.pdf*

## 6.3. Assessment of timing and adequacy

The Finnish Climate Change Panel estimates that reducing emissions (excluding LULUCF) is progressing faster than anticipated, leading to an emission levels of 18-19 million tonnes in 2035, instead of the earlier plans of 21 million tonnes. This does not yet factor in policy changes from the new government, some of which are expected to increase emissions, at least in the short term. The Panel also points out that there are uncertainties involved in making these estimates and additional measures, particularly in the effort-sharing sector, are still needed.[19]

19. The Finnish Climate Change Panel. (2023). *Suuntaviivoja Suomen ilmastotoimien Tehostamiseen [Guidelines for enhancing climate action in Finland].* Retrieved from, https://www.ilmastopaneeli.fi/wp-content/uploads/2023/02/ilmastopaneelin-julkaisuja-1-2023-suuntaviivoja-ilmastotoimien-tehostamiseen.pdf

This promising progress is, however, overshadowed by the collapse of the net LULUCF sink. To bridge the gap, 19 million tonnes' worth of measures in the LULUCF sector would be required. As already announced measures are estimated to provide 5 million tonnes, the remaining gap is 14 million tonnes. The panel recommends a range of measures to reduce emissions and increase sinks in the LULUCF sector as well as to introduce technical sinks.[20]




■ Fossil and process emissions (the striped part is the range)
■ The net sink of land use sector and technological sinks (the striped part is the range)

**Figure 6:** The required emissions reduction and increase in sinks to reach carbon neutrality by 2035

*Source: The Finnish Climate Change Panel. (2023). Suuntaviivoja Suomen ilmastotoimien Tehostamiseen*
https://www.ilmastopaneeli.fi/wp-content/uploads/2023/02/ilmastopaneelin-julkaisuja-1-2023-suuntaviivoja-ilmastotoimien-tehostamiseen.pdf

20. The Finnish Climate Change Panel. (2023). *Suuntaviivoja Suomen ilmastotoimien Tehostamiseen [Guidelines for enhancing climate action in Finland].* Retrieved from, https://www.ilmastopaneeli.fi/wp-content/uploads/2023/02/ilmastopaneelin-julkaisuja-1-2023-suuntaviivoja-ilmastotoimien-tehostamiseen.pdf

In the **energy sector**, emissions have declined and are expected to decline more rapidly than previously anticipated. According to the Low-carbon roadmap by Finnish Energy [21] (updated in 2021), which anticipates the demand for electricity, heating and gas, the energy transition in Finland is progressing well and the emissions are decreasing faster than expected. The energy industry is committed to reducing emissions from energy production by half by 2030, compared to 2018. This objective might already have been achieved in 2023, according to the updated roadmap.

In **domestic transport**, the share of electric vehicles in newly purchased cars has been increasing. However, the effect on the total car fleet only materialises slowly and trucks are more difficult to electrify. The blending obligation of biofuels provides a quick and effective way to reduce emissions in land transport and has been the main driver in reducing transport emissions. However, because of its impact on fuel prices, targets adopted earlier have been reduced, leaving a gap between transport emissions and emission targets.

In **industry**, phasing out fossil fuels in energy use and industrial processes is progressing. However, reducing emissions in the sector hinges on the success or failure of a handful of key projects, most notably in the metal industry. Realising plans requires a significant increase in the provision of affordable, clean electricity.

In **waste management**, emissions have declined and are projected to continue to decline rapidly. However, emissions from waste incineration – addressed under the energy sector – have increased rapidly in recent years. Further emission reductions can be found in moving towards a circular economy, including reductions in waste and higher recycling rates.

In **agriculture and forestry**, reducing emissions and increasing sinks faces significant challenges. The biggest single source of agricultural emissions – farming on organic soils – is socially and politically tricky to address. Reversing the rapid decline of forest sinks and shifting the LULUCF sector from a net source back to a large net sink would require a range of measures, many of which would take time to have an impact and are likely to face strong opposition, both from political parties and the industry. Currently, the sink development in the LULUCF sector is the biggest obstacle for Finland to reach carbon neutrality by 2035.

21. Energiateollisuus [Finnish Energy]. (2022). *Energia-alan vähähiilisyystiekartta [Low-carbon roadmap for the energy sector].* [PowerPoint prensentation]. Retrieved from, https://energia.fi/files/6691/Energia-alan_vahahiilisyystiekartta_paivitetty_1_2022.pdf

# 7. Iceland

## 7.1. Climate neutrality target

Iceland aims to be climate neutral (is: "kolefnishlutlaust") by 2040. The target was codified in law in 2021[22] and submitted as the long-term low emissions strategy in 2021 to the UNFCCC[23]. In addition to reaching climate neutrality, Iceland aims to be independent of fossil fuels by 2040[24].

The Icelandic climate neutrality target is defined as when emissions are equal to, or less than, removals[25]. The target is therefore a "net-zero" target and applies to the GHGs covered by the Paris Agreement. All domestic sectors are included, but it is stipulated that the exact inclusion of the LULUCF sector and its contribution to climate neutrality must be elaborated further due to its unusually high share in total emissions, the need for improved data and the character of the emissions. Emissions from international aviation or international shipping are excluded. The aim as stated should be reached with domestic actions, as no official current plans/statements exist for mitigation abroad to contribute to national climate neutrality. This issue, however, is currently being reviewed.

The climate neutrality target has been set nationwide but has not been broken down by sector and as such does not contain specific interim targets. It is defined as the longer-term target for national climate action as described in the national climate action plan[26]. The climate action plan thus operates as the foundation for reaching climate neutrality. The plan, which is currently being updated, contains 50+ sector-focused, cross-cutting and enabling actions that focus on shorter-term mitigation obligations within sectors that are subject to international mitigation commitments[27] . The short-term focus of the climate action plan is not coordinated with the long-term target of climate neutrality. As climate action can take time to materialise in reduced

22. Government of Iceland. (2021, June 15). *Markmið um kolefnishlutleysi lögfest á Alþingi [Target for carbon neutrality enacted in Althingi].* Retrieved from, https://www.stjornarradid.is/efst-a-baugi/frettir/stok-frett/2021/06/15/Markmid-um-kolefnishlutleysi-logfest-a-Althingi/
23. Ministry for the Environment and Natural Resources. (2021, October), *On the path to climate neutrality: Iceland's long term low emissions development strategy*. Government of Iceland. Retrieved from, https://www.stjornarradid.is/library/02-Rit--skyrslur-og-skrar/Iceland_LTS_2021.pdf
24. Ministry of Industries and Innovation. (2020, September). *A Sustainable Energy Future, An Energy Policy to the year 2050.* Government of Iceland. Retrieved from, https://www.stjornarradid.is/library/01--Frettatengt---myndir-og-skrar/ANR/Orkustefna/201127%20Atvinnuvegaraduneytid%20Orkustefna%20A4%20EN%20V4.pdf
25. Government of Iceland. (2021, June 15). *Markmið um kolefnishlutleysi lögfest á Alþingi [Target for carbon neutrality enacted in Althingi].* Retrieved from, https://www.stjornarradid.is/efst-a-baugi/frettir/stok-frett/2021/06/15/Markmid-um-kolefnishlutleysi-logfest-a-Althingi/
26. Ministry of Environment and Natural Resources. (2020, June). *Aðgerðaáætlun í loftslagsmálum, 2. útgáfa [Climate Action Plan, 2nd Edition].* Retrieved from, https://www.stjornarradid.is/library/02-Rit--skyrslur-og-skrar/Adgerdaaetlun%20i%20loftslagsmalum%20onnur%20utgafa.pdf
27. Ministry of Environment and Natural Resources. (2020, June). *Aðgerðaáætlun í loftslagsmálum, 2. útgáfa [Climate Action Plan, 2nd Edition].* Retrieved from, https://www.stjornarradid.is/library/02-Rit--skyrslur-og-skrar/Adgerdaaetlun%20i%20loftslagsmalum%20onnur%20utgafa.pdf

emissions, this lack of coordination between interim and longer-term goals may lead to an internal imbalance in the action plan both in terms of timelines and comprehensiveness.

In an updated, nationally determined contribution under the Paris Agreement, Iceland committed, jointly with the EU and Norway, to enhance mitigation commitments to at least 55% net GHG emissions' reduction by 2030 compared to 1990. This increased ambition results in deeper short-term mitigation commitments in sectors subject to the EU's Effort Sharing Regulation where the Icelandic mitigation target is expected to increase from 29% to close to 40% by 2030 compared to 2005. In addition to EU commitments, Iceland has set its own independent mitigation target for sectors subject to the Effort Sharing Regulation of 55% reduction in emissions in 2030 compared to 2005[28]. Targets for LULUCF remain as described by the "no-debit rule" to 2025 but will change in 2026 in accordance with EU regulations to a country specific target to be reached in 2030. This target has yet to be determined for Iceland. Iceland assumes EU targets for sectors subject to the EU ETS system.

28. Government of Iceland (2021). *Agreement on the Platform for the Coalition Government of the Independence Party, the Left Green Movement and the Progressive Party*. Retrieved from, https://www.stjornarradid.is/library/05-Rikisstjorn/Agreement2021.pdf

## 7.2. Status of GHG emissions

Total emissions in Iceland, including LULUCF, have increased by 5.8% since 1990. Emissions from LULUCF account for 67% of total emissions and have remained somewhat stable since 1990. Forestry is slowly sequestering accumulating amounts of carbon but the significant emissions from the LULUCF sector remain a challenge. Figure 7 illustrates the fractional shares of each sector as defined in this report[29].

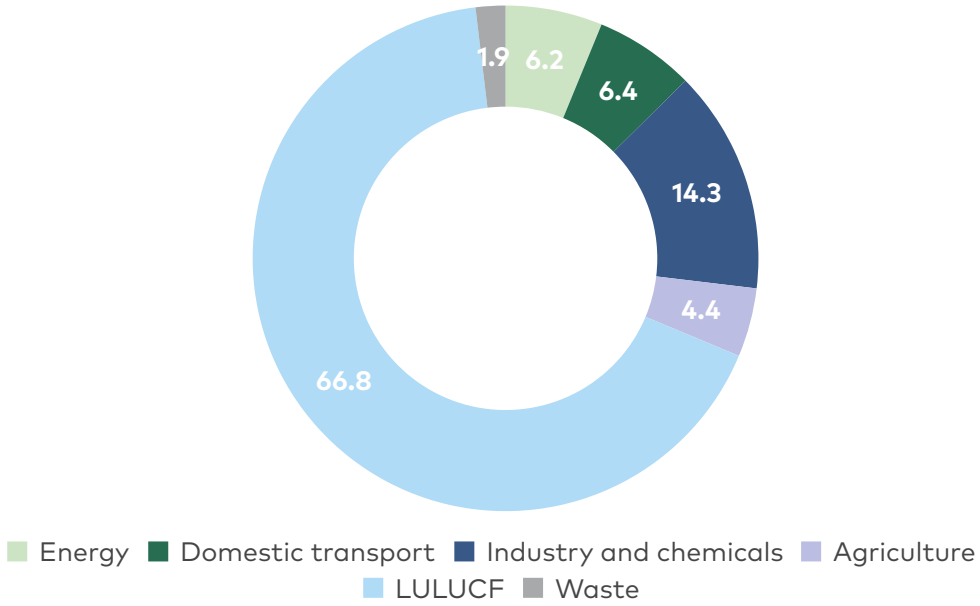



**Figure 7:** Emissions (by land use, land-use change and forestry – LULUCF, excluding international flights and international shipping)

*Source: Environment Agency of Iceland (2023). National Inventory Report.*
*https://ust.is/library/Skrar/loft/NIR/ISL_NIR%202023_15%20april_on_web.pdf*

29. Keller, N., Helgadóttir, Á.K., Einarsdóttir, S.R., Helgason, R., Ásgeirsson, B.U., Helgadóttir, D.,Helgadóttir, I.R., Barr, B. C., Thianthong C. J. Hilmarsson, K.M., Tinganelli, L., Snorrason, A., Brink, S.H. & Þórsson, J. (2023, April 14). National Inventory Report. Emissions of Greenhouse Gases in Iceland from 1990 to 2021. Environment Agency of Iceland. Retrieved from, https://ust.is/library/Skrar/loft/NIR/ISL_NIR%202023_15%20april_on_web.pdf

Total emissions excluding LULUCF have increased by 26.6% since 1990 (see Figure 8). Emissions peaked in 2008, but after the financial crash, emissions derived from transport and waste declined as private consumption contracted. As the economy bounced back, total emissions rose slowly again until the Covid pandemic. During the pandemic, transport-related emissions declined, albeit only temporarily. The most recent preliminary data from the Environmental Agency for 2022 shows that emissions are increasing in the transport sector due to the return of tourism after the pandemic. The emerging transition to electric light duty vehicles is expected to eventually work against increases in transport demand affecting transport-related emissions.

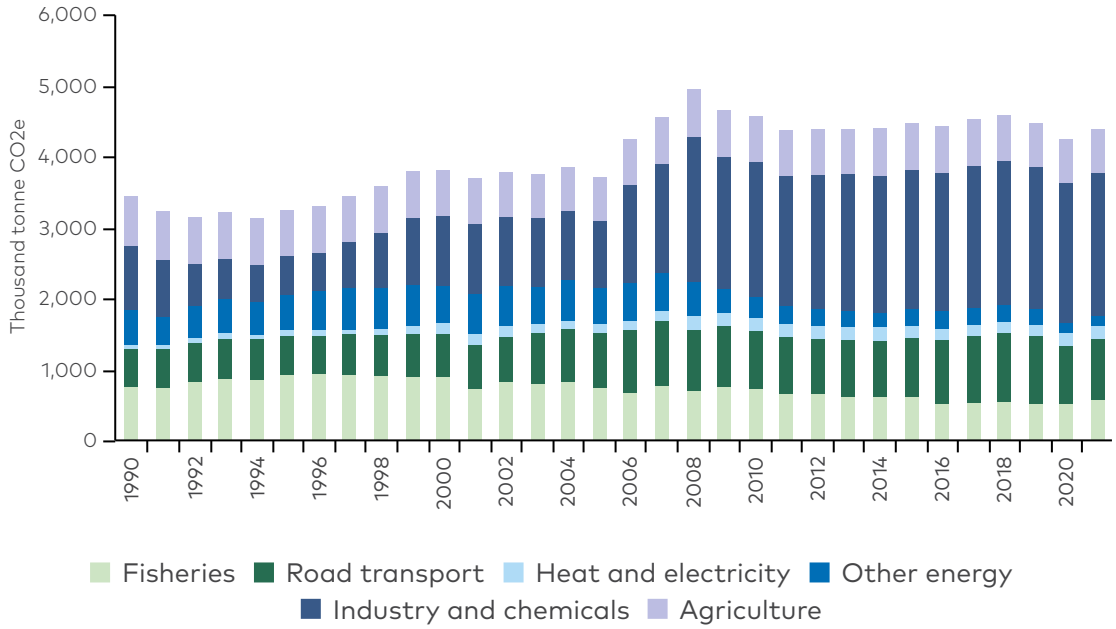



**Figure 8:** Emissions in 2021 by sector (kt CO2 eq), excluding LULUCF.

*Source: Environment Agency of Iceland (2023). National Inventory Report.*
*https://ust.is/library/Skrar/loft/NIR/ISL_NIR%202023_15%20april_on_web.pdf*

Figure 9 illustrates the somewhat unusual structure of total GHG emissions by sector (excluding LULUCF). The figure shows the large share of emissions derived from the industrial sector and processes (43%), and small share from heat and electricity (4%). Road transport is responsible for 19% of total emissions. Agriculture and fisheries are responsible for 13% and 12% of total emissions, respectively, and waste accounts for 6% of total emissions.

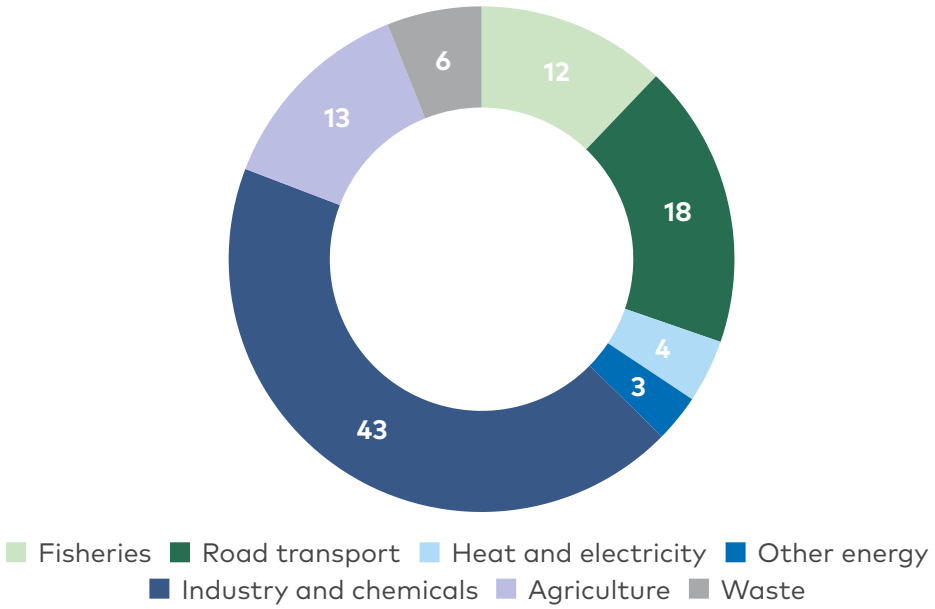



**Figure 9:** Emissions in 2021 by sectoral share (%), excluding LULUCF (source Environmental Agency 2023[30]

*Source: Environment Agency of Iceland (2023). National Inventory Report.*
*https://ust.is/library/Skrar/loft/NIR/ISL_NIR%202023_15%20april_on_web.pdf*

There is some evidence that synergies with other regulations, economic development and to a lesser extent mitigation actions, have affected GHG emissions. Emissions from fishing vessels declined 24.5% in 2021 compared to 1990, largely due to the impact of the Icelandic fisheries management system[31]. Emissions from agriculture have declined (10.7%) since 1990 due to a reduction in livestock (sheep). Emissions from waste have increased (10.2%) since 1990 but are showing signs of a decline as new regulations for handling organic waste are enacted and recycling efforts are increased. Domestic transport emissions have trended upwards (50% higher than in 1990), but it is expected that emissions from light duty vehicles will plateau soon, as increasing investment in battery-powered electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEV) (13.3% of total fleet; 56% of registered new vehicles in 2022) may counteract rising transport demand. It is, however, unclear how changes in the structure of subsidies for low-emitting vehicles will affect the transition. Emissions have trended upwards in industry and chemicals (increase of 122% since 1990) largely due to the expansion of the aluminum industry. The expansion in the aluminum industry has increased considerably faster than emissions, indicating significant

30. Keller, N., Helgadóttir, Á.K., Einarsdóttir, S.R., Helgason, R., Ásgeirsson, B.U., Helgadóttir, D.,Helgadóttir, I.R., Barr, B. C., Thianthong C. J. Hilmarsson, K.M., Tinganelli, L., Snorrason, A., Brink, S.H. & Þórsson, J. (2023, April 14). *National Inventory Report. Emissions of Greenhouse Gases in Iceland from 1990 to 2021.* Environment Agency of Iceland. Retrieved from, https://ust.is/library/Skrar/loft/NIR/ISL_NIR%202023_15%20april_on_web.pdf
31. Kristofersson, D., Gunnlaugsson, S. and Valtysson, H. (2021). Factors affecting greenhouse gas emissions in fisheries: evidence from Iceland's demersal fisheries. *ICES Journal of Marine Science*, 78(7), pp.2385–2394. doi:https://doi.org/10.1093/icesjms/fsab109.

improvements in process efficiency and thereby reduction in emissions per tonne in aluminum production.

Despite low emissions from heat and electricity production, as the energy industry already relied on renewable energy in 1990, increased use of geothermal resources for electricity production has increased emissions the industry.  Mitigation is already evident at geothermal power plants as a particular type of a CCS, the so-called carbon capture and mineralization (CCM) or the Carbfix process[32]. The Carbfix process captures $CO_2$, dissolves the captured $CO_2$ in water and injects it into underground basaltic rock formations, where a natural process literally turns it into stone. The entire process from capture to mineralization is achieved within approximately two years. The use of this method for the industrial sector is being explored and if successful, can materially contribute to reaching climate neutrality.

## 7.3. Assessment of timing and adequacy

The mitigation strategy as shown by the Climate action plan[33], is based on four main pillars: a transition away from the use of fossil fuels; improved management of inputs and waste, for example in agriculture; reduced waste and demand for transport; and improved land management and forestry. These pillars are then implemented through sector-based actions as well as some cross-cutting initiatives that range from regulatory to economic instruments, improved information and data collection, and educational initiatives to research.

Initial assessment of the action plan stipulated that the plan could result in mitigation in sectors subject to the Effort Sharing Regulation of 35% in 2030, compared to 2005, when accounting for already implemented measures with up to +11 percentage points in addition for measures to be implemented[34]. This is beyond current binding international commitments (29%), but lower than domestic pledges (55%) for effort sharing sectors.

32. Carbfix (n.d.). We turn CO2 into stone. Retrieved from, https://www.carbfix.com. [Accessed 02.06.2023]
33. Ministry of Environment and Natural Resources. (2020, June). *Aðgerðaáætlun í loftslagsmálum, 2. útgáfa [Climate Action Plan, 2nd Edition].* Retrieved from, https://www.stjornarradid.is/library/02-Rit--skyrslur-og-skrar/Adgerdaaetlun%20i%20loftslagsmalum%20onnur%20utgafa.pdf
34. Ministry of Environment and Natural Resources. (2020, June). *Aðgerðaáætlun í loftslagsmálum, 2. útgáfa [Climate Action Plan, 2nd Edition].* Retrieved from, https://www.stjornarradid.is/library/02-Rit--skyrslur-og-skrar/Adgerdaaetlun%20i%20loftslagsmalum%20onnur%20utgafa.pdf

The Environmental Agency[35] provides assessment of expected fulfilment of mitigation pledges given current mitigation measures. The assessment illustrates that both in the short term (2030) and long term (2040), Iceland is far from reaching its short term and long-term mitigation targets[36]. The report shows that if emissions from **LULUCF are included,** net emissions are expected to be 5% and 11% lower in 2030 and 2040, respectively, compared to emissions in 2021. If emissions from **LULUCF are not included**, total emissions are expected to be 8% and 24% lower in 2030 and 2040, respectively, compared to emissions in 2021. If only looking at expected mitigation in sectors that fall under the EU Effort Sharing Regulation, emissions are to be 16% and 37% lower in 2030 and 2040, respectively, compared to emissions in 2021.

It should be noted that the assessment by the Environmental Agency does not capture the impact of all climate actions, does not adequately capture the expected impact of economic instruments and excludes the expected impact of the EU ETS system. If all measures were to be assessed, including the impact of the EU ETS system, it is likely that expected emissions would be lower.

Overall, the assessment of the Environmental Agency, keeping in mind the aforementioned limitations, shows the Icelandic climate plan is neither adequate to reach set interim targets nor approach climate neutrality. Ample possibilities exist to enhance ambition, comprehensiveness and clarify pathways in all sectors in addition to coordinating long and short run targets. Recent common initiatives by business sectors and the government to define responsibility and identify mitigation opportunities (is: Loftslagsvegvísar atvinnulífsins) may be the beginning of such increased ambition which must materialise in reduced emissions[37].

35. Helgadóttir, Á.K., Einarsdóttir, S.R., Keller, N., Helgason, R., Ásgeirsson, B.U., Helgadóttir, I.R., Barr, B.C., Hilmarsson, K.M., Thianthong, J.C., Snorrason, A., Tinganelli, L. & Þórsson, J. (2023, March 15). *Report on Policies, Measures, and Projections. Projections of Greenhouse Gas Emissions in Iceland until 2050.* Environment Agency of Iceland. Retrieved from, https://ust.is/library/Skrar/loft/NIR/0_PaMsProjections_Report_2023_WITH%20BOOKMARKS.pdf
36. Helgadóttir, Á.K., Einarsdóttir, S.R., Keller, N., Helgason, R., Ásgeirsson, B.U., Helgadóttir, I.R., Barr, B.C., Hilmarsson, K.M., Thianthong, J.C., Snorrason, A., Tinganelli, L. & Þórsson, J. (2023, March 15). *Report on Policies, Measures, and Projections. Projections of Greenhouse Gas Emissions in Iceland until 2050.* Environment Agency of Iceland. Retrieved from, https://ust.is/library/Skrar/loft/NIR/0_PaMsProjections_Report_2023_WITH%20BOOKMARKS.pdf
37. Loftlagsvegvísar Atvinnulífsins (n.d.). *Atvinnulífið afhendir 332 tillögur*. Retrieved from, https://www.loftslagsvegvisar.is

# 8. Norway

## 8.1. Climate neutrality target

In 2008, the Norwegian Parliament passed a climate neutrality target for 2050 and declared that it should be moved forward to 2030, provided major mitigation commitments by other industrialized countries. The Parliament saw this condition as met by the time of Norway's ratification of the Paris Agreement in 2016 and asked the government to ensure emission reductions equivalent to the Norwegian emissions from 2030.

The assumption behind this decision was that emissions could be offset through international allowance trading and carbon credits.[38] The target is named 'climate neutrality', whereas the Norwegian target could be interpreted as a balancing of the country's gross anthropogenic GHG emissions by corresponding removals. The target is not necessarily implemented within its own borders. The interpretation and operationalisation of this ambition in the context of Norway's other climate policy commitments and ambitions have generated debate. The climate neutrality target is not part of the Norwegian Nationally Determined Contribution (NDC).

Norway has international commitments within two frameworks. First, in November 2022 Norway updated its NDC under the UNFCCC (the UN's Framework Convention on Climate Change) and the Paris Agreement. The emissions are to be reduced by at least 55% by 2030 as compared to 1990 levels. Second, Norway has a legally binding agreement of climate policy collaboration with the EU (and Iceland) from 2016 relating to the European legislation for implementing NDCs of at least 40% reduction. Norway seeks cooperation with the EU on implementing the respective NDCs of at least 55% reduction. However, EU legislation was only in place in 2023 and the process related to the EEA agreement has just begun (ultimo June). These elements are reflected in the Norwegian Climate Act (that came into force in 2017 and was updated in 2022) along with the long-term target for 2050. The goal is to become a low-emission society, defined as mitigating emissions by 90-95% from the 1990 level.

Cooperation with the EU on implementing the respective NDCs will likely imply that Norway adopts an adapted Fit-for-55 legislation, with commitments along three pillars. The first pillar is the European emissions trading system (EU ETS), which has an emissions cap for the involved sectors, including electricity, fossil fuel extraction and energy-intensive industry. The emissions cap corresponds to a 62% cut from the 2005 level. States fulfil their parts, as domestic companies facing the allowance price are

38. The decision by Stortinget reads: "Stortinget ber regjeringen legge til grunn at Norge skal sørge for klimareduksjoner tilsvarende norske utslipp fra og med 1. januar 2030, og at klimanøytralitet kan oppnås gjennom EUs kvotemarked, internasjonalt samarbeid om utslippsreduksjoner, kvotehandel og prosjektbasert samarbeid." This target does not give any direction to domestic emissions.

incentivised to abate emissions or trade ETS allowances. The second pillar is EU's Effort Sharing Regulation (ESR), which covers emissions that are not included in EU ETS, including agriculture and transportation. For ESR, the EU's Fit-for-55 goal is a 40% reduction from the 2005 level. Norway will likely be assigned a cap of 50% of the 2005 level for 2030, as well as caps for each of the years from 2021 to 2030. The third pillar relates to land use, where the EU has a net removal target of at least 310 million tonnes of $CO_2$ for the land use, land-use change and forestry sector (LULUCF). There will be flexibility in the fulfilment of all these targets, not only for the ETS-covered emissions, but also for ESR and LULUCF. Commitments can be fulfilled across borders, including some opportunities for trading within and across pillars across time.

## 8.2. Status of GHG emissions

The figure below shows Norway's GHG emissions and removals since 1990. Removals are dominated by carbon fixation by a growing forest. Figure 10 shows a minor emission reduction in recent years compared to 1990, whereas the forest sink is significantly larger than 1990 (although it was larger in the period 2000-2015 than currently).

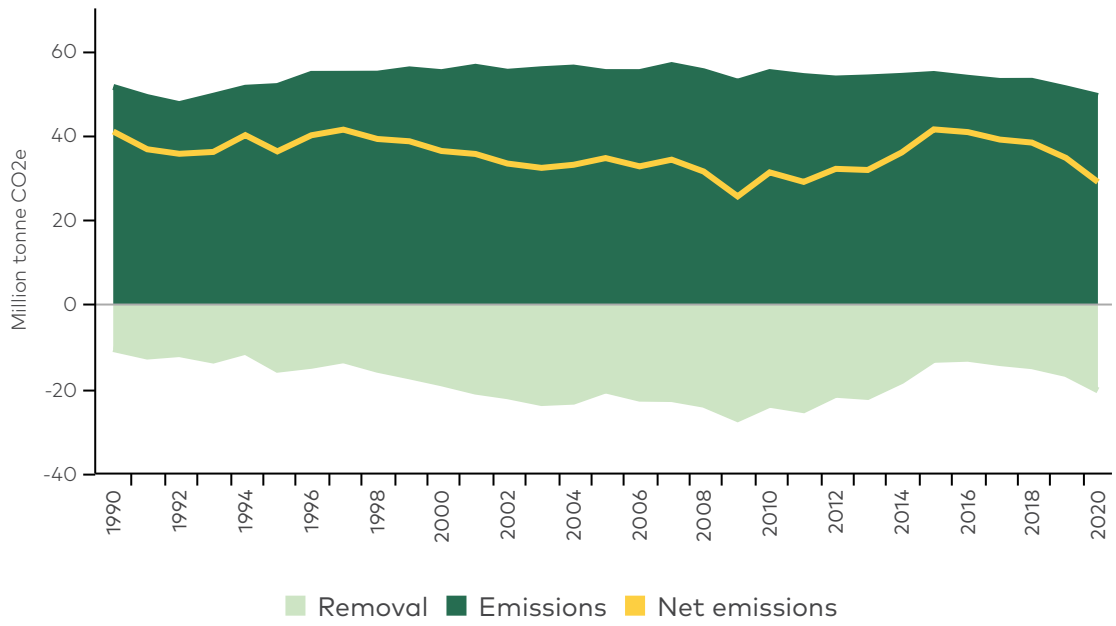



**Figure 10:** Emissions and removals of GHG in Norway, 1990-2020

*Source: Miljøstatus (2023a). Norske utslipp og opptak av klimagasser. Norwegian Environment Agency.*
*https://miljostatus.miljodirektoratet.no/tema/klima/norske-utslipp-av-klimagasser/*

Table 2 breaks down Norwegian GHG emissions since 1990 into sectors covered by EU ETS and sectors outside of EU ETS, adding projections until 2035. Transportation, buildings and other non-EU ETS emissions are slightly reduced from 1990 till 2021, whereas the decline in industry emissions has been balanced by higher energy related emissions - mainly from oil and gas production.

**Table 2:** GHG emissions by sector until 2021, divided into EU ETS sectors and non-EU ETS sectors, including projections until 2035.

| | 1990 | 2005 | 2021 | 2025 | 2030 | 2035 |
|---|---|---|---|---|---|---|
| **Emission of green-house gases** | 51.4 | 54.9 | 49.1 | 44.8 | 38.6 | 33.8 |
| ***Emission subject to quotas*** | 23.2 | 27.7 | 23.8 | 22.2 | 19.1 | 16.6 |
| Oil and gas pro-duction | 7.2 | 12.9 | 11.5 | 10.8 | 8.0 | 6.3 |
| Industry and mining | 15.3 | 13.7 | 10.7 | 10.2 | 9.8 | 9.1 |
| Other sources[(i)] | 0.7 | 1.1 | 1.5 | 1.2 | 1.2 | 1.2 |
| ***Emissions not subject to quotas*** | 28.3 | 27.2 | 25.4 | 22.6 | 19.5 | 17.2 |
| Aviation, shipping, and fishing | 4.6 | 5.5 | 6.7 | 6.1 | 5.6 | 5.0 |
| Road traffic | 7.4 | 9.5 | 8.7 | 7.1 | 5.3 | 3.9 |
| Agriculture | 4.8 | 4.6 | 4.6 | 4.6 | 4.7 | 4.7 |
| Other sources[(ii)] | 11.4 | 7.6 | 5.4 | 4.8 | 3.9 | 3.6 |

[(i)] Includes quota-obliged energy supply and aviation.

[(ii)] Includes non-quota-obligatory emissions from industry, petroleum operations and energy supply in addition to heating and other sources.

*Source: Norwegian Ministry of Climate and Environment (2022). Regjeringas klimastatus og -plan. (https://www.regjeringen.no/contentassets/fad4e2d774cf45ac8ad0e8cbb1ea093f/no/pdfs/kld_regjeringas_klimastatus_og_-plan.pdf*

Transportation and petroleum are large GHG emitting sectors in Norway, and where emission reductions are most challenging. Industry is the third largest emissions sector, but where a clear long-term decline of emissions is found. The net removal in the LULUCF sector was 20.3 million tonnes of $CO_2$ equivalents in 2020, whereas the average annual net sequestration from the LULUCF sector for the period 1990-2020 was 18.0 million tonnes of $CO_2$ equivalents per year.[39]

## 8.3. Assessment of timing and adequacy

Norway has adopted the same ambitious climate policy targets as the EU but cannot cut GHG emissions in its power sector, which is exclusively based on hydro power and some wind energy. Currently adopted policies and measures are substantially inadequate to meet these climate goals domestically as well as realising the goal to become a low emission society by 2050. Stronger or additional climate measures to meet the goals are especially needed for petroleum and agriculture to realise substantial domestic reductions. Some goals can be met through utilising flexibility in the cooperation with the EU (and through acquisition of carbon credits with the help of mechanisms in the Paris Agreement).

Figure 10 depicts Norway's GHG emissions since 1990 and expected emissions cuts until 2030 for transportation, buildings, waste and agriculture (which are the sectors that are not included in EU ETS). The main policy tool is carbon taxing, where the plan is to increase the tax to 2000 NOK/t $CO_2$ by 2030. In **addition**, there is a biofuel mixing requirement for passenger vehicles and aviation.

Climate policy tools and measures currently implemented in addition to the planned strengthening of the carbon tax are not sufficient to meet Norway's emissions reduction goal through domestic emission reductions alone. In Figure 11, the black dotted line shows projected emissions until 2030, the grey bars show a path for annual emissions aligned with the agreement with the EU for 2030 (40% reduction compared to 2005), the blue area illustrates the expected emission mitigation effect of the increasing carbon tax, the orange area illustrates the effect of biofuel mixing, and the shaded green area illustrates the expected emission reductions from policies and measures that are under development.

39. Norwegian Environment Agency (2022), *Greenhouse Gas Emissions 1990-2020 – National Inventory Report*, M-2268. https://www.miljodirektoratet.no/publikasjoner/2022/april/greenhouse-gas-emissions-1990--2020-national-inventory-report/

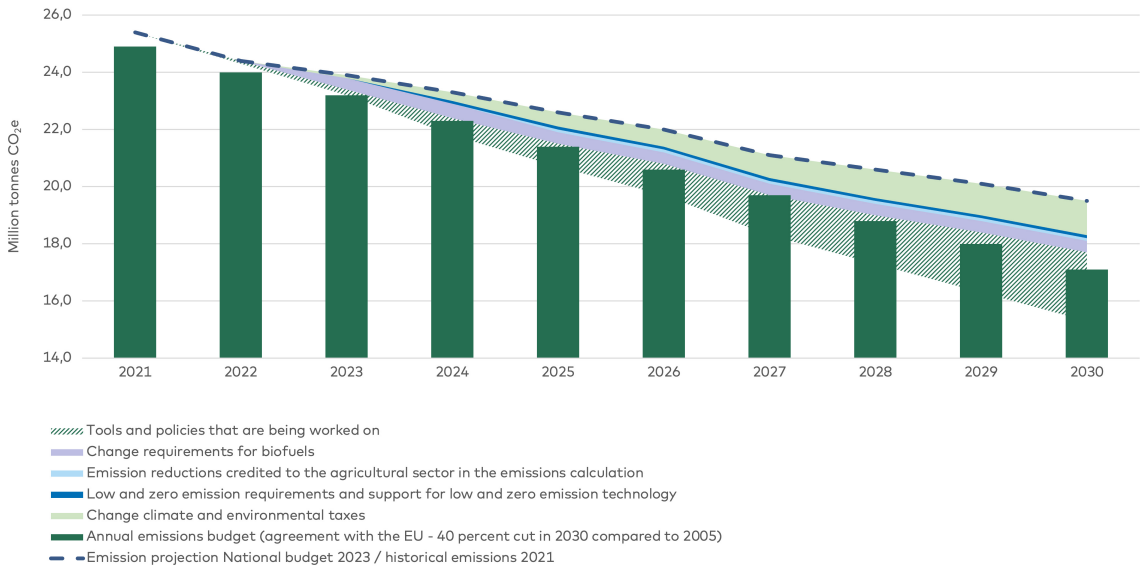



**Figure 11:** The contribution of various policy tools to GHG reductions for transport, buildings, waste and agriculture (non-EU ETS sectors)

*Source: Norwegian Ministry of Climate and Environment (2022). Regjeringas klimastatus og –plan. https://www.regjeringen.no/contentassets/fad4e2d774cf45ac8ad0e8cbb1ea093f/no/pdfs/kld_regjeringas_klimastatus_og_-plan.pdf*

The biggest challenges for reducing emissions in Norway include a petroleum sector that is difficult and expensive to align with the climate challenge. There are also land-use conflicts with local communities and nature values related to more hydro power, wind power and solar energy development, in addition to expensive and uncertain development of floating wind turbines, large investments required in energy-intensive industries, difficult and controversial measures in agriculture, and technical and economic limitations for removing all GHG emissions from transportation.

All types of energy efficiency improvements in production and demand, as well as increased user flexibility, will reduce the need for additional energy development, measures and technologies such as development of $CO_2$ capture and removal technologies (e.g. for waste-to-energy plants and some energy-intensive industries, such as cement and fertilizer production), electrification of transportation, and new process technologies in energy-intensive industries will, over time, contribute to GHG emission reductions.

# 9. Sweden

## 9.1. Climate neutrality target

In 2017, Sweden adopted a new climate policy framework and it consists of a climate act, climate targets and a climate policy council. The year after, a special planning and follow-up system for climate policy was introduced in Sweden through the Climate Act. That same year, other parts of the climate policy framework were also introduced, such as the milestone targets for how emissions of greenhouse gases should be reduced nationally by 2030 and 2040 and the target for net-zero emissions by 2045 at the latest, with net negative emissions thereafter.

The Climate Act requires that the government report its work towards reaching the climate goals to the Swedish parliament (Riksdag) every year. At the beginning of each parliamentary term, the newly appointed government must also produce a climate policy action plan that shows how the goals can be achieved. The second climate policy action plan will be presented by the Swedish Government during the fall of 2023.

The Swedish goal for zero net GHG emissions by 2045 means that Swedish territorial GHG emissions must be at least 85% lower by 2045 at the latest in comparison with 1990. So-called supplementary measures may be used for the remaining 15% of emissions.

Emissions of GHG in Sweden that are covered by the EU ETS are included in the long-term 2045 climate target. Emissions by sources and removals by sinks from land use, land-use change and forestry (LULUCF) are not included directly in the long-term climate target to 2045. However, certain increases in net removal within LULUCF that are additional to what would otherwise occur can be credited as a supplementary measure.

In order to reach the long-term target until 2045 (and the milestone targets for 2030 and 2040), "supplementary measures" may be credited in accordance with internationally decided rules. Such measures may be used to meet a maximum of 15 percentage points for the long-term goal until 2045. Supplementary measures are also needed to reach negative net emissions after 2045. As supplementary measures, the following three categories of measures may primarily be used:

- additional increased net removal of GHG in forests and land,
- capture and geological storage of carbon dioxide of biogenic origin, so-called BECCS or bio-CCS, and
- verified emission reductions through investments outside Sweden's borders (Article 6 ITMOs[40].

*Milestone targets to 2020, 2030 and 2040*

The milestone targets on the way to the long-term goal include emissions of GHG in the so-called non-trading sector (ESD until 2020, then ESR). Supplementary measures may be used towards the milestone targets at limited percentages. Figure 12 illustrates the historical emissions development in Sweden 1990–2021, the milestone targets in 2030 and 2040, the target for domestic transport to 2030, and the net-zero target for the year 2045. The area from 1990 to 2005 shows the sum of different sectors before the EU ETS was introduced in 2005.

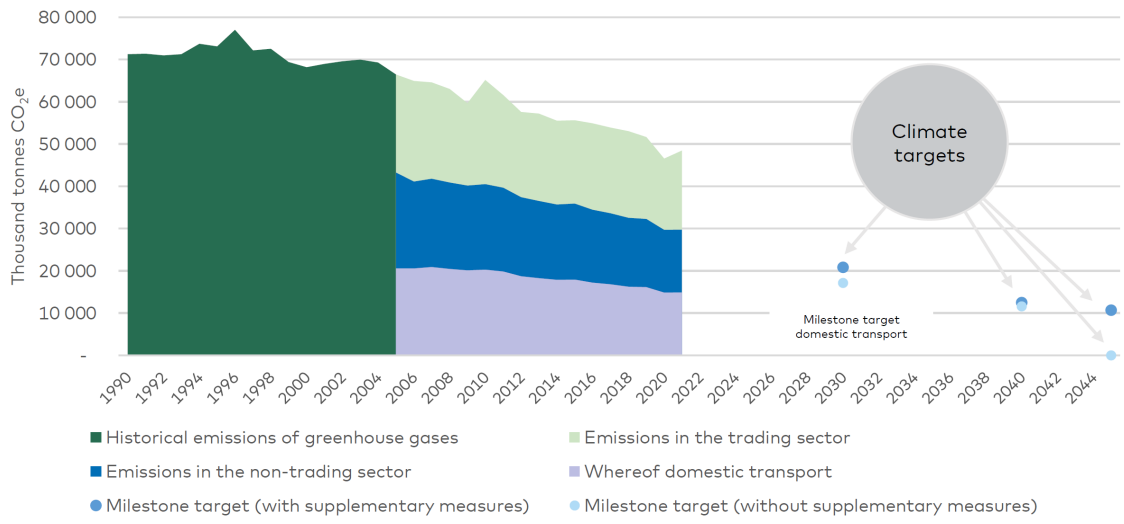



**Figure 12:** The historical emissions development in Sweden 1990–2021 and the four milestone targets in 2030 and 2040 for the non-trading sector, domestic transport to 2030 and the net-zero target for the year 2045.

*Source: Naturvårdsverket 2023. Underlag till regeringens kommande klimathandlingsplan och klimatredovisning*. NV-08102-22.

40. UNDP. (n.d.). *What is Article 6 of the Paris Agreement, and why is it important?* United Nations Development Programme. Retrieved from, https://www.undp.org/energy/blog/what-article-6-paris-agreement-and-why-it-important.

The milestone target for 2030 says that emissions in the so-called non-trading sector should be 63% lower than in 1990, of which 8 percentage points can be reached with the help of supplementary measures. Thus, emission reductions of at least 55% are required to reach the target. The 2030 milestone target also includes a sector-specific milestone that reads: emissions from domestic transport, apart from domestic flights, must be reduced by at least 70% by 2030 at the latest compared to 2010[41].

The milestone target for 2040 says that emissions in the so-called non-trading sector should be 75% lower than in 1990, of which 2 percentage points can be reached with the help of supplementary measures. Thus, emission reductions of at least 73% are required to reach the target.

## 9.2. Status of GHG emissions

Sweden's territorial GHG emissions were 48 million tonnes of $CO_2e$ in 2021. Compared to 1990, total GHG emissions decreased by 33%[42].

Emission reductions in Sweden have been realised in parallel with strong economic growth, with the exception of the global economic crisis in 2009, as well as a growing population. The most significant contribution to emission reductions since 1990 has been in the sector for heating homes and premises. The main reasons for the emission reductions are the expansion of the district heating networks and the subsequent transition from oil-fired heating boilers to both electric and district heating and also to heat pumps[43].

The industry's emissions have decreased since 2010 despite a strong economic development between 2011 and 2018. Remaining emissions consist of more than two-thirds of emissions that are linked to production processes. In order to reduce this type of process emissions, technological development, large investments in new process technology and an increased supply of electricity are required, among other things, for the production of hydrogen.

Within the electricity and district heating sector and the pulp and paper industry, GHG emissions have decreased, due to a rapid transition from burning coal and oil to waste and biofuels, the latter mainly in the form of residual products from the forest industry and logging residues.

41. Naturvårdsverket (n.d.). *Sweden's Climate Act and Climate Policy Framework*. Retrieved from, https://www.naturvardsverket.se/en/topics/climate-transition/sveriges-klimatarbete/swedens-climate-act-and-climate-policy-framework/
42. Swedish Environmental Protection Agency (2023, April 6). *National Inventory Report Sweden 2023*. Retrieved from, https://unfccc.int/documents/627663
43. Naturvårdsverket (2023). *Underlag till regeringens kommande klimathandlingsplan och klimatredovisning*. NV-08102-22. Retrieved from, https://www.naturvardsverket.se/499a4f/contentassets/4c414b0778e9409fb2836fc4d3dc6259/underlag-till-regeringens-kommande-klimathandlingsplan-och-klimatredovisning-2023-04-13.pdf

More efficient vehicles and an increased use of biofuels through the GHG reduction mandate have contributed to reduced emissions from road traffic in domestic transport.

Emissions from the waste sector have decreased steadily since 1990, mainly as a result of reduced landfilling of organic waste as a result of the landfill ban introduced in the early 2000s.

The total net removal in forests and land, the so-called carbon sink, was 42 million tonnes of $CO_2e$ in 2021. During the period 1990–2021, net removals have averaged just under 45 million tonnes of $CO_2e$ per year, but the interannual variation is large.

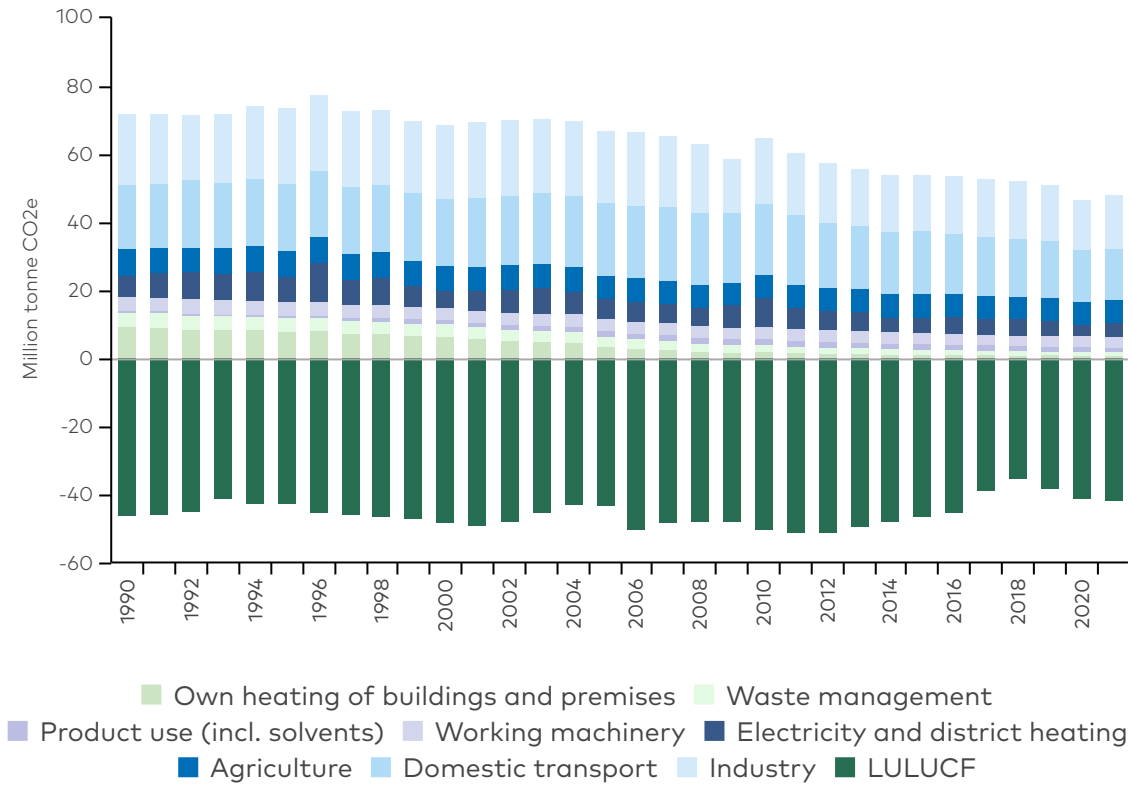



**Figure 13:** Swedish GHG emissions and removals by sector 1990 until 2021. The sectors in the figure are national sector categories, and not by CRF code.

*Source: Naturvårdsverket. (2023, June 15). Sveriges utsläpp och upptag av växthusgaser. https://www.naturvardsverket.se/data-och-statistik/klimat/sveriges-utslapp-och-upptag-av-vaxthusgaser/ [Accessed 31.08.2023]*

## 9.3. Assessment of timing and adequacy

The Swedish Environmental Protection Agency developed updated target scenarios in 2021 aiming to clarify how the national climate targets can be achieved and at what pace emission reductions can take place in different sectors. The scenarios showed that the conditions for achieving the interim goals in the Swedish climate framework had improved in several ways compared to the assessment as done in the previous target scenario five years earlier[44].

In the target scenarios, remaining emissions in 2045 mainly originate from the agricultural sector. The agricultural sector is assumed to reduce emissions per unit of output, but total emissions will not decrease much as it is assumed that there will be an increase in food production. Measures in the sector mainly concern changes in storage of manure and changes in fertilization methods. There are, moreover, relatively small process emissions from industry (CCS technology were assumed not to be able to completely remove emissions), methane and nitrous oxide emissions from combustion processes and from other handling of organic substances in various parts of society.

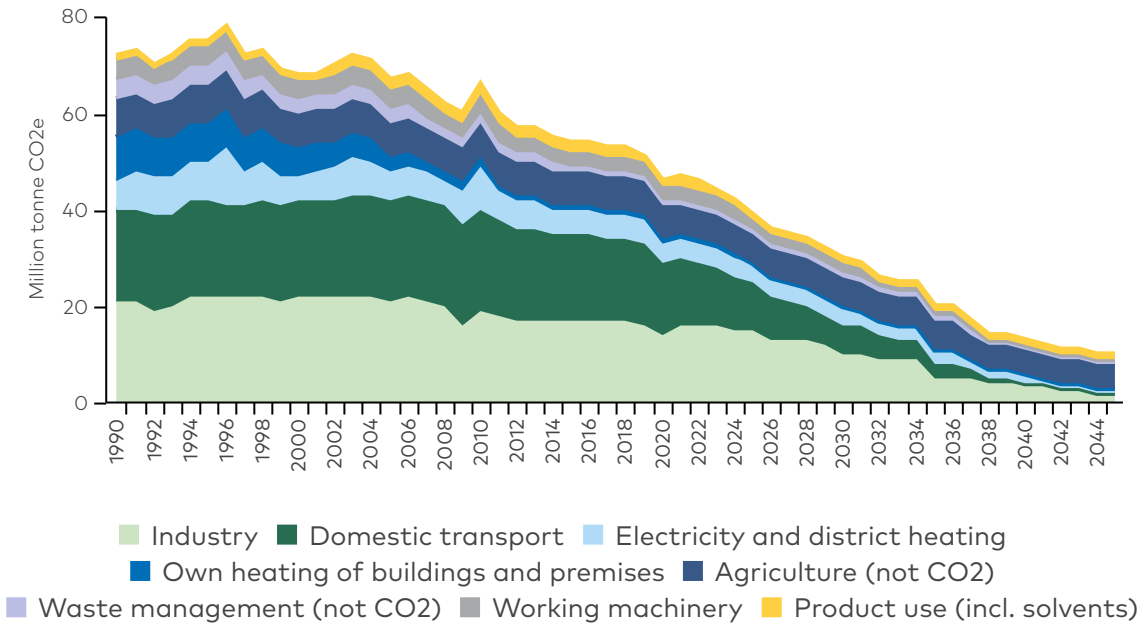



**Figure 14:** Target scenario for Sweden, 1990-2045. The sectors in the figure are national sector categories, and not by CRF code.

*Source: Naturvårdsverket (2022, January). Fördjupad analys av den svenska klimatomställningen 2021.* Rapport 7014.

44. Naturvårdsverket (2022, January). *Fördjupad analys av den svenska klimatomställningen 2021.* Rapport 7014. Retrieved from, https://www.naturvardsverket.se/publikationer/7000/fordjupad-analys-av-den-svenska-klimatomstallningen-2021/

In December 2023 the Swedish government will present a climate action plan which will describe how the climate goals are to be achieved, but it was not yet published at the time this report was finished.

According to the latest projection from the Swedish Environmental Protection Agency [45], which included decided and proposed policy measures nationally and in the EU until March 2023, the total emissions of GHG in Sweden in 2045 are projected to be around 70% lower compared to 1990. This means that the goal for 2045 will not be reached with current policy instruments. The implementation gap for achieving the goal in 2045 is about 20 million tonnes of $CO_2e$ if supplementary measures are not used, or around 10 million tonnes of $CO_2e$ if supplementary measures are fully used.

The implementation gap to 2045 has decreased compared to previous projections. One of the main explanations for this change is that several major technology shifts within industry are included. The timeframe for the arrival of these investments and the manner in which they are implemented depend on numerous uncertain factors and the projections assume that important basic conditions such as the supply of fossil-free electricity, expansion of the electricity grid, access to raw materials and other components, sufficient skills and effective permit processes, are in place.

Both an increased emissions reduction target with the EU ETS, as well as its inclusion of Carbon Border Adjustment Mechanism (CBAM), have impacted upon this assessment. In addition, climate financing options via EU or national funds have also increased. Investments in carbon-neutral technologies are, from the perspective of many companies in the industry sector, necessary to meet a growing demand for carbon-neutral products and to keep up with the ongoing transition. A high electrification rate in the transport sector and the EU-wide requirement that only 'zero-emission cars' be permitted in new light-vehicle sales by 2035 at the latest, also contributes to the result.

The emissions that remain in the projection until 2045 come in descending order from industry, agriculture, from the incineration of waste in the electricity and district heating sector and to some extent from construction equipment and transport.

For facilities with waste incineration in electricity and district heating production, CCS may be an alternative in the long run. Among the other remaining emissions in the projection, there are mainly emissions from the agricultural sector and partly also from construction equipment, for which there are no clear policy instruments under development at national or EU level.

45. Naturvårdsverket (2023). *Underlag till regeringens kommande klimathandlingsplan och klimatredovisning*. NV-08102-22. Retrieved from, https://www.naturvardsverket.se/499a4f/contentassets/4c414b0778e9409fb2836fc4d3dc6259/underlag-till-regeringens-kommande-klimathandlingsplan-och-klimatredovisning-2023-04-13.pdf

Despite the fact that the conditions for the climate transition have improved in several respects, it is uncertain whether current measures are sufficient to reach the milestone targets for 2030 and 2040.

Since these projections were elaborated, there have been several new proposals discussed that could make reaching the climate targets more difficult. The latest projection from the Swedish EPA indicated that the national milestone targets for 2030 will be difficult to reach with the government's announced weakening of the GHG reduction mandate for diesel and gasoline.

# 10. Pathways, challenges, and opportunities in the different sectors in the Nordic countries

The Nordic countries' total GHG emissions, including the LULUCF sector, have been reduced from 203 million tonnes of $CO_2e$ in 1990 to 150 million tonnes of $CO_2e$ in 2021, corresponding to a 26% reduction. This overall reduction can primarily be attributed to the emission reductions in the energy sector of 54 million tonnes of $CO_2e$ from 1990 to 2021.

However, emissions from industrial processes, domestic transport and agriculture have only fallen slightly in the period, while the LULUCF sector has seen an increase in net emissions by 21 million tonnes of $CO_2e$. Figure 15, below, provides an overview of the total Nordic sectoral emissions.

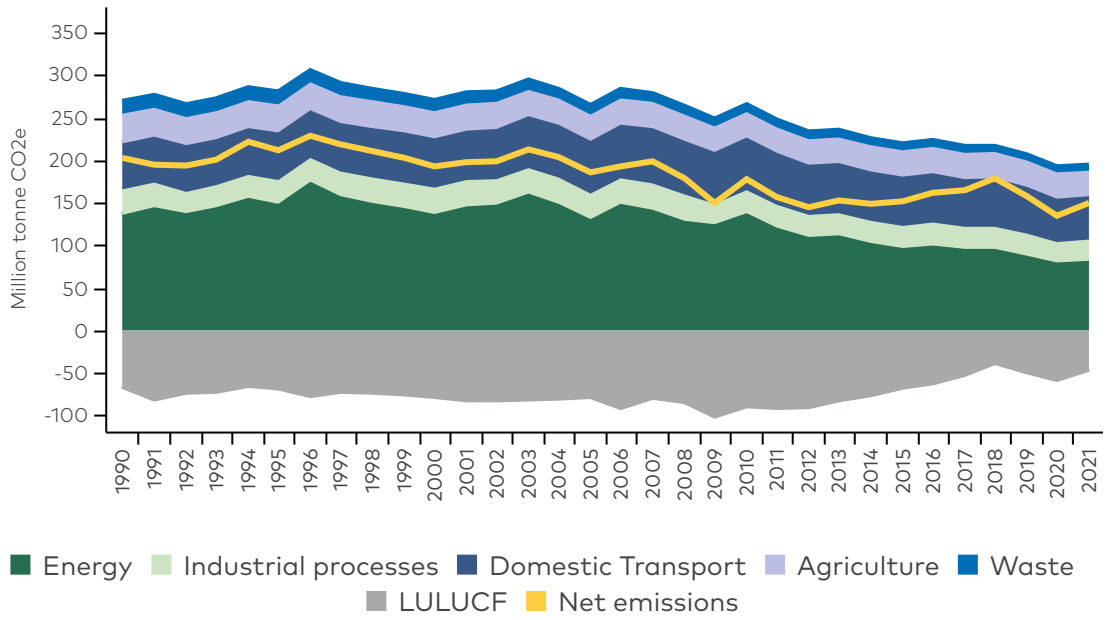



**Figure 15:** Territorial GHG emissions in the Nordic countries 1990-2021, split by sector.

*Source: UNFCCC. GHG data from UNFCCC.* https://unfccc.int/topics/mitigation/resources/registry-and-data/ghg-data-from-unfccc

In the following chapters, we will take an in-depth look at the GHG emissions in the different sectors in the Nordic countries, the planned pathways to climate neutrality and the challenges associated with these pathways. Finally, each chapter will conclude with a set of recommendations for opportunities for Nordic collaboration.

In this report, we are looking at five sectors (covering all domestic emissions). With the exception of domestic transport, the sectors follow the definitions in the IPCC Guidelines[46]:

- **Energy**[47]: the energy sector comprises exploration and exploitation of primary energy sources, including oil and gas production, conversion of primary energy sources into more useable energy forms in refineries and power plants, transmission and distribution of fuels, and use of fuels in stationary and mobile applications (with the exception of emissions related to domestic transport, see below). Emissions arise from these activities by combustion and as fugitive emissions or escape without combustion.
- **Domestic transport**[48]: this covers domestic emissions from fuels used for different modes of transportation. Thus, it does not include international shipping and international aviation.
- **Industrial processes**[49]: This covers GHG emissions occurring from industrial processes and from non-energy uses of fossil fuel carbon. The main emission sources are releases from industrial processes that chemically or physically transform materials, such as ammonia and other chemical products manufactured from fossil fuels used as chemical feedstock and the cement industry. Initiatives and pathways in this sector have strong ties to the energy sector. Note that all GHG emissions from energy use in "manufacturing industries and construction" (CRF 1A2) are reported under the energy sector according to the IPCC Guidelines.
- **Waste management**[50]: this covers fugitive emissions from landfill, wastewater treatment and similar. Note that all GHG emissions from waste-to-energy, where waste material is used directly as fuel or converted into a fuel, are reported under the energy sector according to the IPCC Guidelines.

46. IPCC (2019). *2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Buendia, E.C., Tanabe, K., Kranjc, A., Baasansuren, J., Fukuda, M., Ngarize, S., Osako, A., Pyrozhenko, Y., Shermanau, P. & Federici, S. (eds). Published: IPCC, Switzerland. Retrieved from, https://www.ipcc-nggip.iges.or.jp/public/2019rf/index.html
47. CRF 1 (except 1A3)
48. CRF 1A3
49. CRF 2
50. CRF 5

- **Agriculture, forestry and other land use**[51]: also denoted AFOLU, this sector refers to emissions/sinks from agriculture and changes in territorial land-use. This covers the "Agriculture" and "LULUCF" emissions/sinks in Figure 15 above. Emissions include, for example, nitrous oxide ($N_2O$) emissions from all managed soils, $CO_2$ emissions associated with liming and urea application to managed soils, and $CH_4$ emission from livestock (enteric fermentation).

For the sake of comparison across the Nordic countries, a large amount of the emissions data presented is from the country reporting to the UNFCCC (in the Common Reporting Format). The latest data submission provides data on national 2021 GHG emissions. The UNFCCC data is supplemented with national data and projections in the specific sectors and sections, if available and necessary.

51. RF 3 + CRF 4

# 11. Energy

## 11.1. Introduction and summary

As shown previously, 55% of total GHG emissions incl. LULUCF in the Nordic region take place in the energy sector. Omitting the LULUCF sector, the energy sector is responsible for 42% of territorial Nordic emissions.

Following the IPCC Guidelines, the emissions from the energy sector comprise exploration and exploitation of primary energy sources, conversion of primary energy sources into more useable energy forms in refineries and power plants, transmission and distribution of fuels, and use of fuels in stationary and mobile applications (except for emissions related to domestic transport as these are covered in a separate chapter). In other words, all emissions (except transport) stemming from fuel combustion activities and fugitive emissions from fuels are included here, irrespective of the sector in which they take place.

Denmark and especially Norway have a large production of oil and gas, which contributes with fugitive emissions in this sector (and from the energy use in extracting and processing).

From 1990 to 2021, the GHG emissions from the Nordic energy sector have been reduced by 54 million tonnes' $CO_2e$, corresponding to a 40% emission reduction in the sector across the Nordic countries. Denmark, Sweden and Finland have contributed in particular to this trend with emission reductions of 59%, 45% and 41%, respectively, from 1990 to 2021. In Iceland, emissions declined by 30%. Emissions from the energy sector have increased by 16% in Norway (and by 60% specifically for oil and gas production).

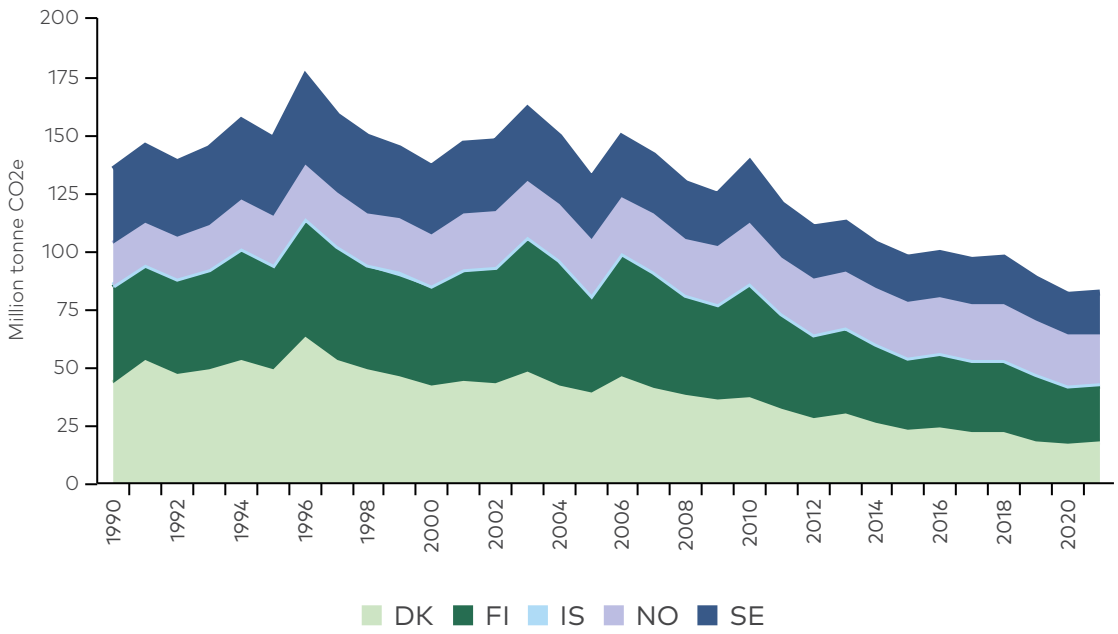



**Figure 16:** Net GHG emissions from the energy sector across the Nordic countries, 1990-2021

*Source: UNFCCC. GHG data from UNFCCC. https://unfccc.int/topics/mitigation/resources/registry-and-data/ghg-data-from-unfccc*

Across the Nordic countries, current development is focused on the expansion of green electricity, particularly with respect to bioenergy, wind and solar. In addition, improved energy efficiency, grid development and various solutions for energy storage will contribute to an energy system aligned with the transition to a climate neutral society. Favourable conditions, such as high potential for geothermal and hydro power in some of the Nordic countries, have also helped the transition towards a low-carbon energy sector. Despite the large reductions achieved since 1990 in the Nordic region, there are still substantial emissions from this sector that needs to be addressed in order to reach climate neutrality. Moreso because of the importance of this sector for the decarbonisation of other sectors, in particular transport and industry, that will require large amounts of green power to realise e.g. the electrification of those sectors.

The energy sector plays a large and important role in the different Nordic pathways to climate neutrality. The Nordic countries plan a large expansion of renewable power in order to decarbonise their power as well as other sectors and to provide renewable energy for mitigation initiatives in hard to abate sectors. Across the Nordic countries, there is also strong focus on testing out and scaling up technologies for negative emissions.

Table 3 and Table 4, below, give a brief overview of emissions and emissions development in the energy sector across the Nordic countries. Table 4 summarises the main country challenges described in the section later in this chapter.

**Table 3:** The energy sector across Nordic countries – a summary

| | Denmark | Finland | Iceland | Norway | Sweden |
|---|---|---|---|---|---|
| **Emissions, 1990** *Mt $CO_2e$* | 42.7 | 41.3 | 1.2 | 18.5 | 32.2 |
| **Emissions, 2010** *Mt $CO_2e$* | 37.1 | 47.5 | 1.1 | 25.6 | 26.2 |
| **Emissions, 2021** *Mt $CO_2e$* | 17.7 | 24.4 | 0.9 | 21.5 | 17.7 |
| **Development 1990-2021** | -58.7% | -41.1% | -29.9% | +16.2% | -45% |
| **Development 2010-2021** | -52.4% | -48.8% | -23.5% | -16.1% | -32% |

*Note: emissions from the energy sector comprise exploration and exploitation of primary energy sources, conversion of primary energy sources into more useable energy forms in refineries and power plants, transmission and distribution of fuels, and use of fuels in stationary and mobile applications (except for emissions related to domestic transport).*
*Source: UNFCCC. GHG data from UNFCCC. https://unfccc.int/topics/mitigation/resources/registry-and-data/ghg-data-from-unfccc*

**Table 4**: The energy sector across the Nordic countries – summary of main challenges

| Country | Summary of main challenge(s) |
|---|---|
| **Denmark** | • Maintaining energy security while increasing use of renewable energy and scaling down use of biomass and fossil fuels |
| **Finland** | • Addressing emissions from heating<br>• Bottlenecks with infrastructure and investments<br>• Addressing subsidies targeted towards fossil fuel use and gaps in energy taxes |
| **Iceland** | • Addressing expected large increase in demand for electricity<br>• Bottlenecks in transmission and distribution of electricity<br>• Technological limitations to reducing emissions from fishing vessels |
| **Norway** | • Addressing emissions from the petroleum sector |
| **Sweden** | • Creating the conditions for expanding fossil-free energy, mainly wind power (addressing lack of local support, investments in grid and delays from long review/permit processes) |

Despite their country differences, similar challenges to decarbonisation in the energy sector can be identified across the Nordic countries. These include, but are not limited to:

- accelerating renewable energy production – permit processes and local scepticism to development of renewables
- renewable power intermittency in, and balancing of, the energy system.

Being able to identify similar challenges across all or several of the Nordic countries emphasises the need for, and value of, cross-Nordic collaboration. In particular, we see Nordic added-value in collaboration on the following:

- knowledge-sharing on increasing acceptability – and reducing potential negative impacts on nature and local populations – for renewable energy installations
- cross-Nordic analysis/overview on future energy supply and demand, especially regarding balancing power capacity supplementing increasing renewable power
- knowledge-sharing on energy efficiency policies.

## 11.2. Status of the energy sector across the Nordic countries

In **Denmark**, emissions from the energy sector have decreased by 59% from 1990 to 2021. Today, biomass and wind energy are the dominant renewables in the Danish energy mix. The historical reduction of emissions in energy production is thus due to a shift from coal to biomass, primarily straw, wood chips and wood pellets, combined with increasing production of wind energy. The last coal-fired power plant is due to shut down in 2028 at the latest.

Consumption of electricity is expected to more than double from 36 TWh in 2022 to 80 TWh in 2030, due to, e.g., direct electrification, more electric vehicles (EVs), heat-pumps, datacenters and especially for green hydrogen (PtX)[52]. It is thus paramount to secure a speedy expansion of renewable energy from wind and solar to cover the increased demand from other sectors, while maintaining security of supply.

In **Finland**, emissions from the energy sector have decreased by 41% from 41.3 million tonnes $CO_2e$ in 1990 to 24.4 million tonnes in 2021. Since 2005, the emissions have been decreasing, on average, 3% per year. 2021 was an exception: the emissions grew 4% from the previous year which is explained by increased consumption of coal. The consumption increased because of colder weather conditions than the previous year and the market price of natural gas was high. The energy sector covers about 80% of Finnish emissions in the EU emissions trading sector. The emissions from individual heating of buildings have also been decreasing in recent years but there is fluctuation between different years depending on weather conditions and the associated need for heating. The reduction in emissions in individual heating of buildings is a result of improved energy efficiency in buildings and replacing oil heating. In 2020, the emissions were 2.1 million tonnes' $CO_2e$ of which 48% came from heating of residential buildings, 36% from buildings which are used by businesses and different services and 18% from agriculture. Compared to the emissions from 2005, the emissions from heating have decreased 55%.

The production of heat and electricity in **Iceland** is already largely decarbonised, accounting for 4% of total emissions if excluding LULUCF, with the only significant emissions coming from geothermal power plants. The transition in the Icelandic energy industry (heat and electricity) from fossil fuels to renewable energy was completed 4-5 decades ago[53], and thus before 1990. In 2021, close to 100% of all electricity in the country was produced with renewable resources (70.38% hydropower, 29.58% geothermal power, 0.03% wind). Despite very low emissions from energy production, the remaining emissions from geothermal power plants are expected to be mitigated. Carbon emissions from two geothermal power plants already are captured

52. Energistyrelsen (2023). *Analyseforudsætninger til Energinet*. Retrieved from, https://ens.dk/service/fremskrivninger-analyser-modeller/analyseforudsaetninger-til-energinet
53. Davíðsdóttir, B. (2022). 'Towards an Icelandic Sustainable Energy System Relying on Domestic Renewable Energy', in de La Porte, C., et al. (ed.) Successful Public Policy in the Nordic Countries. Oxford University Press. https://doi.org/10.1093/oso/9780192856296.003.0017

and mineralised using the Carbfix process, which relies on proven CCS technology, that is, carbon capture and mineralisation (CCM). Emissions from fishing vessels declined by 24% between 1990 and 2021, but remain the largest percentage share of emissions in the sector.

In **Norway**, GHG emission from the industry and energy sectors have levelled out since 2010. In the energy sector, GHG emissions from oil and gas production, representing 25% of national Norwegian emissions, increased by 48% from 1990 till 2022, but with some decline after 2015.[54] GHG emissions from petroleum production have increased by 48% since 1990, mostly before 2000. Thereafter the emissions stabilised, before declining after 2019[55]. The primary reason for reduced emissions is that land-based power through cables replaces gas turbines for some of the oil and gas production platforms in the North Sea. Today, 90% of power production is hydro-based, of which ¾ is flexible due to magazines and the remaining are turbines in rivers where the production cannot be regulated. A fast development of land-based wind power over the last decade has led to a 10% share of wind power at national level.

In **Sweden**, the GHG emissions from the energy sector decreased by 45% from 1990, from 32.2 million tonnes of $CO_2e$ in 1990 to 17.7 million tonnes in 2021.

Emissions from *electricity and district heating* production have decreased by 40% (to 4 million tonnes) since 1990. The low emissions are basically explained by the fact that hydropower and nuclear power account for a dominant part of the electricity production, while the cogeneration is bioenergy-based and the power capacity that has been added in recent years is mainly from wind power. The majority of the remaining emissions come from incineration of the plastic fraction in waste. These emissions have more than tripled since 1990. Around 80% of all plastic waste is incinerated today and less than 10 is recycled[56]. The capacity for energy extraction is high and the economy is favourable for waste incineration in Swedish facilities. Emissions from *combustion in manufacturing industries and construction* were 6 million tonnes of $CO_2e$ in 2021, 42% lower than in 1990. Extensive fuel switch has taken place, for example in the pulp and paper industry where electricity and biomass have displaced fuel oil. The refinery sector's emissions, on the other hand, have increased since 1990, which is due to increased production[57].

54. Miljøstatus (2023, June 19). *Olje- og gassutvinning står for en firedel av klimagassutslippene i Norge.* Miljødirektoratet. Retrieved from, https://miljostatus.miljodirektoratet.no/tema/klima/norske-utslipp-av-klimagasser/klimagassutslipp-fra-olje--og-gassutvinning/
55. Miljøstatus (2023). *Norske utslipp og opptak av klimagasser*. Norwegian Environment Agency. Retrieved from https://miljostatus.miljodirektoratet.no/tema/klima/norske-utslipp-av-klimagasser/ [Accessed 20.05.2023]
56. Naturvårdsverket (2022). *Kartläggning av plastflöden i Sverige 2020.* Rapport 7038. Retrieved from, https://www.naturvardsverket.se/publikationer/7000/978-91-620-7038-0/
57. Swedish Environmental Protection Agency (2023, April 6). *National Inventory Report Sweden 2023*. Retrieved from, https://unfccc.int/documents/627663

## 11.3. Pathways towards climate neutrality in the energy sector

Increased production of renewables from solar and wind is paramount to meet the **Danish** climate targets short and long-term. In recent years a number of political agreements have been made with the ambition to substantially increase electricity production from wind and solar in 2030 and onwards. Scaling up wind and solar will ensure there is enough supply of renewable electricity to meet the rising demand for electricity from electrification of transport, industry, new data centers and power-to-X (e.g. green hydrogen).

Production of offshore wind is expected to deliver the majority of green power in Denmark in the long term. The DEA expects offshore wind to grow from approximately 2 GW in 2021 to around 10GW in 2030[58]. In 2023, the Parliament agreed on the foundation for how to tender the already agreed expansion in offshore wind until 2030 [59]. With this agreement, the state will take a 20% ownership of the majority of the projects and ensure a concession from developers to ensure a revenue for the Danish state. Moreover, developers gain the opportunity to explore up to 14GW from the areas for offshore wind in 2030.

In the long term, the DEA expects offshore wind to grow to more than 35GW in 2050. The majority of the power will be exported in the long term and some will be used for PtX, such as hydrogen, which may also be exported to e.g. Germany.

Onshore wind is also expected to increase from about 5 GW in 2021 to 7 GW in 2030, before declining to 6 GW in 2050 as older onshore wind stops operating. Solar energy capacity is expected to increase from around 2 GW in 2021 to around 17GW in 2030, and steadily increase towards 35GW in 2050. Most of the solar capacity is expected to come from installation on land with a minor amount coming from rooftop installation.

Denmark sees CCS as an important pathway for climate change mitigation and has an ambition to make Denmark a hub for European $CO_2$ storage.

The Danish subsoil is well suited for storage both offshore and onshore. The Geological Survey of Denmark and Greenland (GEUS) estimate the total subsoil storage potential to be between 12-22Gt. In 2023, the DEA awarded the first three exploration licenses for $CO_2$ storage in the northern part of the North Sea to TotalEnergies and a consortium consisting of INEOS E&P and Wintershall DEA[60]. Several sites onshore

58. Energistyrelsen (2023, Januarary 5). *Analyseforudsætninger til Energinet 2022.* Retrieved from, https://ens.dk/sites/ens.dk/files/Hoeringer/af22_-_sammenfatningsnotat.pdf
59. Klima-, Energi-, og Forsyningsministeriet (2023, May 30). *Danmarkshistoriens største havvindsudbud er på plads.* Retrieved from, https://kefm.dk/aktuelt/nyheder/2023/maj/danmarkshistoriens-stoerste-havvindsudbud-er-paa-plads
60. Danish Energy Agency (2023, Febuary 6). *The Ministry of Climate, Energy and Utilities grants Denmark's first full-scale CO2 storage permits in the Danish North Sea.* Ministry of Climate, Energy and Utilities. Retrieved from, https://ens.dk/en/press/ministry-climate-energy-and-utilities-grants-denmarks-first-full-scale-co2-storage-permits [Accessed 20.05.2023]

and offshore could be developed before 2030, with new tenders for both off- and onshore exploration licenses under preparation as of the autumn of 2023.

Carbon capture and storage is expected to play a significant role in achieving the Danish 70% reduction target in 2030. Current expectations are that CCS will deliver 3.2 million tonnes of reductions in 2030[61]. The effect comes from a combination of the EU ETS price, a green tax reform and two additional national funding schemes[62].

The first tender for one of the funding schemes was won by energy company Orsted in the Spring of 2023. Orsted has committed to capture and permanently store 0.43 million tonnes biogenic $CO_2$ in 2026 and 20 years onwards as part of the contract with the state. Orsted's CCS project comprises capture of biogenic $CO_2$ from two of its biomass fired CHP, one using straw and the other one wood chips. The captured $CO2_2$ will be transported to Norway by ship and stored in the Northern Lights storage reservoirs in the North Sea[63]. The $CO_2$ will be counted as negative emissions as it comes from biomass, which is defined as $CO_2$-neutral energy according to UN accounting.

The DEA assesses the Danish technical potential for CCS in 2040 to be between 5.4 and 10.8 million tonnes[64] from industry, biomass CHP, waste incineration and biogas upgrading plants. The bulk of this technical potential (3.5-6 million tonnes) is biogenic $CO_2$.

The **Finnish** pathway to climate neutrality is detailed in the Low-carbon roadmap by Finnish Energy[65] (updated in 2021) which anticipates the demand for electricity, heating and gas. The roadmap identifies a few policies that are needed to achieve carbon neutrality: the emission trading system should be developed and broadened further, and an energy tax roadmap should be developed to remove taxes that make it harder to cut emissions. Finnish Energy also calls for investment in RDI supporting carbon neutrality.

Producing energy with coal has been banned by law starting in 2029. In 2020 the government published an investment aid program of 90 million euros to support energy projects to replace the use of coal. In 2020 and 2021, seven projects received a total of 30 million euros from the program. The 60 million that was unused will be transferred to other energy projects, e.g. solar power, energy efficiency and biogas

61. Energistyrelsen (2023, April). *Klimastatus og -fremskrivning 2023.* Retrieved from, https://ens.dk/sites/ens.dk/files/Basisfremskrivning/kf23_hovedrapport.pdf#page=16
62. Sørensen, T.J. & Capion, K. (2023, March). *The potential for Carbon Capture and Storage in Denmark.* CONCITO. Retrieved from, https://concito.dk/files/media/document/The%20potential%20for%20Carbon%20Capture%20and%20Storage%20in%20Denmark.pdf#page=7
63. Ørsted (2023, May 15). *Ørsted awarded contract – will capture and store 430,000 tonnes of biogenic CO2.* Retrieved from, https://orsted.com/en/media/newsroom/news/2023/05/20230515676011
64. Energistyrelsen (2023, February 7). *Punktkilder til CO2 – potentialer for CCS og CCU*
65. Energiateollisuus [Finnish Energy]. (2022). *Energia-alan vähähiilisyystiekartta [Low-carbon roadmap for the energy sector].* [PowerPoint prensentation]. Retrieved from, https://energia.fi/files/6691/Energia-alan_vahahiilisyystiekartta_paivitetty_1_2022.pdf

production. In addition, energy aid provides support for piloting and deploying other clean energy projects. In 2021, aid was granted for 900 projects, 157 million euros in total.

To fulfil energy efficiency objectives, Finland uses voluntary contracts to steer different sectors and communities to improve their efficiency. Over 600 businesses and their 7,000 places of business and almost 120 municipalities have participated in the efficiency contracts. It is estimated that the annual emission reduction from these contracts has been 7.7 million tonnes of $CO_2$. If the contract period (2017-2025) continues as intended, the annual emission reduction will be 9.5 million tonnes of $CO_2$ by 2030[66].

Oil heating is responsible for the majority of heating emissions in the individual heating of buildings. To further reduce the emissions, the use of fossil oil in heating will gradually end by 2030 according to the programme of the previous government. There is a separate programme for actions to encourage the transition to alternative heating sources. The government has also made an energy efficiency agreement (2017–2025) for distribution of heating fuels with the oil industry to improve energy efficiency of buildings heated by oil and to increase the use of renewable heating oil.

It is estimated that the emissions from heating will further decrease as a result of the regeneration of building stock, repair construction and changes in heating systems. Also, the blending obligation of biofuels and replacing fossil oil with other heating options (most notably heat pumps) will result in major reductions in emissions.[67]

The development of energy industry emissions is influenced by the decreasing use of fossil fuels, the demand for electricity by industry and the energy use for heating which depends heavily on winter temperatures. The decrease of emissions from the emission trading sector happens primarily through the price signal created by the emissions trading system.[68]

The overall strategy emerging in the **Icelandic** climate action plan is for the heat and electricity industry to become climate neutral by relying on the Carbfix process (CCM) in the case of geothermal power plants or applying carbon capture and use where applicable[69]. The action plan includes initiatives set by the industry itself, as the two largest energy companies have pledged to become climate neutral by 2030[70] at the latest.  The government has, through legal development, enabled mineralised storage

66. Ympäristöministeriö Helsinki [Ministry of the Environment] (2022). *Ilmastovuosikertomus 2022 [Annual Climate Report 2022].* Retrieved from, https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/164392/YM_2022_24.pdf?sequence=1&isAllowed=y
67. Ympäristöministeriö Helsinki [Ministry of the Environment] (2022). *Ilmastovuosikertomus 2022 [Annual Climate Report 2022].* Retrieved from, https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/164392/YM_2022_24.pdf?sequence=1&isAllowed=y
68. Ympäristöministeriö Helsinki [Ministry of the Environment] (2022). *Ilmastovuosikertomus 2022 [Annual Climate Report 2022].* Retrieved from, https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/164392/YM_2022_24.pdf?sequence=1&isAllowed=y
69. Ministry for the Environment and Natural resources (2020, October). *Iceland's 2020 Climate Action Plan.* Government of Iceland. Retrieved from, https://www.government.is/library/01-Ministries/Ministry-for-The-Environment/201004%20Umhverfisraduneytid%20Adgerdaaaetlun%20EN%20V2.pdf
70. National Energy Company (Landsvirkjun) by 2025; Reykjavik Energy (Orkuveita Reykjavíkur) by 2030.

using the Carbfix process. Furthermore, Reykjavik Energy and international research funds, e.g. the EU innovation fund[71], have enabled launching the Carbfix process to industrial scale operations at the Coda terminal[72].

The overall strategy in mitigation from the fishing industry is to facilitate an energy transition in the industry to renewable energy and continue improving fuel efficiency through collaborative efforts between the industry and the authorities. Neither the climate action plan nor the analysis by the Environmental Agency[73] contain details as to the specific actions to be taken in the industry.

The electricity industry is instrumental in enabling climate neutrality in the transport and fishing industry, the two remaining sectors in Iceland that rely on fossil fuels. The sector is expected to generate the electricity required for electrification of the vehicle fleet and the production of e-fuels or synthetic fuels such as methanol. It will also provide electricity and heat/hot water to harbours for vessels while docked. As the exact shape of the energy transition in transport and fisheries is uncertain, not the least due to emerging technological development and thereby the amount of electricity required, the government launched an effort to evaluate the amount of electricity required for a full transition, given current technologies and including international shipping and aviation[74].

In **Norway,** total energy consumption (2022) is at 284 TWh, of which 52% is renewable energy.[75] Renewables provide close to 100% of the total electricity use, where 90% is hydropower and 10% is wind power. The largest energy users are industry (76 TWh), petroleum (63 TWh), transportation (56 TWh) and households (45 TWh). Due to expected increases in future electricity demand, further expansion of renewables plays a big role in the Norwegian pathway to climate neutrality.

The remaining large waterways in Norway are protected, so further hydropower development is only possible from small hydropower plants, but the scale of this production means little at national level. Existing hydropower plants, however, can be modernised and upgraded to increase Norway's average annual power production at about 150 TWh by 5 15%. Wind energy currently generates around 10% of Norway's power production. During the last three years, after the release of a national framework for wind power in Norway, there has been a moratorium on land-based wind power due to strong criticism from many municipalities since they experienced significant negative impacts, whereas most of the benefits were transferred to power

71. Carbfix (2022, July 12). *Carbfix's Coda Terminal awarded large EU grant*. Retrieved from, https://www.carbfix.com/awarded-large-eu-grant [Accessed 10.05.2023]
72. Carbfix (n.d.). *Coda terminal*. Retrieved from, https://www.carbfix.com/codaterminal [Accessed 10.05.2023]
73. Helgadóttir, Á.K., Einarsdóttir, S.R., Keller, N., Helgason, R., Ásgeirsson, B.U., Helgadóttir, I.R., Barr, B.C., Hilmarsson, K.M., Thianthong, J.C., Snorrason, A., Tinganelli, L. & Þórsson, J. (2023, March 15). *Report on Policies, Measures, and Projections. Projections of Greenhouse Gas Emissions in Iceland until 2050.* Environment Agency of Iceland. Retrieved from, https://ust.is/library/Skrar/loft/NIR/0_PaMsProjections_Report_2023_WITH%20BOOKMARKS.pdf
74. Ministry of the Environment, Energy and Climate (2022, March). *Staða og áskoranir í orkumálum [Status and challenges in energy issues]*. Government of Iceland. Retrieved from, https://www.stjornarradid.is/library/02-Rit--skyrslur-og-skrar/Stöðuskýrsla%20áskoranir%20%C3%AD%20orkumálum%2008032022.pdf
75. Til Null, Norsk Klimastiftelse (2023), Hvor mye av energibruken er fornybar? https://www.tilnull.no/energibruk.

companies and investors at national level or abroad. Over the last two years, the challenges of land-based wind power development have led to politicians and business giving increased attention to ocean-based wind power. The government now has ambitious plans to develop large wind power projects in the southern and western parts of the North Sea. Due to ocean depth this is predominately floating wind turbines, which is less mature technology. This implies a high cost and likely need for significant government subsidies, such that the power won't be available until after 2030.

Due to the higher and more variable power price after the investments in high-capacity power interconnectors to Germany and the UK, there is more focus on upgrading the hydropower system to produce more and with a higher power capacity, as this will be more in demand. Upgrading of the power grid will also be prioritised.

Finally, there is more attention to testing out and scaling up technologies for negative emissions. The most interesting option for BECCS in Norway is the waste-to-energy plants, where about 50% of the waste can be expected to be biogenic. Given a sufficiently effective collection and incineration of biogenic waste coupled to CCS, $CO_2$ removal can be generated. The challenge is the large investment and operation costs compared to the value of reduced $CO_2$ emissions. One example is the Hafslund Oslo Celsio plant, where a public-private agreement with substantial government cost coverage has been established. This project is part of the 'Langskip' CCS project. The future of the project is uncertain due to a strong cost increase, however, and the project has been put on hold for a year in an effort to try to reduce the cost.

In **Sweden**, increased production of electricity will play a central role going forward, both as an enabler and as a potential obstacle[76]. Access to fossil-free electricity at affordable prices enables the electrification of industry and the transport sector, while at the same time providing a competitive advantage for companies. The demand for electricity has been projected to reach up to 280 TWh (double today's demand) by 2035 and projections for 2045 span from 210-370 TWh[77].

Emissions from the Energy sector are largely included in the EU ETS (for example, more than 95% of emissions from production of electricity and district heating) and are thus affected by the higher prices of emissions allowances that have now arisen in the system. The agreed further tightening of the ETS will further strengthen the incentives to mitigate emissions.

The use of fossil fuels in industry in the non-trading sector is subject to carbon dioxide and energy taxes. Emissions have decreased faster in this part of industry over the

76. Naturvårdsverket (2023). *Underlag till regeringens kommande klimathandlingsplan och klimatredovisning*. NV-08102-22. Retrieved from, https://www.naturvardsverket.se/499a4f/contentassets/4c414b0778e9409fb2836fc4d3dc6259/underlag-till-regeringens-kommande-klimathandlingsplan-och-klimatredovisning-2023-04-13.pdf
77. Energimyndigheten (2023). *Myndighetsgemensam uppföljning av samhällets elektrifiering – Rapportering 2022.* ER 2023:2. https://energimyndigheten.a-w2m.se/ResourceComment.mvc?resourceId=212470

past decade compared to industry in the trading sector. The reduction coincides with the phasing out of exemptions to the carbon dioxide tax during 2011–2018 for these operations. Since 2015, investment grants for conversion and energy efficiency have also been available within the framework of the Climate Leap initiative (Klimatklivet).

As noted above, emissions from refineries have increased from 1990 levels. Looking at the refinery sector from a systems perspective, however, it is primarily the change of raw material from fossil to biogenic that can contribute to reducing the climate impact along its entire value chain, since the largest emissions are caused when the products (e.g. petrol and diesel) are used and not from the refinery itself[78].

A national waste incineration tax was introduced on waste incineration facilities on 1 April 2020, but this tax has been removed from 1 January 2023. Interest in using various measures to reduce the incineration of fossil waste and increase the sorting of plastics has increased in recent years.

With respect to new electricity production based on renewables, the relatively rapid expansion of wind power in recent years is largely due to sharply falling costs for wind power. The electricity certificate system, which initially drove the introduction, is now being gradually phased out.

The district heating sector has a significant potential for bioenergy with CCS (BECCS). The Swedish Energy Agency has been assigned to develop the support scheme for BECCS and is currently developing the design of a programme based on reverse auctions. 36 billion SEK have been allocated to the programme for the years 2026-2046. It has been communicated that 1 to 3 reverse auctions are to be held between 2023 and 2026. Supported projects will receive results-based payments per verified tonne of biogenic $CO_2$ captured and stored for up to 15 years[79]. Also, large point sources of biogenic $CO_2$ from pulp and paper production will be eligible for support from the scheme.

According to the latest projection scenario for 2045 from the Swedish Environmental Protection Agency (2023), emissions from electricity and district heating production, for example, are reduced to a slightly lower level in 2045 compared to 2020. Remaining emissions in 2045 are from waste to energy. There is potential to address those emissions with CCS provided that transportation and storage infrastructure are developed. The Swedish government established a national center for CCS, to enhance Swedish readiness for the introduction of CCS. This includes the possibility of combining CCS with waste incineration. Also, emissions from combustion in industry in the trading sector, as well as emissions from industry in the non-trading sector, continue decreasing until 2045.

78. Johnsson, F., Zetterberg, L., Möllersten, K. (2023). *Mot nettonollutsläpp – hur kan BECCS och CCS bidra?* Studieförbundet näringsliv och samhälle.
79. Energimyndigheten (2023, September 1). *Statligt stöd för bio-CCS.* Retireved from, https://www.energimyndigheten.se/klimat--miljo/ccs/statligt-stod-for-bio-ccs/

However, there is further potential for emission reductions that can be tapped in the latter category.

At the time of drafting this report, the Swedish government was preparing a climate action plan to be delivered in the autumn of 2023. The plan will present the government's pathway to reaching the Swedish climate goals.

## 11.4. Challenges in the energy sector on the way towards climate neutrality and opportunities for Nordic collaboration

Despite the impressive number of current and planned efforts across the Nordic countries, there are still challenges that need to be addressed. Some of these are unique to the different countries, but most of them are the same across the Nordic region. Thus, there are ample opportunities for cross-Nordic collaboration and sharing of experiences.

First, this section provides a brief overview on some of the main challenges in the Nordic countries, before going more in-depth with selected cross-Nordic challenges with high potential for Nordic collaboration and knowledge-sharing.

In **Denmark**, biomass has played an important role on phasing out fossil fuels in the energy sector, but today relies heavily on woody biomass and imported wood chips and wood pellets. Sustainable biomass is a limited resource and high consumption can have negative impacts on the climate among other things. This is why the Climate Council recommends a national strategy to decrease the Danish consumption of biomass to a sustainable level[80]. One of the main challenges when scaling up renewables and phasing down use of biomass and fossil fuels is maintaining energy security of electricity supply and heating for the major district heating networks in the largest cities. The Danish Climate Council has analyzed future scenarios with an energy system dominated by wind and solar.[81] The Council concludes that it is possible to maintain a high security of supply when the electricity system is dominated by solar and wind. However, Denmark will become increasingly dependent on imported electricity from neighbouring countries and will need to secure back-up from e.g. gas or hydrogen.

For heavy industry, most likely cement production, CCS will be needed to reach climate-neutrality if Denmark is to produce cement in the future.

The parliament has agreed on an implementation strategy for CCS that aims to secure 3.2 million tonnes in 2029 at the

80. Møllgaard, P., Jacobsen, J.B., Kristensen, N.B., Elmeskov, J., Halkier, B., Heiselberg, P., Knudsen, M.T., Morthorst, P.E. & Richardson, K. (2023, February). *Statusrapport 2023*. Klimarådet. Retrieved from, https://klimaraadet.dk/sites/default/files/node/field_file/Klimaraadet_statusrapport23_digi_01.pdf#page=190
81. Klimarådet (2023, May). *Sikker elforsyning med sol og vind*. Retrieved from, https://klimaraadet.dk/sites/default/files/node/field_files/Analyse%20-%20sikker%20elforsyning%20med%20sol%20og%20vind.pdf

latest[82]. Longer term, due to expected residual emissions particularly in agriculture, forestry and land-use, CDR is important for reaching the Danish climate neutrality target.

According to the **Finnish** Climate Change Panel[83], one of the main challenges of the energy sector in Finland is the emissions from heating. Finland needs almost double the amount of low-emission energy for heating by the year 2050 (compared to 2021). The solutions to this challenge are heating technologies that are not based on burning fuels, such as industrial heat pumps, waste heat recovery, geothermal heat, medium deep thermal wells, heat as a by-product from hydrogen production and, possibly, small modular nuclear reactors. Concerning energy production, the production of fossil-free electricity is expected to increase in market terms. However, there will probably be bottlenecks with infrastructure and investment which will need to be resolved quickly as the demand for clean electricity grows. There are also challenges with environmentally harmful subsidies targeted towards fossil fuel use and gaps in energy taxes. For example, the Finnish Climate Change Panel strongly advises that the tax deduction of peat in energy production should be removed. The Panel also recommends speeding up licensing of wind and solar power in accordance with EU's directives and exploring possibilities to increase wind power production in eastern Finland without compromising national security (i.e. military radars).

In **Iceland**, the main challenges in the energy sector relate to: i) technical challenges in transitioning fishing vessels away from the use of fossil fuels and ii) bottlenecks in transmission and distribution and how to meet the expected increase in demand for electricity, partially due to its contribution to mitigation in other sectors that rely on fossil fuels. Various scenarios have been developed to realize required increases in electricity production, ranging from no expected increase to an increase of 125%[84]. The difference between these scenarios is largely rooted in the expected increase in energy efficiency, the development of the economy towards less energy intensive sectors and the extent by which all demand of e-fuels is fulfilled by domestic production. What they all have in common though is that they have not been assessed in the context of system-level impacts such as the impact on the grid of increased use of wind power, cost, tradeoffs with other industries including tourism or the impact on nature. As a result, more robust analyses are needed. Increasing electricity production in Iceland by 125% by 2040 will create significant challenges for the national economy as well as added pressures on Icelandic nature and energy resources.

A particular **Norwegian** challenge is the petroleum sector. The petroleum sector is of high economic importance to Norway, generating a large income for society and many

82. Klima-, Energi-, og Forsyningsministeriet (2023, September 20). *Klimahandling: Mindst 34 millioner tons CO2 skal ned i undergrunden.* Retrieved from, https://kefm.dk/aktuelt/nyheder/2023/sep/klimahandling-mindst-34-millioner-tons-co2-skal-ned-i-undergrunden- [Accessed 20.05.2023].
83. The Finnish Climate Change Panel (2023). *Suuntaviivoja Suomen ilmastotoimien tehostamiseen [Guidelines for enhancing climate action in Finland].* Retrieved from, https://www.ilmastopaneeli.fi/wp-content/uploads/2023/02/ilmastopaneelin-julkaisuja-1-2023-suuntaviivoja-ilmastotoimien-tehostamiseen.pdf
84. Ministry of the Environment, Energy and Climate (2022, March). *Staða og áskoranir í orkumálum [Status and challenges in energy issues].* Government of Iceland. Retrieved from, https://www.stjornarradid.is/library/02-Rit--skyrslur-og-skrar/Stöðuskýrsla%20áskoranir%20%C3%AD%20orkumálum%2008032022.pdf

jobs, especially along the western coast. Even if oil and gas extraction could be sufficiently reduced to meet the global climate policy goal, this would be very challenging given the current global dependency on fossil fuels. If Norway reduces its production unilaterally - without an agreement among the big producers - international oil and gas markets will incentivize replacement of Norwegian production. A sufficiently high carbon tax on consumption covering most countries would be more efficient. Natural gas will be needed in Europe and elsewhere for decades since the world is still dependent on fossil fuels and since this is the most climate-friendly fossil fuel type. These circumstances have led the government to support many petroleum installations being supplied with land-based power. However, this leads to a problematic side-effect in Europe since the shortage of stable fossil-free power implies that more coal or gas is needed to satisfy an increasing demand, which contributes to $CO_2e$ emissions from the power sector in the EU and the UK. Emissions from the power and industry sectors are, however, capped by EU ETS.

For **Sweden**, continued electrification of transportation and the transformation of the industrial sector require rapid development of the electricity system. Electricity demand by 2035 is likely to double from today's levels. In order to meet such an increased electricity demand, the expansion rate of fossil-free electricity production needs to average 6 TWh/year until 2030 and between 2030 and 2035, increase further to over 12 TWh/year.[85]

One of the main challenges in the sector is that investments that are expected to be implemented are complex and thus risk being delayed by lengthy review processes, especially in cases where the application needs extensive completion or where the permit is appealed. There is a need for increased local acceptance and legitimacy for investments in e.g. wind power and electricity grids and other necessary infrastructure. Commercialisation of CCS will require significant efforts. The technology may play a role to reduce remaining emissions from waste incineration. Deployment of CCS to reduce emissions from waste incineration, however, risks locking-in to non-circular systems[86].

**Across the Nordic countries**, two challenges in particular must be addressed on the road towards climate neutrality:

- accelerating renewable energy production – review and permit processes and local scepticism to development of renewables
- renewable power intermittency in, and balancing of, the energy system.

These are described in further detail in the following sections.

85. Swedish Environmental Protection Agency (2023, April 6). *National Inventory Report Sweden 2023*. Retrieved from, https://unfccc.int/documents/627663
86. Johnsson, F., Zetterberg, L., Möllersten, K. (2023). *Mot nettonollutsläpp – hur kan BECCS och CCS bidra?* Studieförbundet näringsliv och samhälle.

### 11.4.1. Accelerating renewable energy production – permit processes and local scepticism to development of renewables

*The challenge*

As outlined earlier, the Nordic countries plan a large expansion of renewable energy in order to decarbonise their power, as well as other sectors, and to provide renewable energy for mitigation initiatives in hard to abate-sectors, e.g. green hydrogen for industry and other PtX-products for international transport. For example, Iceland expects an increase in electricity demand of up to 125% by 2040 in some scenarios, and Denmark plans to expand offshore wind and solar power production by more than 30 GW for both by 2050.

There are multiple challenges with an expansion of this size, but two in particular will be touched upon in this report:

- slow review and permit-granting processes
- local opposition to and scepticism towards renewable energy expansion.

In Sweden, these two issues are closely connected. Some of the investments that are expected to be implemented in the electricity and heating sector are complex and thus risk being delayed by lengthy review processes, especially in cases where the application needs extensive completion or where the permit is appealed[87]. Trials that affect many stakeholders involve a greater risk of appeal. In individual cases, these review processes can lead to the investment not being implemented.

Between 2014 and 2020, almost half of all wind power applications did not result in a permit and the municipal veto was the reason in over half of these cases. The functionality of the trials will therefore need to be developed. Here, the importance of local anchoring through well-conducted consultations and coordinated party authorities can be particularly important. But it could also be about the municipal veto for wind power, where, for example, the Swedish Energy Agency and the Swedish Environmental Protection Agency jointly proposed a changed municipal authorisation in the national wind power strategy. A public inquiry, "incitamentsutredningen" (Eng. Investigation of Incentives), commissioned by the government, found that local acceptance would be increased if the municipalities in question would receive a share of the revenues from the wind power plants. This type of reward has been successfully applied in Finland and Denmark. But the Swedish public inquiry could not propose this type of compensation in their report since tax proposals were beyond the mandate of the inquiry[88].

87. Energimyndigheten (2021, January 27). Förslag om ändring av bestämmelsen om kommunal tillstyrkan. Retrieved from, https://www.energimyndigheten.se/globalassets/fornybart/strategi-for-hallbar-vindkraftsutbyggnad/forslag-om-andring-av-bestammelsen-om-kommunal-tillstyrkan.pdf
88. Government Offices of Sweden (2023, April 27). *Värdet av Vinden*. SOU 2023:18. Retrieved from, https://www.regeringen.se/rattsliga-dokument/statens-offentliga-utredningar/2023/04/sou-202318/

In **Iceland**, as in Sweden, the two issues are connected. The permit process for new power plants begins with the national Master plan for nature protection and energy utilization[89]. The Master plan specifies, based on multi-criteria analysis including environmental, economic and social impacts, whether energy development options larger than 10MW are allowed to move forward towards obtaining development and operational licenses. The Master plan list of development options is approved by Parliament. Following such approval and additional analysis, a development license (is: virkjanaleyfi) is awarded by the Energy Authority, followed by the approval of operational licenses (is: framkvæmdaleyfi) by municipalities. The Master plan process and its results have been subject to public and political debates and increased public and municipal opposition to plans for expanding energy production is emerging. Recent opposition in particular is directed to plans for wind power development which historically has not been part of the Icelandic energy mix. In addition, municipalities are demanding a fairer share of revenues, and related delays are already materialising in the development of wind power plants[90].

*Opportunities*

We see the following opportunities for cross-Nordic collaboration addressing the challenge outlined above:

- Knowledge-sharing on increasing acceptability - and reducing potential negative impacts on nature and local populations - for renewable energy installations.

In **Denmark**, a recent report commissioned by the Danish Energy Agency[91] indicates that the previous compensation schemes for renewable energy have had no effect on local opposition/support.

Despite the extensive academic research done on addressing local opposition and promoting local support (often referred to academically as "the social acceptance of renewable energy technologies and associated infrastructures"), very few initiatives have actually been shown to help in overcoming the challenges.

Considering the similarity in social acceptance issues regarding renewable energy installations – be it solar, hydro or wind power – across the Nordic countries, there seems to be high co-Nordic value in sharing experiences and developing solutions across the Nordic region.

89. Rammaáætlun (n.d.). *The Master Planfor Nature Protection and Energy Utilization.* Retrieved from, https://www.ramma.is/english [Accessed 10.05.2023]
90. Pálsdóttir, I.Þ. (2023, June 8). *Búrfellslundur blásinn af [Burfellslund blown off].* Mbl.is. Retrieved from, https://www.mbl.is/frettir/innlent/2023/06/08/burfellslundur_blasinn_af/ [Accessed 10.05.2023]
91. Rambøll (2022, December). *Baselineundersøgelse til evaluering af vedvarende energiordninger.* Energistyrelsen. Retrieved from, https://ens.dk/sites/ens.dk/files/Vindenergi/baselineundersoegelse_2022_til_evaluering_af_ve-ordninger.pdf

Knowledge-sharing could be done bilaterally between the Nordic countries or in a dedicated network/forum hosted by the Nordic Council of Ministers. Relevant stakeholders would be energy agencies, municipalities and/or other local government level representatives and renewable energy developers.

### 11.4.2. Renewable power intermittency in, and balancing of, the energy system

*The challenge*

One of the main challenges when scaling up renewables and phasing down use of fossil fuels is maintaining energy security of electricity supply.

With the exception of Iceland, the Nordic countries' electricity grids and markets are strongly interconnected. Physically, interconnectors join countries across land and sea, and economically, a common Nordic spot market ensures trade with energy across Nordic borders. Thus, balancing the electricity grid in future with an energy system dominated by renewable (and intermittent) energy is truly a cross-Nordic challenge.

In **Denmark**, the Danish Climate Council has analyzed future scenarios with an energy system dominated by wind and solar[92]. The Council concludes that it is possible to maintain a high security of supply when the electricity system is dominated by solar and wind. However, Denmark will become increasingly dependent on importing electricity from neighbouring countries and at certain periods. Moreover, it is important to ensure more adjustable electricity capacity, e.g. gas turbines, which could run on bio-natural gas, and potentially hydrogen. Flexible demand will also play an important role but is not enough. The price for maintaining security of supply and the necessary back-up is estimated at the modest price of 0.4€ billion or 13€/person in Denmark per year. Storage of electricity may also play an important role but the price is calculated on the price of gas-turbines as backup as prices and the technology is known.

In a 2021-report, the Finnish Innovation Fund Sitra analysed scenarios for how to enable cost-efficient electrification in Finland[93]. The report concluded that to meet increasing demand resulting from electrification in various sectors, Finnish generation capacities will more than triple by 2050. Despite this growth in production, Finland (in the scenario) would become a net importer from 2040 onwards, highlighting the importance of flexibility from the Nordic hydro (Norway and Sweden) and nuclear generation (Sweden) available to the Finnish System via interconnection capacities.

92. Klimarådet (2023, May). *Sikker elforsyning med sol og vind*. Retrieved from, https://klimaraadet.dk/sites/default/files/node/field_files/Analyse%20-%20sikker%20elforsyning%20med%20sol%20og%20vind.pdf
93. Roques, F., Le Thieis, Y., Aue, G., Spodniak, P., Pugliese, G., Cail, S., Peffen, A., Honkapuro, S.& Sihvonen, V. (2021, September). *Enabling cost-efficient electrification in Finland*. SITRA. Retrieved from, https://www.sitra.fi/en/publications/enabling-cost-efficient-electrification-in-finland/

Due to its flexible hydro power capacity, **Norway** plays an important role in balancing the Nordic electricity systems. A recent report from the Norwegian Water Resources and Energy Directorate[94] concludes that even with the assumption of a highly flexible electricity demand across the Nordic markets, there will be situations in the future where the Nordics will depend on imported electricity to cover demand that is not sufficiently flexible. The Norwegian "battery" in terms of flexible hydropower, is not enough to balance the entire Nordic region. Furthermore, the report highlights the importance of viewing this issue in combination with the national, Nordic and Northern European contexts – which calls for strong collaboration and sufficient grid capacity between countries.

Anticipating the challenges, the Nordic transmission system operators (TSOs) have started developing a new Nordic Balancing Model (*Ny Nordisk Balanseringsmodell, NBM*[95]). Moreover, collaboration has been established between NordREG, CEER and ACER, and in general through EU regulation.

*Opportunities*

Despite the already close collaboration between Nordic TSOs, there is room for further Nordic collaboration in this area. We recommend pursuing the following opportunities for co-Nordic value:

- Cross-Nordic analysis/overview on future energy supply and demand in the Nordic countries, especially regarding balancing power capacity supplementing increasing renewable power.

As noted in the aforementioned NVE-report, there is a need for further cross-Nordic analysis on the future of Nordic energy supply and demand. Knowledge is particularly needed with respect to the **future options for flexible energy demand**. This is valuable information for policy makers in the Nordic countries and for the assumptions underlying national projections and analysis on ensuring a stable and secure energy supply towards climate neutrality.

The Nordic Council of Ministers could procure analysis either directly or through Nordic Energy Research and thus contribute to a better cross-Nordic understanding of the future of the energy system in the Nordic region.

94. Buvik, M., Cabrol, J., Spilde, D., Skaansar, E., Roos, A., Tveten, Å.G., Doorman, G.& Døskeland I. (2022, May). *Norsk og nordisk effektbalanse fram mot 2030*. Norges vassdrags- og energidirektorat. Retrieved from, https://publikasjoner.nve.no/rapport/2022/rapport2022_20.pdf
95. Nordic Balancing Model(n.d.). *Nordic Balancing Model*. Retrieved from, https://nordicbalancingmodel.net/ [Accessed 10.08.2023]

- Knowledge-sharing on energy efficiency policies

In the International Energy Agency's (IEA) scenario for reaching net-zero in 2050 (*Net-Zero by 2050*[96]), energy efficiency is the single largest measure to avoid energy demand, and in the EU, "energy efficiency first" is outlined as one of the key pillars for reaching the EU's climate objectives. Despite this, none of the five Nordic countries have a dedicated strategy for energy efficiency.

The Nordic Council of Ministers could promote this agenda by commissioning studies on energy efficiency policies and their impacts across the Nordic countries. Moreover, studies could also be funded to outline a Nordic strategy for energy efficiency, inspiring and guiding the Nordic countries to further action in this area.

96. International Energy Agency (2021). *Net Zero by 2050 A Roadmap for the Global Energy Sector.* Retrieved from, https://www.iea.org/reports/net-zero-by-2050

# 12. Domestic transport

## 12.1. Introduction and summary

The Nordic domestic transport sector emitted 51 million tonnes of $CO_2e$ in 2021, corresponding to 34% of the total Nordic emissions when including the LULUCF sector. Leaving out emissions/removals from LULUCF, the Nordic domestic transport sector was responsible for 26% of total net GHG emissions in the Nordic region.

This chapter covers domestic emissions from fuels used for different modes of transportation. It does not include international shipping and international aviation.

From 1990 to 2021, the GHG emissions from the Nordic domestic transport sector were reduced by 3 million tonnes of $CO_2e$, corresponding to a 5% emission reduction in the sector. Finland and Sweden in particular contributed to this reduction with domestic transport emission reductions of 17% and 23%, respectively, from 1990 to 2021. In Iceland, Norway and Denmark, domestic transport emissions increased by 45%, 24%, and 14%, respectively, in the same period.

Figure 17, below, shows the development of the Nordic domestic transport sector's GHG emissions.

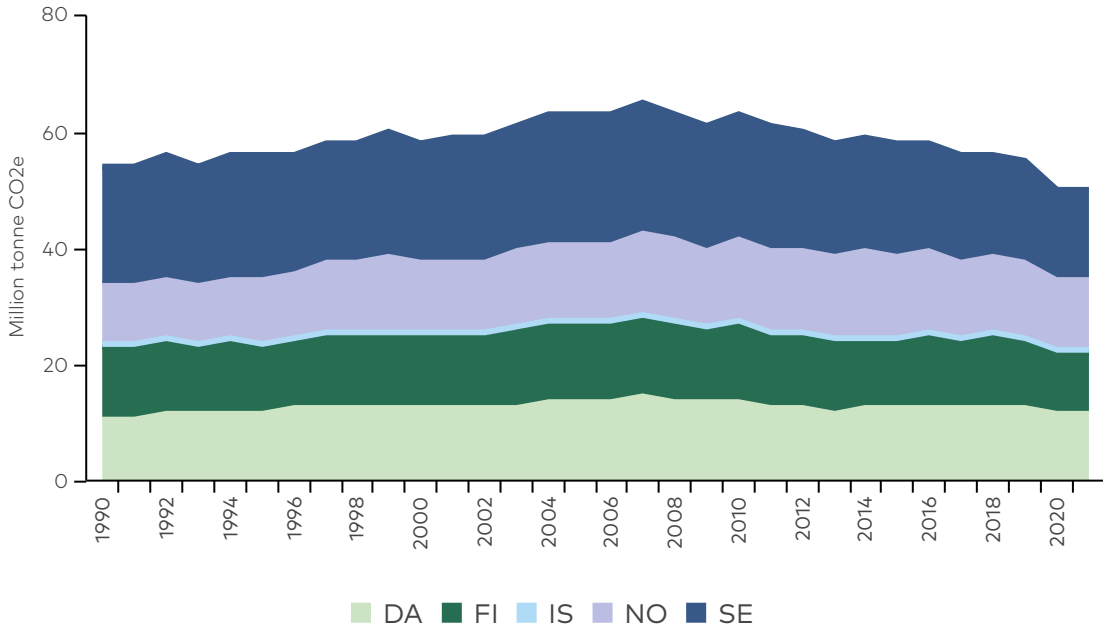



**Figure 17:** GHG emissions from domestic transport across the Nordic countries 1990-2021

*Source: UNFCCC. GHG data from UNFCCC. https://unfccc.int/topics/mitigation/resources/registry-and-data/ghg-data-from-unfccc*

Note that the memo items 'international shipping, bunkering and international aviation' are not included in the emissions above. From 1990 to 2021, the total emissions of the Nordic countries from these items increased slightly (6.7%). Numbers for 2021 might be skewed due to the global pandemic (2019-2021), however, and the development from 1990 to, e.g., 2018 shows an increase of approximately 46% (equal to 13.5 million tonnes' $CO_2e$).

Across the Nordic countries, the emissions in domestic transport have been addressed with a range of initiatives primarily focused on road transport and passenger cars. Electrification of the car fleet has accelerated across the Nordic region in recent years, with Norway as a frontrunner in electrical vehicle uptake. In Norway, electrification of short-range ferries has also been a success. Biofuels and blending requirements, partly driven by EU regulation, have also played a large role.

There are, however, still challenges to overcome to reduce emissions in this sector. The table below provides an overview of GHG emissions and developments in 1990, 2010 and 2021In addition, Table 6 summarises the main country challenges described in the section later in this chapter.

**Table 5:** The domestic transport sector across Nordic countries – a summary

| | Denmark | Finland | Iceland | Norway | Sweden |
|---|---|---|---|---|---|
| **Emissions, 1990** *Mt $CO_2e$* | 11.0 | 12.1 | 0.6 | 9.9 | 20.0 |
| **Emissions, 2010** *Mt $CO_2e$* | 13.6 | 12.7 | 0.9 | 13.9 | 21.1 |
| **Emissions, 2021** *Mt $CO_2e$* | 12.5 | 10.0 | 0.9 | 12.3 | 15.4 |
| **Development, 1990-2021** | +13.9% | -17.5% | +45.1% | +23.8% | -23.0% |
| **Development, 2010-2021** | -8.0% | -21.3% | +0.6% | -11.9% | -26.9% |

*Source: UNFCCC. GHG data from UNFCCC. https://unfccc.int/topics/mitigation/resources/registry-and-data/ghg-data-from-unfccc*

**Table 6:** The domestic transport sector across the Nordic countries – summary of main challenges

| Country | Summary of main challenge(s) |
|---|---|
| **Denmark** | • Emissions from road transportation decreasing too slowly despite policies promoting new EV registration<br>• Reducing emissions of heavy trucks |
| **Finland** | • Decisions to cut the blending obligation<br>• Political challenges in using pricing (taxes, road charges) to steer demand |
| **Iceland** | • Emissions are rising despite electrification efforts due to increased transport demand<br>• Lack of transparency and foresight in the use of economic instruments<br>• Lack of targets and initiatives in harder-to-mitigate sectors (incl. heavy duty vehicles, aviation and domestic shipping) |
| **Norway** | • A combination of topographical, technical and financial challenges<br>• Lack of development of climate-friendly designs and fuels in deep-sea shipping |
| **Sweden** | • Lack of broad political agreements about long term and stable conditions for fuels and electro-fuels, including the production of biofuels in Sweden<br>• Lowered GHG reduction mandate<br>• Need for supplementary policy measures which enable rapid electrification and increased transport efficiency |

Despite previous efforts, emissions in the transport sector remain high across the Nordic region, with almost no actual GHG reductions compared to 1990. Further electrification of the private car fleet, enhanced public and multi-modal transportation and plans to decarbonise heavy transport are part of the plans and strategies towards a domestic transport sector aligned with a climate neutral pathway.

There are many challenges in reducing emissions from the Nordic domestic transport sector. In this report, we have singled out the following two cross-Nordic challenges:

- determining the future role of biofuels
- phasing out ICE (Internal Combustion Engine) car dominance.

In the transport sector, we see the following opportunities for creating added Nordic value through collaboration:

- joint analysis of development, production and use of biofuels in the Nordic region
- developing a Nordic roadmap for the sustainable production and use of biofuels and synthetic fuels
- developing a strategy for how to reallocate ICE cars to those users and uses that would have the lowest travel needs and a supporting assessment framework to identify the GHG trade-offs of different policies
- supporting urban action plans for zero emission passenger and freight transport
- knowledge-sharing on promoting public transport.

## 12.2. Status of the transport sector across the Nordic countries

In **Denmark**, the transport sector was responsible for a total of 12.6 million tonnes of $CO_2e$ emissions in 2021, equal to 27% of Denmark's total $CO_2e$ emissions. In 1990 the sector emitted 11.74 million tonnes of $CO_2e$, and thus from 1990 to 2021 the total $CO_2e$ emissions from the transport sector increased 8%[97]. Most of the emissions were from road traffic. There are no national GHG reduction targets specifically for the transport sector. Denmark has a general target of 50%-54% reduction in 2025, 70% reduction in 2030 and a target of climate neutrality by 2050. In the Danish Energy Agency's scenarios for 2050 (presented in the chapter on Denmark), the transport sector is expected to emit 0.1 to 0.3 million tonnes of $CO_2e$, depending on the scenari0[98]. Electrification of almost all road transport is expected to contribute most of the reductions. Further, the DEA scenarios show that smarter planning, infrastructure and behavioural change can decrease the need for transport, or slow the growth in transport work, and may make the transition faster.

97. Energistyrelsen (2023, April). *Klimastatus og -fremskrivning, 2023*. Retrieved from, https://ens.dk/sites/ens.dk/files/Basisfremskrivning/kf23_hovedrapport.pdf
98. Energistyrelsen (2022, September 23*). Resultater for KP22-scenarier*. Retrieved from, https://ens.dk/sites/ens.dk/files/Basisfremskrivning/resultater_for_kp22-scenarier_23-09-2022.pdf

The EU effort sharing regulation has increased the Danish target from 39% to 50% reduction in 2030 compared to 2005. The latest frozen policy projection from the DEA projects that the accumulated shortage to reach the target is 16 million tonnes of $CO_2e$[99] from 2021-2030. This means that further initiatives are needed in the non-ETS sectors to live up to the effort sharing regulation.

The emissions from domestic transport in **Finland** have been mostly decreasing since 2007. In 2021 the emissions from transport (without domestic air traffic) were 9.9 million tonnes of $CO_2e$, which is little over 20% of the overall emissions and about 37% of the emissions from the effort sharing sector. Compared to 1990, the emissions have decreased 25% (11.7 million tonnes in 1990). In 2020, the emissions were 10.4 million tonnes, 6% lower than in 2019, partly caused by the COVID pandemic which reduced transport momentarily. Additionally, in 2021 the share of renewable fuels in transport went up from 11% to 18%.

In 2021, 95% of the emissions from domestic transport came from road traffic. The majority of the emissions from road traffic (53%) came from passenger cars and 33% from trucks. Only 3% of emissions come from waterborne transport and 1% from rail traffic. The domestic air traffic is responsible for less than 1% of the emissions from transport, although the emissions from air transport are calculated into the emissions trading sector. The decrease of transport sector emissions is heavily influenced by the increase in biofuel use and the improved energy efficiency of new vehicles. The emissions from transport will somewhat increase during 2022-2023 as a result of the reduction of the blending obligation of renewable fuels. It is estimated that the 7.5 pp. reduction in the obligation will increase emissions by 1.7 million tonnes- a fairly sizable increase in the effort sharing sector.[100] The future blending obligation rates will be reduced from the levels set in the law, therefore rising more slowly than previously planned. This will increase emissions compared to the existing policies baseline and make it harder to reach emission reduction goals.

In **Iceland**, the emissions from domestic transport consist of road traffic (95.7% in 2021), domestic aviation (2.3% in 2021) and domestic shipping (2.0% in 2021). The sector is responsible for 19.3% of total national emissions in 2021 if LULUCF is excluded, but 6.4% of emissions from LULUCF are included. Emission profiles differ within the sector, where emissions from road transport have increased by 62% in 2021 compared to 1990, but emissions in domestic aviation and domestic shipping were 38% and 47% lower, respectively, in 2021 compared to 1990[101].

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99. Energistyrelsen (2023, April). *Klimastatus og -fremskrivning, 2023*. Retrieved from, https://ens.dk/sites/ens.dk/files/Basisfremskrivning/kf23_hovedrapport.pdf#page=26
100. Ympäristöministeriö Helsinki [Ministry of the Environment] (2022). *Ilmastovuosikertomus 2022 [Annual Climate Report 2022]*. Retrieved from, https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/164392/YM_2022_24.pdf?sequence=1&isAllowed=y
101. Keller, N., Helgadóttir, Á.K., Einarsdóttir, S.R., Helgason, R., Ásgeirsson, B.U., Helgadóttir, D.,Helgadóttir, I.R., Barr, B. C., Thianthong C. J. Hilmarsson, K.M., Tinganelli, L., Snorrason, A., Brink, S.H. & Þórsson, J. (2023, April 14). *National Inventory Report. Emissions of Greenhouse Gases in Iceland from 1990 to 2021. Environment Agency of Iceland.* Retrieved from, https://ust.is/library/Skrar/loft/NIR/ISL_NIR%202023_15%20april_on_web.pdf

Emissions from road transport have fluctuated since 1990, with emissions peaking in 2008 followed by a temporary decline. As the economy rebounded with the help of expanding tourism, emissions from road transport rose again and reached an all-time high in 2018. Climate actions and then later the Covid pandemic led to a temporary reduction in emissions but recent data indicates that emissions are increasing again from increased transport demand particularly due to the return of tourism[102].

In **Norway**, GHG emissions from road traffic have increased by 17% from 1990 to 2021, primarily caused by increased freight transportation by trucks. The sector was responsible for 25% of total national emissions in 2021 excluding LULUCF, and 37% of emissions when LULUCF is included. For passenger vehicles, emissions were stable from 1990 to 2015, where increased mileage was compensated by an increasing number of electric passenger vehicles and more efficient engines. After 2015, emissions were primarily reduced due to more electric vehicles and more biofuels. Emissions from the maritime sector (domestic shipping, including fishery) and domestic aviation increased by 41% between 1990-2021. Aviation-related emissions have been stable whereas maritime emissions have grown.

Domestic transport accounts for about a third of **Sweden's** total emissions of GHG and about half of the emissions in the non-trading sector. GHG emissions from domestic transport amounted to 15.1 million tonnes $CO_2e$ in 2021, which is a decrease of roughly 27% compared to 2010. Emissions from passenger cars have decreased by 26%, while emissions from heavy vehicles are estimated to have decreased significantly more, by 34% compared to 2010. The larger decrease is due to the mixing of biofuels at significantly higher levels in diesel than in gasoline. In principle, heavy traffic uses diesel exclusively, while passenger car traffic used 40% more gasoline than diesel in energy terms at the beginning of the 2020s[103].

Emissions from domestic shipping were 0.7 million tonnes of $CO_2e$ in 2021, which was nearly 40% higher than 1990. Emissions from domestic aviation in 2021 were approximately 0.2 million tonnes $CO_2e$, which corresponds to just under 30% of the emissions in 1990.

102. Keller, N., Helgadóttir, Á.K., Einarsdóttir, S.R., Helgason, R., Ásgeirsson, B.U., Helgadóttir, D.,Helgadóttir, I.R., Barr, B. C., Thianthong C. J. Hilmarsson, K.M., Tinganelli, L., Snorrason, A., Brink, S.H. & Þórsson, J. (2023, April 14*). National Inventory Report. Emissions of Greenhouse Gases in Iceland from 1990 to 2021. Environment Agency of Iceland.* Retrieved from, https://ust.is/library/Skrar/loft/NIR/ISL_NIR%202023_15%20april_on_web.pdf
103. Swedish Environmental Protection Agency (2023, April 6). *National Inventory Report Sweden 2023*. Retrieved from, https://unfccc.int/documents/627663

## 12.3. Pathways towards climate neutrality in the transport sector

In **Denmark**, national as well as EU mitigation measures are expected to reduce the GHG emissions in the transport sector[104]. Projections from the DEA estimate that this will lead to a reduction of 2.2 million tonnes $CO_2$e between 2021 and 2030 (around 17%). In this projection the transport sector will make up 35% of the expected emissions in 2030[105].

The Climate Council is critical of this projection, as only few political initiatives are at an implementation stage and most policies are only proposals, analyses, or technical potentials. Thus, the Climate Council projects that implemented political initiatives can reduce emissions in the transport sector by 0.8 million tonnes of $CO_2$e between 2020 and 2030, while proposals, analyses, or technical potentials are estimated to have a reduction potential of 7.99 million tonnes of $CO_2$e between 2020 and 2030[106].

According to the Climate Council, the majority of the projected GHG reductions in the transport sector are a result of EU policies[107].

The main national initiative is the green transport agreement adopted in 2020. This agreement includes initiatives such as a kilometer-based toll for trucks, a tax reform that is projected to deliver 750,000 zero and low emission cars in 2030, a fuel blending mandate[108].

To reach carbon neutrality in **Finland** by 2035, a target has been set to cut transport emissions by half by 2030 compared to 2005. Furthermore, the goal is to achieve carbon neutrality in transport by 2045. In line with the then Government Programme, in 2021 the Ministry of Transport and Communications issued a Roadmap for fossil-free transport[109] to reduce emissions from transport. The roadmap included three phases:

104. Klimarådet (2023). *Sektorvurderinger, Baggrundsnotat til Klimarådets Statusrapport 2023, kapitel 3.* Retrieved from, https://klimaraadet.dk/sites/default/files/paragraph/field_download/Baggrundsnotat%20Sektorvurderinger.pdf
105. Energistyrelsen (2023, April). *Klimastatus og -fremskrivning, 2023.* Retrieved from, https://ens.dk/sites/ens.dk/files/Basisfremskrivning/kf23_hovedrapport.pdf
106. Klimarådet (2023). *Sektorvurderinger, Baggrundsnotat til Klimarådets Statusrapport 2023, kapitel 3.* Retrieved from, https://klimaraadet.dk/sites/default/files/paragraph/field_download/Baggrundsnotat%20Sektorvurderinger.pdf
107. Klimarådet (2023). *Sektorvurderinger, Baggrundsnotat til Klimarådets Statusrapport 2023, kapitel 3.* Retrieved from, https://klimaraadet.dk/sites/default/files/paragraph/field_download/Baggrundsnotat%20Sektorvurderinger.pdf
108. Regeringen (2021, October 4). Aftale om grøn omstilling af dansk landbrug. Retrieved from, https://fm.dk/media/18511/aftale-om-groen-omstilling-af-vejtransporten_a.pdf
109. Liikenne-ja viestintäministeriö (2021). *Fossiilittoman liikenteen tiekartta.* Retrieved from, https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/163258/LVM_2021_15.pdf?sequence=1&isAllowed=y

1. Implementation of a wide range of support and incentives to promote emission-free transport such as inclusion of biogas and electric fuels in the blending obligation, various subsidies related to the procurement and distribution infrastructure of electric and gas vehicles, support for promoting walking, cycling and public transport services, transport infrastructure maintenance and digitalisation in logistics.
2. In 2021, there was an evaluation of development trends and additional measures which could influence the emissions from transport but there was not yet enough information on these when the roadmap was released. These measures/trends include the increase in remote work, promoting multi-modal options in freight transport and Mobility as a Service (MaaS), and increasing the blending obligation. It is estimated that with these measures, traffic emissions could be reduced by 0.4-0.6 million tonnes by 2030, if the remote work and MaaS progress as estimated and if there was a 4 pp. increase in the blending obligation.[110]
3. Once the progress of EU-level measures and impacts of all measures of phases 1 and 2 are known, the Government was supposed to assess and decide on the possible need for additional national measures in the transport sector.

However, a new Finnish government has introduced changes in policy. Because increasing the blending obligation raises fuel prices for consumers, the government has decided to cut future blending rates. According to the current law, the rates would be increased to 28% in 2024, 29% in 2025–26, 30% in 2027, 31% in 2028, 32% in 2029 and 34% in 2030. Because of the policy changes, the new rates will be considerably lower: 13.5% in 2024, 16.5% in 2025, 19.5% in 2026 and 22.5% in 2027. This will make reaching emission targets in the transport sector significantly more difficult.

The electrification of passenger cars and light trucks is progressing, which will lower emissions in future. That said, the current development will not be enough to reach the emission reduction targets set for transport[111]. Finland used to offer subsidies for those who purchase electric cars, but the amount was low (2,000 euros) compared to other European countries and now the subsidy has been removed. Finland has also spent less than many other countries in Europe in developing the charging infrastructure and the new government has decided to cut support.[112]

110. Hankeikkuna (n.d.). *Fossiilittoman liikenteen tiekartta – 3. Vaih.* Retrieved from, https://api.hankeikkuna.fi/asiakirjat/d99a3ae3-b7f9-49df-afd2-c8f2efd3dc1d/794806f8-1616-44c5-a533-f0e575d6371e/MUISTIO_20220125084826.PDF
111. Liikenne- ja viestintävirasto Traficom (2023, January 27). *Henkilöautoja liikenteessä 2,74 miljoonaa - sähköautojen määrä miltei kaksinkertaistui.* [online] Retrieved from, https://www.traficom.fi/fi/ajankohtaista/henkiloautoja-liikenteessa-274-miljoonaa-sahkoautojen-maara-miltei-kaksinkertaistui [Accessed 20.05.2023].
112. Harju, J., Kosonen, T., Laukkanen, M., Kuitunen, S. & Palanne, K. (2022, October 3). *FIT #2/2022: Liikenteen ilmastopäästöjen vähentäminen vaatii ripeämpää liikenteen sähköistymistä.* Verotutkimuksen huippuyksikkö. Retrieved from, https://verotutkimus.fi/liikenteen-ilmastopaastojen-vahentaminen-vaatii-ripeampaa-liikenteen-sahkoistymista/

As in the other Nordic countries, the **Icelandic** transport sector is a sector governed under the EU's Effort Sharing Regulation and the domestic aim of 55% reduction in GHG emissions by 2030 compared to 2005. Given the access to low-carbon electricity the climate action plan prioritises electrification of road transport, building infrastructure for electricity use in the harbours and reducing travel demand by car by enhancing active mobility and public transport. No formal plans have yet focused on domestic aviation. Rapid mitigation in the transport sector is key to reaching climate neutrality by 2040 and for road transport it is both economically and technically feasible, despite slower technological development in heavy duty transport. Current initiatives in road transport focus on electrification of light duty vehicles, enhanced active transport and improved public transportation.

The overall country strategy for transport aims to be independent of fossil fuels by 2040 and reach climate neutrality through electrification and e-transport. The strategy can be broken into three key pillars: i) facilitating rapid electrification of light duty vehicles including rental cars, ii) reducing travel demand by private vehicles, iii) facilitating the energy transition in heavy transport, shipping and aviation e.g. by stimulating and funding research and development and funding demonstration projects.

Numerous policy instruments are being applied to facilitate electrification, including both economic instruments and regulations: subsidies for low-and zero emissions vehicles such as reduced VAT and import duties for BEVs and hydrogen vehicles, subsidies for BEV rental cars, carbon taxes, funding infrastructure for low and zero emission vehicles and a requirement to buy low-emitting vehicles in government agencies. New registration of gasoline and diesel vehicles will be banned after 2030. E-transport is also expected to emerge for heavy duty vehicles, yet given less mature technologies the transition is expected to take longer.

Infrastructure is being enhanced for active transport and incentives are being given for active mobility, for example no VAT is levied on electric bikes. Public transport is also being enhanced in the capital area.

In the domestic shipping sector, all harbours will have charging infrastructure by 2025, and domestic ferries are expected to transition to electric ferries. In 2020, grants were given for infrastructure projects in harbours for electrical connections and heating/hot water onboard.

No initiatives have been implemented for aviation in Iceland.

Despite these efforts and the fact that 57% of all newly registered light duty vehicles in 2022 were BEV or PHEV, the Environmental Agency[113] expects emissions from

113. Helgadóttir, Á.K., Einarsdóttir, S.R., Keller, N., Helgason, R., Ásgeirsson, B.U., Helgadóttir, I.R., Barr, B.C., Hilmarsson, K.M., Thianthong, J.C., Snorrason, A., Tinganelli, L. & Þórsson, J. (2023, March 15). *Report on Policies, Measures, and Projections. Projections of Greenhouse Gas Emissions in Iceland until 2050.* Environment Agency of Iceland. Retrieved from, https://ust.is/library/Skrar/loft/NIR/0_PaMsProjections_Report_2023_WITH%20BOOKMARKS.pdf

transport to be only 15% and 65% lower in 2030 and 2040, respectively, compared to emissions in 2021. The large % difference in mitigation between 2030 and 2040 illustrates the significant stock effects on the near-term effectiveness of mitigation efforts.

**Norway** has a plan to increase the share of biofuels – biodiesel and bioethanol – in fossil fuels, where the main policy tool is a mixing requirement for dealers. From 2023 the requirement is 17 % biofuels of which 12.5 % should be advanced biofuels (i.e. based on waste products, not crops[114]. Currently, 75% of biofuel is advanced. The mixing requirement for aviation is 0.5% biofuels. The government has proposed a 6% biofuel mixing requirement for the maritime sector from autumn 2023. For total biofuels 94% of the raw materials are imported. Some biogas is produced and based on domestic resources, but there is no mixing requirement for this fuel category. There are plans for hydrogen production based on electrolysis (green hydrogen) to serve maritime transportation, as well as hydrogen production from natural gas combined with CCS (blue hydrogen), where government seems willing to offer substantial subsidies. The blue hydrogen plans are directed foremost at exports to EU countries.

Electric vehicles have been promoted and supported by many tax and road toll exemptions and other benefits since 2008. This has led to a very high share of electric passenger cars sold in Norway. In 2022 the electric car share for newly registered cars was at 83 %, increasing the electric vehicle share of the total car stock to 21 %.

Low-carbon fuels have been introduced in freight transportation. The leading grocery transport company Asko, for example, currently has a 40 % share of low-carbon fuels in their truck fleet. This is a mix of biofuels, biogas and battery operation. The first electric truck was introduced in 2016. The leading public transport company in the Oslo region – Ruter – has introduced electric buses, as well as biofuel, biogas and natural gas-fueled buses. The renewable fuel share in 2020 for buses was at 74 %. A pilot on hydrogen-fueled buses has ended.

Norway has been successful in the domestic ferry segment, where most of the connections will soon have fully electric or hybrid-electric systems. This development has been possible due to requests for low-carbon solutions by counties and the state in public procurement processes for ferry services, in addition to public support for investments in local grid and charging facilities. Battery solutions are relatively straightforward for ferries due to short distances and frequent charging opportunities. Low-carbon solutions for express boats are more challenging, but hydrogen solutions are being developed.

There has been an ambition to transfer more freight from trucks to rail and ships to save energy and GHG emissions, but sufficient measures and progress are missing.

114. Norwegian Environment Agency (2023), *Biodrivstoff*. Retrieved from hrtps://www.miljodirektoratet.no/ansvarsomrader/klima/transport/biodrivstoff/

In **Sweden**, the climate strategy for the transport sector has been implemented through efforts in three areas: energy efficiency of vehicles, a more transport-efficient society and an increased use of sustainable fossil-free fuels, especially biofuels[115].

EU regulation has a key role for the transition in the transport sector. The Swedish commitment to a tightened ESR requires a 50% emissions reduction in 2030 compared to 2005, which is more relaxed than is required by the relevant Swedish milestone target without the full use of allowed supplementary measures. At the EU level, it is above all the carbon dioxide requirements for new light and heavy road vehicles that drive the introduction of vehicles that use an electric motor for their main propulsion and an increased fuel efficiency of vehicles that use a combustion engine. Common EU requirements for the expansion of infrastructure for alternatively powered vehicles are also significant.

The latest projection from the Swedish EPA indicated that the national milestone targets for 2030 will be difficult to reach with the government's announced weakening of the GHG reduction mandate for diesel and gasoline.

The use of biofuels in diesel and gasoline is regulated by the GHG reduction mandate, which was introduced in 2018 and gradually increased until the beginning of 2022. In 2023, the increase has been paused at the 2022 level, which was decided during the previous term.

The current government has suggested reducing the blending level to 6 % for diesel and gasoline for the years 2024-2026, from previous levels of 30.5 % for diesel and 7.8 % for gasoline. The reduction levels for 2027-2030 are not yet suggested.[116] The upcoming climate action plan to be delivered in the autumn of 2023 will present the government's pathway to reaching the Swedish climate goals.

In addition to the GHG reduction mandate, the tax exemptions and reductions that are given for E85, rape seed oil-based biodiesel, HVO etc. is of importance. The energy and carbon dioxide taxes on petrol and diesel also affect the development in general in the sector.

The control towards reduced emissions of GHG for inland shipping is initially weak compared to road traffic. The EU's Fit for 55 package resulted in a regulation to promote sustainable fuels and the use of sustainable alternative energy carriers in shipping. Fossil fuels for commercial shipping are not subject to energy and carbon dioxide tax or to blending mandates in Sweden. Fuel for leisure boats, on the other hand, is taxed in the same way as road traffic, with energy tax, carbon dioxide tax and value added tax and is also covered by the blending mandate. Several authorities,

115. Naturvårdsverket (2023). *Underlag till regeringens kommande klimathandlingsplan och klimatredovisning*. NV-08102-22. Retrieved from, https://www.naturvardsverket.se/499a4f/contentassets/4c414b0778e9409fb2836fc4d3dc6259/underlag-till-regeringens-kommande-klimathandlingsplan-och-klimatredovisning-2023-04-13.pdf
116. Regeringskansliet (2023). *Budgetpropsitionen för 202.* Prop. 2023/24:1 (UO 20) Retrieved from, https://www.regeringen.se/rattsliga-dokument/proposition/2023/09/prop.-2023241

regions and municipalities set climate requirements when procuring ships and transport or transport services. The procurements have entailed both ships with electric operation and the introduction of biofuels in both ferries for public transport and road ferries[117].

Airline operators that emit more than 10,000 tonnes of carbon dioxide per year from flights to and from airports in the EEA are included in the EU ETS. The majority of Sweden's commercial domestic flights are included in the EU ETS. At national level, airlines operating flights from airports in Sweden are obliged to pay passenger tax. The flight tax applies to both domestic and international travel and the size of the tax depends on the final destination of the flight. There are also climate-differentiated take-off and landing fees for Arlanda and Landvetter airports.

In 2021, a blending mandate on aviation kerosene was introduced in Sweden. In the first year, the requirement for blending in biofuels was 0.8% and it was planned for this to be gradually ramped up to 27% in 2030. However, the government decided in 2023 that the level of the blending mandate in Sweden from 1 January 2024 would be reduced to the minimum level decided by the EU[118].

The Fit for 55 package also resulted in an extension of the EU ETS to ships over 5,000 gross tonnage (with certain exemptions) which will come into full effect from 2026.

## 12.4. Challenges in the transport sector on the way towards climate neutrality and opportunities for Nordic collaboration

The Nordic countries face very similar challenges in decarbonising their transport sectors.

In **Denmark**, the DEA estimates that GHG emissions from the transport sector will have been reduced by 11% compared to 1990 in 2030 and make up 35% of Denmark's total emissions in 2030[119].

The Climate Council finds the current policies and strategies inadequate and untimely if Denmark is to reach its reduction targets for 2030 and is calling for a concretisation of the political strategies[120].

Road transport accounted for 91% of the emissions from the transport sector in 2021

117. Naturvårdsverket (2023). *Underlag till regeringens kommande klimathandlingsplan och klimatredovisning*. NV-08102-22. Retrieved from, https://www.naturvardsverket.se/499a4f/contentassets/4c414b0778e9409fb2836fc4d3dc6259/underlag-till-regeringens-kommande-klimathandlingsplan-och-klimatredovisning-2023-04-13.pdf
118. Regeringen (2023), *Promemoria Sänkning av reduktionsplikten för bensin och diesel*. Retrieved from, https://www.regeringen.se/contentassets/de853e9b01aa453399187bfa5d6be326/promemoria-sankning-av-reduktionsplikten-for-bensin-och-diesel.pdf
119. Energistyrelsen (2023, April). *Klimastatus og -fremskrivning, 2023*. Retrieved from, https://ens.dk/sites/ens.dk/files/Basisfremskrivning/kf23_hovedrapport.pdf
120. Klimarådet (2023). *Sektorvurderinger, Baggrundsnotat til Klimarådets Statusrapport 2023, kapitel 3*. Retrieved from, https://klimaraadet.dk/sites/default/files/paragraph/field_download/Baggrundsnotat%20Sektorvurderinger.pdf

and poses the main challenge for reducing emissions adequately to contribute to net zero. An adequate GHG reduction will require a reduction in the number of fossil fuel cars. However, so far there has been no political will to speed up the transition. Instead, political focus has mostly been on the development of blending of biofuels and increasing the number of electric cars, which is an approach that has been deemed highly risky and inadequate by the Climate Council[121]. Big challenges lie also in reducing emissions of heavy trucks and air traffic, because there are not many affordable low-emission technologies available on the market yet; however, a new road pricing system for heavy duty trucks[122] may push more towards electrification from 2025. There is a lot of interest in electric or synthetic fuels (PtX) in the medium future and possibly fuel cell technologies and hydrogen in the more distant future.

The current national policies and EU emissions trading for transport will not be enough to achieve the **Finnish** emission reduction targets for the effort sharing sector by 2030. The Finnish Climate Change Panel suggests that Finland could set up a national emissions trading system for emissions of transport in 2026 which would be compatible with the EU's system. Other measures to cut emissions could be investing in public transport and the infrastructure for walking and cycling, using biofuels in trucks and developing the charging infrastructure for electric vehicles, especially on the highways.[123]

In **Iceland**, the climate action plan has strong focus on the transport sector and electrification of private passenger vehicles is emerging. The challenges in the sector include the three following issues: i) **emissions are rising again.** The transition to electric vehicles has not yet materialised in lower emissions due to the large remaining stock vehicles powered by fossil fuels. As the results from the Environmental Agency [124] illustrate, despite a shift to electric vehicles in recent years, oil use continues to increase in the road transport sector. This indicates that more needs to be done to reach set aims beyond increasing investment in electric light duty vehicles, for example to emphasise even further the need for modal shifts and reduced travel demand. ii) **Lack of foresight and transparency in use of economic instruments**. Subsidies are changing for BEVs at the end of 2023. How the subsidies will change is not yet clear, and thus the expected impact on the transition to BEVs is unclear. iii) **Lack of targets and initiatives in harder to mitigate sectors**. Government targets and initiatives in

121. Klimarådet (2023). *Sektorvurderinger, Baggrundsnotat til Klimarådets Statusrapport 2023, kapitel 3.* Retrieved from, https://klimaraadet.dk/sites/default/files/paragraph/field_download/Baggrundsnotat%20Sektorvurderinger.pdf
122. Skatteministeriet (2023, March 29). *Ny aftale om kilometerbaseret vejafgift for lastbiler gør Danmark grønnere*. Retrieved from, https://www.skm.dk/aktuelt/presse-nyheder/pressemeddelelser/ny-aftale-om-kilometerbaseret-vejafgift-for-lastbiler-goer-danmark-groennere/#:~:text=Som%20en%20del%20af%20det,2%2C%20der%20udledes%20fra%20k%C3%B8rslen [Accessed 10.05.2023]
123. The Finnish Climate Change Panel. (2023). *Suuntaviivoja Suomen ilmastotoimien Tehostamiseen [Guidelines for enhancing climate action in Finland].* Retrieved from, https://www.ilmastopaneeli.fi/wp-content/uploads/2023/02/ilmastopaneelin-julkaisuja-1-2023-suuntaviivoja-ilmastotoimien-tehostamiseen.pdf
124. Helgadóttir, Á.K., Einarsdóttir, S.R., Keller, N., Helgason, R., Ásgeirsson, B.U., Helgadóttir, I.R., Barr, B.C., Hilmarsson, K.M., Thianthong, J.C., Snorrason, A., Tinganelli, L. & Þórsson, J. (2023, March 15). *Report on Policies, Measures, and Projections. Projections of Greenhouse Gas Emissions in Iceland until 2050.* Environment Agency of Iceland. Retrieved from, https://ust.is/library/Skrar/loft/NIR/0_PaMsProjections_Report_2023_WITH%20BOOKMARKS.pdf

addition to R&D and demonstration are needed for heavy duty vehicles, aviation and domestic shipping.

In **Norway** the major challenges for reducing transport-related GHG emissions are topographical, technical, and high cost and investments. Railway is the most climate-friendly short- to medium-distance transportation mode, but expensive due to fjords, mountains, long distances and thin populations. Battery-electric vehicles can take over most of the passenger segment but have been dependent on large government subsidies as compared to fossil-fueled cars. For lorries and freight transportation, the available battery technology constrains the emission reduction potential, but increased availability of biofuels and development of a hydrogen-based infrastructure are promising alternatives. In the marine sector, battery-hybrid ferries are a success story, but express boats and other near-shore ships depend on more biofuels, and future availability of hydrogen or ammonia. The biggest challenge is for deep sea shipping, where climate-friendly designs and fuels are little developed.

In **Sweden**, there is a need for combinations of policy instruments, both those that make fossil alternatives more expensive and those that contribute to the increased use of alternatives to use of fossil fuels, in order for the use of fossil fuels to be phased out and to attain the ESR commitments, as well as national milestone targets.

A further challenge is to accomplish a just transition. The faster and more comprehensive the transition, the greater consideration needs to be given to companies and households lacking the resources to change their choice of measures to fossil-free and energy-efficient alternatives at the required rate[125].

The weakening of the GHG reduction mandate will challenge Sweden's climate targets.

**Across the Nordic countries,** this report indicates that the biggest challenges on the path towards climate neutrality lie in the road transport sub-sector. Despite the increased uptake of electrical vehicles, emissions have stagnated or are even rising in some countries.

While electric passenger cars produce significantly lower emissions than Internal Combustion Engine (ICE) cars, due to the high energy efficiency of electric propulsion and the low or declining $CO_2$ emissions from electricity production, there are significant obstacles for a swift reduction in transport emissions.

For the present, in most Nordic countries, barriers remain for consumers on the car markets, in terms of higher purchase prices compared to ICE cars combined with limited availability of (especially) cheap electric car models limited driving range of

125. Naturvårdsverket (2023). *Underlag till regeringens kommande klimathandlingsplan och klimatredovisning*. NV-08102-22. Retrieved from, https://www.naturvardsverket.se/499a4f/contentassets/4c414b0778e9409fb2836fc4d3dc6259/underlag-till-regeringens-kommande-klimathandlingsplan-och-klimatredovisning-2023-04-13.pdf

available models, and limited availability of charging points for some user segments, for example dwellers in apartment housing. Those barriers are currently being addressed by market actors and via EU and national policies with Norway as the leading example.

However, even with accelerating uptake of electric cars and future bans on new ICE car registrations in the EU, ICE cars are still widely purchased and a huge number of those cars will remain in the vehicle fleets of the Nordic countries for several years to come, where they will emit and cumulate large amounts of GHG emissions beyond 2030. Policies to curb remaining ICE fleet emissions have so far mostly been limited to the deployment of biofuels though blending mandates or GHG reduction requirements for fuels. This approach follows EU-regulations, supplemented by national measures in most Nordic countries.

However, measures to promote biofuels are now becoming more controversial due to issues like high fuel costs, concerns over indirect climate impacts, alternative uses of scarce raw material and the persistence of pollutant emissions in urban areas. For example, Sweden, which adopted the strongest pro-biofuel policy in the EU so far (reaching a 25% share of renewable fuels in the transport sector by 2021) has recently reversed their position completely, towards compliance at the EU minimum level. In Denmark, the Climate Council has recently advised against the government's intentions to fulfill the 2025 climate target via increased biofuel blending, due to the indirect market and land-use effects.

Other alternative fuels based on hydrogen, or even synthetic fuels for combustion engines are not considered by climate and energy policy authorities as realistic alternatives for passenger cars, due to low energy efficiency and very high fuel costs for years to come, meaning that EV's will deploy before and make those solutions unattractive.  Hence, the remaining ICE car fleets represent a huge challenge for climate and environment policies in the Nordic countries and beyond, not least in urban areas where ICE cars in particular create multiple externalities while also taking up urban space and capacity for driving and parking that could be put to other beneficial uses.

While electrification, as above, has penetrated passenger road transport (including both cars and buses) the transition to electric or electricity-based transport has hardly begun in the road freight sector (representing around 20-30% of road transport emissions). Significantly higher vehicle costs, limited market supply of e.g. electric or hydrogen trucks, limited driving range of available models, and so far poorly developed infrastructure represent significant obstacles in this area. Meanwhile, the continued dominance of diesel for freight transport is most urgently felt in urban areas, where freight vehicles represent a much larger proportion of emissions and environmental impacts than their numbers indicate, creating a strong momentum for zero emission alternatives. While there are diverging views and market outlooks regarding the future propulsion systems for long distance trucks, electrification is likely to become the

preferred solution for most trucking operations towards and after 2030 as technologies mature and costs are expected to come down. Yet due to the uncertainties involved and the long lead time for this transition, the issue of a role for biobased or synthetic alternatives as possible transition or niche fuels is particularly pronounced in the road freight sector. Business interests in existing or potential new alternatives such as Liquified Biomethane (biogas), HVO, hydrogen and various PtX-based products are currently pushing for government attention and support in Nordic countries and elsewhere. It is a challenge for Nordic governments to define clear strategies and business framework conditions for decarbonising road freight transport and especially to devise a clear role (if any) for biofuels.

Based on these observations, we have singled out the following two cross-Nordic challenges:

- the role of biofuels
- phasing out ICE car dominance.

These are described in further detail below.

### 12.4.1. Determining the future role of biofuels

*The challenge*

EU and national regulations in the Nordic countries prescribe suppliers to limit $CO_2$ emissions from fuel combustion on a life cycle basis. The metrics used allow the blending of sustainable biofuels to count towards reduction targets depending on the particular feedstock and production methods. This has been a cornerstone in strategies to obtain $CO_2$ reductions from transport in Nordic countries like Sweden, Norway and Finland, some of which are currently suspending previous targets. Bodies like the IPCC, the European Scientific Advisory Board on Climate Change and the Danish Climate Council have recently highlighted that the production of biofuels is limited by land resources, competing with food production and ecosystems services. Some types of biofuels, like first generation based on food crops, have been increasingly restricted while other 'advanced' ones, based on non-food items, residues and waste, are favoured. The rationale is that First Gen biofuels compete with other uses of the feedstock leading to higher market prices and expansion of cultivated areas which may lead to indirect emissions. The Indirect land use change (ILUC) emissions are, however, difficult to calculate, and they are not currently included in GHG accounting metrics for biofuels in countries like Denmark or Sweden. There are ongoing technical and policy debates on how such criteria could best be applied (see, e.g., Malins 2021[126]) in the case of continued or extended use of biofuels.

126. Malins, C. (2021, December). *Considerations for addressing indirect land use change in Danish biofuel regulation.* Cerulogy. https://ens.dk/sites/ens.dk/files/Basisfremskrivning/chris_malins_rapport_-_concicerations_for_adressing_iluc_in_danish_biofuel_regulation.pdf

It has been argued that the Nordic region has a rich base of biological waste and residues stemming from large agricultural and forest sectors, and thus a large potential feedstock capacity for producing sustainable biofuels without indirect land-use consequences. However, some of these feedstocks (like lignin in wood waste) are difficult to process, requiring further research and development before they could potentially be deployed at scale.

Hence, by now the vast majority of transport biofuels consumed in the Nordic countries are based on imported raw materials. This has also led to questioning the overall sustainability of the current approach, due to the fact that waste feedstocks are globally limited and not all countries could base their biofuel on imports. This emphasises the need for realistic evaluations of the potential for sustainable biofuel production in the Nordic region.

Finally, there is a discussion about which sector should be allowed to utilise the limited biofuel resources if production and scale-up becomes successful. Road transport will be increasingly electrified over the coming years with a potential need to supplement with hydrogen or ammonia for some long-distance freight trips. By contrast, sectors like aviation and shipping will likely be more difficult to electrify although technological developments are progressing there as well. Allocating biofuels to hard-to-mitigate sectors (that cannot be electrified directly) could be one option.

*Opportunities*

- Developing a Nordic roadmap for the sustainable development, production, and use of biofuels and synthetic fuels

The Nordic Council of Ministers should commission a cross-Nordic study on how the development, production and use of different types of biofuels in the Nordic region could best contribute to a reduction in GHG emissions over the coming decades, avoiding overutilisation of sparse bio-resources and negative externalities.

This work should conclude with a Nordic roadmap for sustainable development, production and use of biofuels and synthetic fuels. The roadmap should address to what extent expansive, contractive or more differentiated strategies could be pursued, in the light of global constraints, regional opportunities and different sectoral needs.

### 12.4.2. Phasing out ICE (Internal Combustion Engine) car dominance

*The challenge*

There is a high risk that ICE cars constituting the bulk of the vehicle fleets will maintain high levels of transport GHG emissions for several years ahead, despite strong increases in EV sales in Nordic countries. Solving this challenge likely requires a strategy to de-scale and phase out the dominance of ICE cars in use well ahead of any future bans of new ICE car sales. Such a phasing-out strategy should clearly recognise

and support the various mobility needs of current ICE users, as well as the potential climate and environmental impacts of early phasing out/scrapping existing ICE cars, taking into account life-cycle emissions as well as any spillover impacts from the export and life extension of used ICE cars in other countries or other regions outside the Nordics.

EV's should ideally proliferate first in those contexts where they would benefit zero emission mobility the most, especially by replacing ICE cars. This would likely include much of today's and future ICE car use in urban areas. ICE passenger cars continue to dominate cities in the Nordics and elsewhere despite opportunities for extensive use of public and active transport modes and shared solutions offered by the density and proximity of urban areas. The negative aspects of this dominance extend to factors like emissions, environmental quality, safety and the use of space. Shift to EV's will help alleviate some but far from all of those problems. Hence, urban mobility strategies should include a combination of so-called Avoid, Shift and Improve measures, within a framework of Sustainable Urban Mobility Planning as promoted by the EU New Urban Mobility Framework. To be effective, such plans would not only need to include measures to promote greener forms of mobility and access (shared EV's, public transport, cycling, walking, virtual mobility, etc.) but also to gradually constrain access by ICE cars to more parts of the cities.

It is paramount that national governments support cities in conceiving and implementing such strategies within a multi-level governance framework. National support programmes are strongly encouraged by recent EU mobility policies, while existing models for green multilevel transport governance are already partly applied in the Nordic countries through programs such as Norway's so-called 'Byvekstavtaler' aiming to curb car traffic growth, and the 'Stadsmiljöavtal' in Sweden, where national funding supports comprehensive sustainable local plans.  There is a need to better understand and compare the potential for such multi-level arrangements to speed up the transformation to climate neutral urban mobility in the Nordic countries, with a clear potential for transfer to other regions of the world.

ICE cars gradually discouraged from maneuvering in or entering cities could either be considered for early scrapping or for shifting to a second life serving car users and families outside cities with limited needs for driving, and hence lower daily and yearly transport emissions. It would be a highly interesting challenge to explore a set of policy measures that could underpin such a shift in the remaining (and shrinking) ICE fleet towards gradually lower transport need contexts, without introducing significant socio-economic burdens to groups of citizens.

Early retirement of ICE's could also be potentially beneficial, provided it would not either cause excessive emissions and waste from the destruction and recycling of useful capital, or lead to export of ICE's to, for example, LDC's in the global South where they, in contrast, could end up remaining in active (and highly emitting) service for many more years than would be the case in their Nordic country of origin. The

challenge could be to better understand the trade-off between such outcomes for various vehicle categories considering life cycle GHG emissions within and outside the Nordic region, and to devise appropriate policies.

*Opportunities*

- Developing a strategy for how to reallocate ICE cars to those users and uses that would have the lowest travel needs and a supporting assessment framework to identify the GHG trade-offs of different policies

The Nordic Council of Ministers could assist the countries with phasing out ICE car dominance by developing a strategy for how to potentially reallocate ICE cars to those users and uses that would have the lowest travel needs and vehicle kilometers, via suitable policy measures, considering socio-economic and mobility impacts. To support and advise on this strategy, an assessment framework to address GHG trade-offs between policies that would shift ICE cars to lower use, exporting to external regions, or early scrappage should also be developed in parallel.

- Supporting urban action plans for zero emission passenger and freight transport

This would include analysing and comparing multi-level governance frameworks and arrangements for decarbonised sustainable mobility in urban regions. Different levels of government have responsibilities for different parcels of the spatial domain, different sections of the transport system and different levers in the policy toolbox. Aligning transport planning and policy measures across levels of government, therefore, has the potential to achieve more effective decarbonisation[127]. The Nordic Council of Ministers could strengthen decarbonisation efforts in the transport sector by commissioning a study on multi-level governance frameworks in different countries, suggesting strategies applicable to the Nordic region and focusing on models empowering cities to diminish car dependence in general and eliminate the use of ICE cars.

- Knowledge-sharing on promoting public transport across the Nordic countries to further lower emissions from the use of ICE cars, and coordination of rail transport systems across the Nordics

127. Marsden, G. & Gudmundsson, H. (2023, March 31). *Aligning Transport Decarbonisation Across Policy Levels - a comparative review of countries*. Concito. Retrieved from, https://concito.dk/files/media/document/Aligning%20Transport%20Decarbonisation%20across%20levels%2011.04.pdf

# 13. Industrial processes

Emissions from industrial processes across the Nordic region totalled 25 million tonnes of $CO_2e$ in 2021, corresponding to 17% of total Nordic emissions, including the LULUCF sector. Omitting the LULUCF sector, emissions from industrial processes are responsible for 13% of territorial Nordic emissions.

This chapter covers a combination of emissions from industrial processes and product use, following the categories in the IPCC Guidelines, and the emissions and challenges in the broader industry sector in the Nordic countries, following national delimitations of this part of the economy. If necessary, delimitations are described in the respective country sections. The emissions described in this introductory section do not include the energy use of the industrial (business) sector – this is covered instead in the Energy chapter.

The main emissions sources for industrial processes and product use are releases from industrial processes that chemically or physically transform materials, such as ammonia and other chemical products manufactured from fossil fuels used as chemical feedstock and the cement industry.

From 1990 to 2021, the GHG emissions from the Nordic industry sector have been reduced by 5 million tonnes of $CO_2e$, corresponding to a 17% emission reduction in the sector.

Norway in particular has driven this reduction, with emission reductions in their industry sector of 39% from 1990 to 2021. In the same period, Denmark and Sweden reduced industrial process emissions by 9% and 6%, respectively, while Iceland and Finland experienced emissions increases in the sector of 122% and 3%, respectively.

Figure 18 provides an overview of the GHG emissions from industrial processes and product use across the Nordic countries.

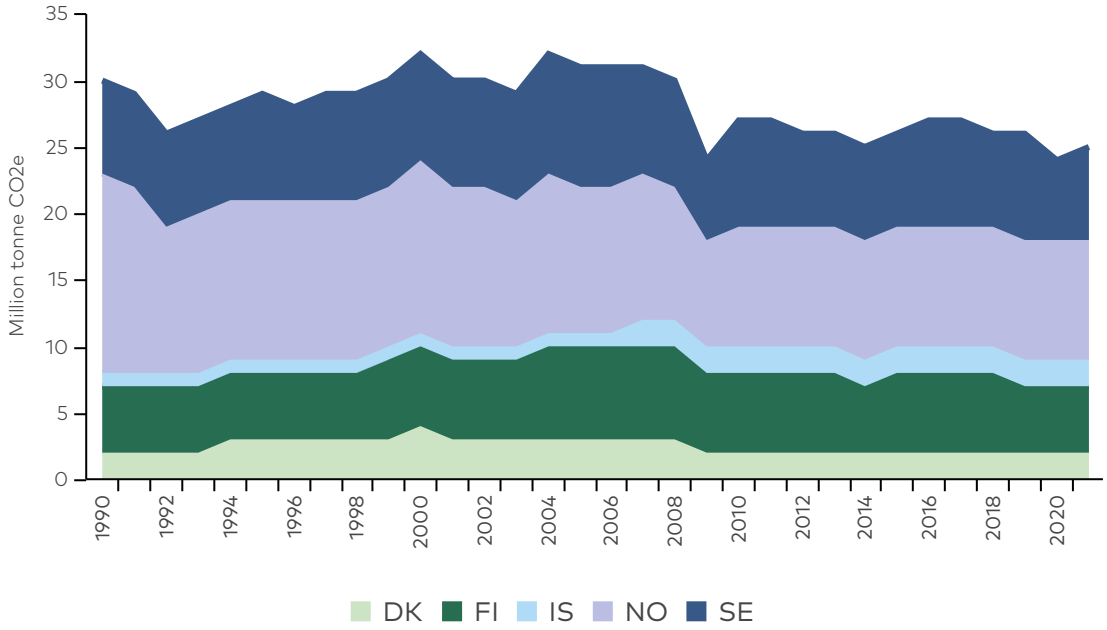


**Figure 18:** GHG emissions from industrial processes and product use across the Nordic countries 1990-2021

*Source: UNFCCC. GHG data from UNFCCC.*
*https://unfccc.int/topics/mitigation/resources/registry-and-data/ghg-data-from-unfccc*

The paper and pulp industries are large in Sweden and Finland, and the mineral and metals industries are important in Sweden, Finland, Norway and Iceland. The emissions from calcination from cement production is particularly an issue in Denmark, Sweden and Finland.

The emissions from the industrial sector in the Nordic countries have primarily been regulated through the EU ETS and different national carbon pricing mechanisms. For example, in Denmark, the green tax reform of 2022 with a $CO_2$-tax on emissions on top of ETS is expected to drive a large part of the transition in this sector.

Table 7 and Table 8, below, give a summary of industrial process emissions across the Nordic countries, based on the sections following.

**Table 7:** Emissions from industrial processes across the Nordic countries – a summary

| | Denmark | Finland | Iceland | Norway | Sweden |
|---|---|---|---|---|---|
| **Emissions, 1990** *Mt $CO_2e$* | 2.1 | 5.2 | 0.9 | 14.7 | 7.4 |
| **Emissions, 2010** *Mt $CO_2e$* | 1.9 | 6.1 | 1.9 | 8.9 | 8.2 |
| **Emissions, 2021** *Mt $CO_2e$* | 1.9 | 5.3 | 2.0 | 9.0 | 7.0 |
| **Development, 1990-2021** | -9.0% | +2.5% | +122.3% | -38.7% | -6.1% |
| **Development, 2010-2021** | +1.5% | -12.3% | +5.7% | +1.4% | -14.5% |

*Source: UNFCCC. GHG data from UNFCCC. https://unfccc.int/topics/mitigation/resources/registry-and-data/ghg-data-from-unfccc*

**Table 8:** Industrial processes across the Nordic countries – a summary of main challenges

| Country | Summary of main challenge(s) |
|---|---|
| **Denmark** | • Scaling up CCS to address process emissions from metallurgical, ceramic and other processes that require high temperatures<br>• Availability of affordable, green electricity |
| **Finland** | • Large investments needed for emission reduction technologies in the steel industry<br>• Maturing and commercialisation of key decarbonisation technologies |
| **Iceland** | • Development of technological solutions including carbon capture for process emissions<br>• Lack of targets and sector-focused strategy to reduce emissions |
| **Norway** | • The large investments needed, the need for a long time horizon, an increasing power price, and the risk of reduced competitiveness within international markets |
| **Sweden** | • Expanding Sweden's fossil-free power production capacity<br>• Lack of competent labour in northern Sweden, where green production is planned<br>• Timely mitigation of process emissions from the cement industry |

The industrial sector is also largely dependent on developments in the energy sector with respect to the access to dependable – and preferably cheap – fossil-free energy to electrify industrial processes without losing international competitiveness. CCS, CCU and similar technologies, together with green fuels, are expected to play a large role in achieving net-zero emissions in this sector and the Nordic countries are piloting different initiatives such as government support for CCS on point-sources and prioritizing R&D for CCS-technologies. Regarding green fuels, Denmark, for example, expects that its gas consumption will be 100% biogas in 2030.

Achieving emissions reductions in the industrial sector necessitates overcoming financial barriers, as the transition to low-carbon industrial technologies often involves higher upfront costs and long payback periods.

The cross-Nordic challenges focused on in this report in the industrial processes and are:

- reducing emissions through economic incentives while preserving international competitiveness.
- scaling up and providing incentives for carbon capture, utilisation and storage (CCUS) and carbon dioxide removal (CDR).

In the industry sector, we see the following opportunities for creating added Nordic value through collaboration:

- piloting public procurement for low-carbon industrial products
- knowledge-sharing on best practices in incentivising direct electrification of suitable industrial processes across the Nordic countries.
- intensifying collaboration on the value chain of Carbon Capture and Storage across the Nordic countries.
- developing a joint Nordic CCS strategy to increase the potential to realise economies of scale in transportation and storage infrastructure for captured carbon dioxide.
- Nordic research on governance and business models for generating $CO_2$ removal (negative emissions).

## 13.2. Status of industrial processes across the Nordic countries

In **Denmark**, the DEA's projections on industrial emissions also encompass emissions from energy use in the building and manufacturing sector. Emissions from oil and gas production are also included below, as well as from refineries. Thus, emissions described in the following are higher than presented in the introductory section. According to the DEA, emissions from industry were 10 million tonnes of $CO_2$e in 1990, down to 7.8 million tonnes in 2021, a 22% decrease. The DEA expects the emissions to decrease to 4 million tonnes in 2030, a 60% decrease from 1990[128]. The decrease towards 2030 is primarily due to incentives created by the green tax reform and the EU ETS. A major proportion of industrial emissions in Denmark are from the production of cement, oil and gas, and refineries. As shown previously (and following the IPCC sectors), these process emissions have been reduced by 9% from 1990 to 2021.

128. Energistyrelsen (April 2023). *Klimastatus og -fremskrivning, 2023*. Retrieved from, https://ens.dk/sites/ens.dk/files/Basisfremskrivning/kf23_hovedrapport.pdf

The direct emissions from manufacturing industries and construction cover about 13% of **Finland's** total emissions and have declined by about 44% from 2005. In addition to the direct emissions, industrial production has emissions allocated to the energy sector. Many significant Finnish industrial sectors, like the forest and steel industries, are energy intensive and thus the availability of low-carbon energy is key to reducing industrial emissions. Circular economy and hydrogen are seen as future solutions to reduce emissions in, for example, the chemical industry.[129]

The direct emissions of the mineral and metal sector cover approximately 6.5% of Finland's total emissions. The majority of sector-related emissions come from the steel industry, but the emissions and the share of the mining industry are increasing due to rapidly increasing production[130].

The **Icelandic** minerals and metals industry accounts for 92% of emissions from industrial process and product use. The sector currently consists of three operating aluminum smelters, a ferro silicon plant and a silicon metal production plant and is responsible for close to 40% of total national emissions when excluding LULUCF. In 1990, a cement plant was also operating but was closed in 2011. As the minerals and metals industry already runs on low emissions electricity, emissions are largely process emissions. As expected with the increase in production capacity, emissions in 2021 from minerals and metals were 107% higher than emissions in 1990, with emissions from aluminum 133% higher in 2021 compared to 1990. The smaller increase in emissions compared to the increase in production capacity over the same time-period illustrates improvement in production efficiency and process management that has been achieved since 1990[131].

The minerals and metals industry is subject to EU ETS regulations and as a result has not received much focus in the Icelandic climate action plan. The action plan simply refers to the overall goal of the EU ETS sector, which was a 43% reduction in emissions by 2030 compared to 1990. The plan has not been updated since the EU increased its ambition for sectors governed by the EU ETS system, but the climate action plan refers to the need for this to be done. No additional climate policy instruments beyond the EU-ETS system have been applied.

In **Norway**, industrial GHG emissions have been reduced by 41% since 1990, mostly before 2010, due to various process changes for aluminum and fertiliser production (and closure of magnesium

129. Kemianteollisuus (2020, June). *Roadmap to reach carbon neutral chemistry in Finland 2045.* Pöyry. Retrieved from, https://kemianteollisuus.studio.crasman.cloud/file/dl/i/W03X2Q/PB5Ml6LzO_u6iKyGGkWFUQ/Kemianteollisuusroadmapandexecutivesummary.pdf
130. Kaivosteollisuus (2023, April 5). *Ilmastopäästöt kuriin.* [online] Retrieved from, https://www.kaivosteollisuus.fi/fi/vastuullista-toimintaa/ilmastopaastot-kuriin# [Accessed 20.05.2023].
131. Keller, N., Helgadóttir, Á.K., Einarsdóttir, S.R., Helgason, R., Ásgeirsson, B.U., Helgadóttir, D.,Helgadóttir, I.R., Barr, B. C., Thianthong C. J. Hilmarsson, K.M., Tinganelli, L., Snorrason, A., Brink, S.H. & Þórsson, J. (2023, April 14). *National Inventory Report. Emissions of Greenhouse Gases in Iceland from 1990 to 2021. Environment Agency of Iceland.* Retrieved from, https://ust.is/library/Skrar/loft/NIR/ISL_NIR%202023_15%20april_on_web.pdf

plants)[132]. The two major metal industries in Norway are aluminum and steel, where power is the dominating energy source and considerable emissions are process related.

Cement production is a major mineral-based industry in Norway, located near limestone deposits. The largest plant is Norcem Heidelberg Brevik, which is a major point source of $CO_2$ that is included in the Langskip CCS project.[133] Most of the large cost of the $CO_2$ capture facility at the plant is covered by the government.

In **Sweden**, the GHG emissions from industrial processes and product use amounted to 7 million tonnes of $CO_2e$ in 2021. The emissions in this sector are process-related and stem from the materials used in industrial processes as well as the use of various products[134].

The GHG emissions were 6% lower compared to 1990. The emissions in the sector are to a large extent linked to a few larger industrial plants in the iron and steel industry, mineral industry, chemical and refinery industry as well as mines and other metal industries. Among the industries within this sector, the metal industry was the largest contributor to GHG emissions in 2021, accounting for 3 kt $CO_2$ eq. or 43%. The second largest contributor of GHG emissions in this sector is the mineral industry. Process-related emissions have decreased to a lesser extent than traditional measures to reduce emissions such as displacing fuel oil (and that part of the industry is included in the energy sector in this report). The decrease that has taken place is due to the introduction of new process technology.

## 13.3. Pathways towards climate neutrality in industrial processes

In **Denmark**, emissions are expected to decrease following the implementation of the national tax reform in combination with greener electricity, more biogas in the gas grid and electrification of industry. In the long term, oil and gas production emissions will decrease as fields are getting older and will eventually stop production in 2050 at the latest, according to the political agreement on oil and gas production in the North Sea [135]. Emissions from refineries are, with some degree of uncertainty, expected to decline as the national carbon tax is introduced, thus incentivising e.g. process electrification and the use of renewable fuels, leading to $CO_2$-reductions[136].

132. Miljøstatus (2023). *Norske utslipp og opptak av klimagasser*. Norwegian Environment Agency. Retrieved from, https://miljostatus.miljodirektoratet.no/tema/klima/norske-utslipp-av-klimagasser/ [Accessed 20.05.2023].
133. CCS Norway (n.d.). *Longship timeline*. Retrieved from, https://ccsnorway.com/ [Accessed 20.05.2023].
134. Swedish Environmental Protection Agency (2023, April 6). *National Inventory Report Sweden 2023*. Retrieved from, https://unfccc.int/documents/627663
135. Klima-, Energi-, og Forsyningsministeriet (2020, December 4). *Bred aftale om Nordsøens fremtid*. [online] Retrieved from, https://kefm.dk/aktuelt/nyheder/2020/dec/bred-aftale-om-nordsoeens-fremtid [Accessed 20.05.2023].
136. Energistyrelsen (2023, April). *Klimastatus og -fremskrivning, 2023*. Retrieved from, https://ens.dk/sites/ens.dk/files/Basisfremskrivning/kf23_hovedrapport.pdf

In **Finland**, the reduction of industrial emissions is mainly guided by the low-carbon roadmaps produced by the business sectors with the support of the government. The roadmaps will be updated, where applicable, during 2023. Electrification and hydrogen play a key role in reducing emissions from the process industry and the government supports this development. An electrification subsidy for energy-intensive companies has been introduced to promote low-carbon investments in industry[137], although only part of the subsidy is earmarked for actual electrification measures. Investment support has also been available.

The emission intensity per production unit in Finland has decreased in both the mining and steel industries, but the largest potential lies in the adoption of new technology. The steel sector is focusing on the development of new HYBRIT technology that aims to replace coking coal, traditionally needed for ore-based steelmaking, with green hydrogen. The first batch of raw material was produced in 2021[138], and commercial production is expected to start in 2026[139]. The launch of this technology alone would reduce Finland's total carbon dioxide emissions in the 2030s by about 7%. Other industrial initiatives include biomass as an alternative to coke[140], intelligent process control technologies, increased use of side streams and recycled materials, electrification of mining machines and different parts of the steel process[141], alternative sources of energy like small modular nuclear reactors[142] as well as CCUS[143].

In **Iceland**, the sector is subject to the EU ETS system and no domestic policy initiatives beyond that system have materialised. Industry-driven initiatives have, however, begun to emerge that focus on carbon capture and mineralisation and in addition use the replacement of carbon electrodes. A Memorandum of Understanding (MOU) was signed between the government, Reykjavik Energy (via its subsidiary Carbfix) and the metals industry to explore the possible use of the Carbfix process to capture and mineralise emissions (CCM).

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137. Ministry of Economic Aairs and Employment of Finland (2022, September 9). *Carbon neutral Finland 2035 – national climate and energy strategy*. Retrieved from, https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/164323/TEM_2022_55.pdf?sequence=4&isAllowed=y
138. Sipola, T. (2021, August 18). *Maailman ensimmäinen erä fossiilivapaata terästä on valmiina – uusi teknologia vähentää pian Suomen hiilidioksidipäästöjä seitsemän prosenttia.* Yle. [online] Retrieved from, https://yle.fi/a/3-12062634 [Accessed 20.05.2023].
139. SSAB (n.d.). *Time line for fossil-free steel production*. [online] Retrieved from, https://www.ssab.com/en/company/sustainability/first-in-fossil-free-steel/timeline [Accessed 20.05.2023].
140. Teknologiateollisuus (2020, January 9). *Teknologiateollisuuden vähähiilitiekartta raportti – vaihe 1.* Pöyry. Retrieved from, https://teknologiateollisuus.fi/sites/default/files/inline-files/Teknologiateollisuuden%20tiekartta1_Teknologiaselvitys%20vähähiiliratkaisuista_Pöyry.pdf
141. Teknologiateollisuus (2020, January 9). *Teknologiateollisuuden vähähiilitiekartta raportti – vaihe 1.* Pöyry. Retrieved from, https://teknologiateollisuus.fi/sites/default/files/inline-files/Teknologiateollisuuden%20tiekartta1_Teknologiaselvitys%20vähähiiliratkaisuista_Pöyry.pdf
142. Fortum (2023, March 23). *Fortum ja Outokumpu selvittävät mahdollisuuksia terästeollisuuden hiilidioksidipäästöjen vähentämiseksi.* [online]. Retrieved from, https://www.fortum.fi/media/2023/03/fortum-ja-outokumpu-selvittavat-mahdollisuuksia-terasteollisuuden-hiilidioksidipaastojen-vahentamiseksi [Accessed 20.05.2023].
143. Teknologiateollisuus (2020, January 9). *Teknologiateollisuuden vähähiilitiekartta raportti – vaihe 1.* Pöyry. Retrieved from, https://teknologiateollisuus.fi/sites/default/files/inline-files/Teknologiateollisuuden%20tiekartta1_Teknologiaselvitys%20vähähiiliratkaisuista_Pöyry.pdf

The Coda Terminal[144], the first industrial scale CCM operation in Iceland not associated with a geothermal power plant, will be located at the site of the Rio Tinto aluminum smelter in SW Iceland. Opportunities are being explored for CCM from the smelter but cost-effective carbon capture remains a challenge. Other initiatives in the aluminum industry include using inert cathode material, such as by the company Arctus.

The ferro silicon plant, Elkem, is exploring options for carbon capture and use and has signed an MOU with Carbfix to potentially use the Carbfix CCM process in their operations.

In **Norway**, the most promising technological options to reduce GHG emissions from e. g. the aluminum, ferro & silicon, and manganese industries are replacement of the carbon anodes with inert anodes, replacing fossil carbon with biochar, using biogas and hydrogen for heating, and CCS. However, this will require large investments that would only be profitable given a high carbon price, and emissions could first be reduced after 2035. In addition, this transition would likely need more power for these industry processes.

Over 90% of total emissions from the **Swedish** industry are regulated within the EU ETS. Revisions of the EU ETS directive have decreased the number of available emissions allowances and will decrease even more rapidly in the future. This has already led to rising prices. In addition to the EU ETS, there are other policies, both at national and EU level, which affect the industry's emissions to varying extents. There is a range of support for research, development and demonstration within the industry. The Industrial Leap Programme (Industriklivet) targets process-related emissions through support towards research, development and demonstration (RD&D). The EU Innovation fund has granted support for several Swedish projects.

In projections[145], emissions from stationary plants within the EU ETS in Sweden are estimated to decrease by 67% by the year 2045 compared to 2005. The decrease is mainly due to a technology shift to hydrogen-based steel production, assumed to be implemented alongside the introduction of CCS technology in the cement industry and in refineries. The technology shifts are assumed to be implemented from 2030. In the projections, the emissions from product use also continue to decrease as an effect of the bans that are gradually coming into force for a number of uses of fluorinated greenhouse gases, as a result of new regulations in the EU.

According to an interview study, companies responsible for the largest emissions in the sector state that they have taken further steps towards meeting the goals for their business's climate transition. Several companies have initiated permitting processes as part of restructuring their operations and are conducting feasibility studies to switch

144. Carbfix (n.d.). *Coda terminal*. Retrieved from, https://www.carbfix.com/codaterminal [Accessed 10.05.2023]
145. Naturvårdsverket (2023). *Underlag till regeringens kommande klimathandlingsplan och klimatredovisning*. NV-08102-22. Retrieved from, https://www.naturvardsverket.se/499a4f/contentassets/4c414b0778e9409fb2836fc4d3dc6259/underlag-till-regeringens-kommande-klimathandlingsplan-och-klimatredovisning-2023-04-13.pdf

to methods with low or no emissions[146]. It is stated that the demand for carbon dioxide-free products is starting to pick up, which could accelerate the transition even further. Several business sectors, including cement and steel, have produced roadmaps for fossil-free competitiveness within the framework of Fossil Free Sweden, an initiative that was started by the Swedish government in 2015. The roadmaps contain both commitments and political proposals which pave the way for an interaction between business and politics.

It is worth noting that the Swedish government is preparing a climate action plan to be delivered by the government in the autumn of 2023, which will describe how the climate goals are to be achieved.

## 13.4. Challenges in industrial processes on the way towards climate neutrality and opportunities for Nordic collaboration

In **Denmark**, the major challenge for decarbonising the industrial sector in the long term is cement production. Cement will likely be needed for many years, but increased use of renewables can only mitigate the energy-related emissions from cement (approximately 50%). Thus, CCS is likely to be necessary to mitigate process emissions (calcination). Both fuel switching and CCS are part of the Danish cement plant Aalborg Portland's 2030 strategy to significantly lower their carbon footprint[147]. The achievement of this transition is in large part conditional on lower CCS costs and/or the incentives provided by the EU ETS and the national carbon tax, as well as, potentially, state aid. This ambition may be supported by the fact that the ETS price is expected to increase towards 2030, significant state aid is already dedicated to CCS and CCS costs, considered broadly, may decrease in the future as basic learning curves and price reductions in the scaling of CCS are enacted.

For **Finland**, the main challenges in the steel industry are that significant emission-reduction technologies require large investment and are not yet in use on a commercial scale. There is also a significant need for affordable low-carbon electricity. Overall, many of the new technologies required to decarbonise process industries are still at relatively low levels of maturity, carrying both higher costs and risks.[148] While CCS is being considered in many industries, Finland does not have suitable geological formations for permanently storing the carbon and no incentives yet to capture biogenic carbon.

146. Naturvårdsverket (2023). *Underlag till regeringens kommande klimathandlingsplan och klimatredovisning*. NV-08102-22. Retrieved from, https://www.naturvardsverket.se/499a4f/contentassets/4c414b0778e9409fb2836fc4d3dc6259/underlag-till-regeringens-kommande-klimathandlingsplan-och-klimatredovisning-2023-04-13.pdf
147. Aalborgportland (n.d.). *2030 Roadmap*. [online]. Retrieved from, https://www.aalborgportland.dk/baeredygtighed/2030-roadmap/ [Accessed 20.05.2023].
148. Teknologiateollisuus (2020, January 9). *Teknologiateollisuuden vähähiilitiekartta raportti – vaihe 1*. Pöyry. Retrieved from, https://teknologiateollisuus.fi/sites/default/files/inline-files/Teknologiateollisuuden%20tiekartta1_Teknologiaselvitys%20vähähiiliratkaisuista_Pöyry.pdf

In **Iceland**, the metals and minerals sector already relies on electricity derived from renewable energy sources. Emissions are therefore process emissions but amount to a significant share of Icelandic emissions. Technological development is still needed to realise mitigation options, for example cost effective capture technology in the aluminum sector and the development of inert cathode materials. To enhance action within the industry, the government needs to sharpen its focus and include the sector formally in its plans and evaluation of future emissions.  For example, the Environmental Agency could include expected impact of policy action such as the EU ETS system in its emissions forecasts[149].

The challenges to ensure effective mitigation from the sector are primarily threefold: **i) Maintain competitiveness:** in particular, as ambition of the EU ETS system increases and CBAM is implemented. **ii) Technological challenges** for example, the aluminum industry lacks cost effective scrubbing technologies and technologies for reduced process emissions. iii) **Lack of targets and sector-focused strategy to reduce emissions:** as the sector is responsible for a large share of national emissions, the government needs to sharpen its focus on the sector beyond its current full reliance on the EU-ETS system.

In **Norway**, the industry has adopted general long-term targets, but the main challenges for a green industry transformation are the large investments needed, the need for a long-term horizon, an increasing power price, and the risk of reduced competitiveness in international markets.

For **Sweden**, the tightening of the EU ETS gives industry stronger incentives to reduce their emissions. At the same time, there is a need for supplementary measures to remove remaining obstacles. Several challenges in this sector have been identified[150]. The future need for electricity requiring an unprecedented expansion of Sweden's fossil-free power production capacity, as well as expansion of transmission capacity. With the current difficulties to get permits for wind power (both on-shore and off-shore), this may delay the needed expansion. Another challenge is the need for competence and labour to settle in northern Sweden where much of the green production is planned. Also, efficient review and permitting processes are required.

In addition to those challenges, timely decarbonisation in the cement industry will be needed. The main cement production company in Sweden, Heidelberg cement, has the ambition and technologies to transform to near zero emissions in 7 years[151]. With EU's new climate package Fit-for-55 (FF55), the price of emissions allowances has exceeded 100 euros for the first time. This is described by Heidelberg cement as a gamechanger. At these levels it's beginning to be commercially advantageous to

149. Helgadóttir, Á.K., Einarsdóttir, S.R., Keller, N., Helgason, R., Ásgeirsson, B.U., Helgadóttir, I.R., Barr, B.C., Hilmarsson, K.M., Thianthong, J.C., Snorrason, A., Tinganelli, L. & Þórsson, J. (2023, March 15). *Report on Policies, Measures, and Projections. Projections of Greenhouse Gas Emissions in Iceland until 2050.* Environment Agency of Iceland. Retrieved from, https://ust.is/library/Skrar/loft/NIR/0_PaMsProjections_Report_2023_WITH%20BOOKMARKS.pdf
150. Swedish Environmental Protection Agency (2023, April 6). *National Inventory Report Sweden 2023.* Retrieved from, https://unfccc.int/documents/627663
151. Fossilfritt Sverige (n.d.). *Cementbranschen.* Retrieved from, https://fossilfrittsverige.se/roadmap/cementbranschen/ [Accessed 10.09.2023]

produce cement with no emissions. However, Heidelberg says that to do the transition the Swedish state will have to fund a power transmission line to the site on the island of Gotland[152].

**Across the Nordic countries**, the industries may differ but the core challenges are the same. Below, we have focused on two where there is high potential for added Nordic value through increased Nordic collaboration. The two chosen challenges are:

- reducing emissions through economic incentives while preserving international competitiveness
- scaling up and providing incentives for negative emissions technologies.

### 13.4.1. Reducing emissions through economic incentives while preserving international competitiveness

*The challenge*

Most, if not all, of the industrial firms in the Nordic countries are competing internationally and a recurring argument against strong regulation on emissions from this sector is the risk of carbon leakage – i.e. that the emitting production "leaks" to another country with firms moving production facilities abroad. As such, to avoid leakage, costly investments in emission reduction technologies tend to need to be incentivised or subsidised.

Public procurement could provide one solution. More than 200 billion euros are spent on public procurement each year across the Nordic countries. This makes public procurement a powerful tool to leverage sustainable practices in the private sector[153]. Public procurement could, for example, be used to push for low-carbon industrial products such as green steel, concrete and various CCU products. There are many industrial investment plans in the Nordics that would benefit from creating first-mover markets for the products. Moreover, recent research has shown that price should not be seen as a barrier for public procurers in setting requirements for low-carbon industrial projects.

In the Mistra Carbon Exit project, the allocation of costs of $CO_2$ abatement across the value chain for steel and cement was assessed. The results showed that the increase in selling price of new low-$CO_2$ steel and cement would neither significantly alter the cost structure nor dramatically increase the price to be paid by end-users[154].

152. Törnwall, M. (2023, May 6). *Norsk klimatbov kan göra det omöjliga*. Svenska Dagbladet. [online]. Retrieved from, https://www.svd.se/a/WR8jK2/klimathotet-kan-cementindustrin-gora-det-omojliga [Accessed 20.05.2023].
153. Nordregio (2022, May 30). *The missing multiplier, How to use public procurement for more sustainable municipalities.* [POLICY BRIEF, 2022:3]. Retrieved from, http://nordregio.org/wp-content/uploads/2022/05/the-missing-multiplier.pdf
154. Mistra Carbon Exit (n.d.) *Pathways to Net Zero Greenhouse Gas Emissions in Supply Chains*. Retrieved from, https://www.mistracarbonexit.com/ [Accessed 20.05.2023].

Besides reducing emissions from industrial processes and product use, electrification is also a part of the way forward for the industry sector in the Nordic region. Industry electrification couples electricity and industry sectors by replacing the fossil fuel demand with electricity demands, thus enabling further integration of renewable electricity and transitioning the hard-to-abate energy sector[155]. Barriers to electrification of industrial processes for the individual firm include up-front costs, planning and technical know-how.

*Opportunities*

We see the following opportunity for cross-Nordic collaboration addressing the challenges outlined above:

- piloting public procurement for low-carbon industrial products.

To leverage the muscle of Nordic public procurement, a forum/network for Nordic public procurers should be established. Within this network, best practice to sustainable procurement of low-carbon industrial products can be shared and common practices developed.

- Knowledge-sharing on best practice in incentivising direct electrification of suitable industrial processes across the Nordic countries

Knowledge-sharing across the Nordic countries could take place both at the government level: sharing experiences and best practice in how to incentivise direct electrification of the industrial sector; and at the industry level: sharing knowledge on direct electrification practices in different subsectors and how to overcome barriers.

The Nordic Council of Ministers could promote knowledge-sharing through forums or networks or by funding cross-Nordic studies with this aim.

### 13.4.2. Scaling up and providing incentives for carbon capture, utilisation and storage (CCUS) and carbon dioxide removal (CDR)

*The challenge*

The attainment of Nordic countries' individual and joint ambitions to reach net-zero GHG emissions may require very significant CCUS and CDR deployment within a couple of decades. But using CCUS and CDR as solutions to emissions and residual emissions in the industry sector is associated with a number of challenges.

In **Denmark**, the current estimated target is 3.2 million tonnes of $CO_2$ pr. year through CCS by 2030. Currently, 0.43 million tonnes are in the pipeline for 2026 with the award of the first contract. The government expects that a tender for negative emissions in

155. Sorknæs, P., Johannsen, R.M., Korberg, A.D., Nielsen, T.B., Petersen, U.R. and Mathiesen, B.V. (2022). Electrification of the industrial sector in 100% renewable energy scenarios. *Energy*, 254, p.124339. Retrieved from, https://www.sciencedirect.com/science/article/pii/S0360544222012427

the autumn of 2023 will result in a further reduction of 0.5 million tonnes pr. year from 2026 . Moreover, there is broad political support to reach the remaining 2.3 million tonnes of $CO_2$ pr. year through two tenders in 2024 and 2025, respectively.

In **Finland**, similar issues arise. There are no dedicated targets, strategies, large-scale RDI funding programmes or incentive schemes for carbon removal in general and technical sinks in particular. A recent study indicates that Finland is lagging behind its Nordic peers in terms of a supportive policy framework. However, the new government has announced new measures, including a target for carbon removal, a reverse auction or a similar incentive for negative emissions and a possible phaseout date for releasing both fossil and biogenic carbon dioxide from large industrial point sources.

The Nordic countries already collaborate on CCUS development in the *Networking group on CCUS (NgCCUS)*[156]; however, individual countries' plans for CCUS primarily focus on national pipelines and national storage capacity.

Current CCS development in the Nordic countries (and beyond) is driven by government tenders and subsidies. To accelerate CCS deployment in the Nordic industry sectors, governments need to have more tools available.

*Opportunities*

This gives rise to the following opportunities for cross-Nordic collaboration:

- intensifying collaboration on the value chain of Carbon Capture and Storage across the Nordic countries

As recently recommended in the report on *Regulatory framework for CCS in the Nordic countries* (2023)[157], the Nordic countries should intensify their cooperation and dialogue, providing for joint efforts to build knowledge, sharing of Nordic experience and lessons learned coordinated through a Nordic forum for collaboration on CCS. If pipelines and storage capacity are dimensioned to large volumes, including import and export of $CO_2$, the price will be lower for both national point sources and potential $CO_2$-exporting countries. Efficient co-ordination could also bring cost savings through facilitating more rational infrastructure configurations across countries.

- developing a joint Nordic CCS strategy to increase the potential to realise economies of scale in transportation and storage infrastructure for captured carbon dioxide

In the same vein as the previous recommendation, the Nordic Council of Ministers could lay the groundwork for a joint Nordic CCS strategy. This has also been recommended by Nordic Energy Research in their *Nordic Clean Energy Scenarios*

156. Nordic Co-operation (n.d.) *Networking group on CCUS*. Norden. Retrieved from, https://www.norden.org/en/organisation/networking-group-ccus [Accessed 20.05.2023].
157. Nordic Council of Ministers (2023, June 22). *Regulatory framework for CCS in the Nordic countries.* Retrieved from, https://pub.norden.org/temanord2023-521/index.html

(2021)[158]. A joint Nordic CCS strategy could inspire similar regional cooperation across the globe, illustrating how countries with different (geographical and technical) opportunities for BECCS can work together.

- Nordic research on governance and business models for generating $CO_2$ removal (negative emissions)

We recommend that the Nordic Council of Ministers – for example through Nordic Energy Research or Nordic Innovation – provide funding for further cross-Nordic research into incentive schemes for producing negative emissions and the practicalities and consequences of implementing these in the Nordic region.

Cross-Nordic research on incentive schemes for producing negative emissions should also attempt to answer the question: how to finance negative emissions in the long-run?

Negative emissions will eventually compensate for residual emissions to reach net-zero and hereafter for some historical emissions. This will likely be expensive, with the average cost of high-quality carbon removal priced at 537$/tonne by second quarter 2023[159]. Although the cost will likely decrease as the market matures, there is a need to look into who should pay to bring back the $CO_2$-concentration to a desirable level in the future.

158. Wråke, M., Karlsson, K., Kofoed-Wiuff, A., Bolkesjø, T.F., Lindroos, T.J., Hagberg, M., Simonsen, M.B., Unger, T., Tennbakk, B., Jåstad, E.O., Lehtilä, A., Putkonen, N. & Koljonen, T. (2021). *Nordic Clean Energy Scenarios: Solutions for Carbon Neutrality*. Nordic Energy Research. Retrieved from, https://norden.diva-portal.org/smash/get/diva2:1589875/FULLTEXT02.pdf
159. CDR.fyi (2023). *CDR.fyi 2023 Mid-Year Progress Report*. Medium. Retrieved from, https://medium.com/@cdr_fyi/cdr-fyi-2023-mid-year-progress-report-656826b7e4cb [Accessed 20.05.2023].

# 14. Waste management

## 14.1. Introduction and summary

The Nordic waste management sector emitted 6 million tonnes of $CO_2e$ in 2021, corresponding to 4% of the total Nordic emissions, including the LULUCF sector. Excluding the LULUCF sector, the waste management sector is responsible for 3% of total emissions in the Nordic region.

Emissions from waste management covers fugitive emissions from landfill, wastewater treatment and similar. Note that all GHG emissions from waste-to-energy, where waste material is used directly as fuel or converted into a fuel, are reported under the Energy Sector according to the IPCC Guidelines.

From 1990 to 2021, the GHG emissions from the Nordic waste management sector have been reduced by 8 million tonnes of $CO_2e$, corresponding to a 59% emissions reduction in the sector.

Sweden and Finland in particular have been driving this reduction, with emission reductions in their waste management sectors of 76% and 65%, respectively, from 1990 to 2021. In the same period, Norway and Denmark have also reduced emissions substantially in the waste management sector with emission reductions of 46% and 37%, respectively, while Iceland has increased emissions in the sector by 10%.

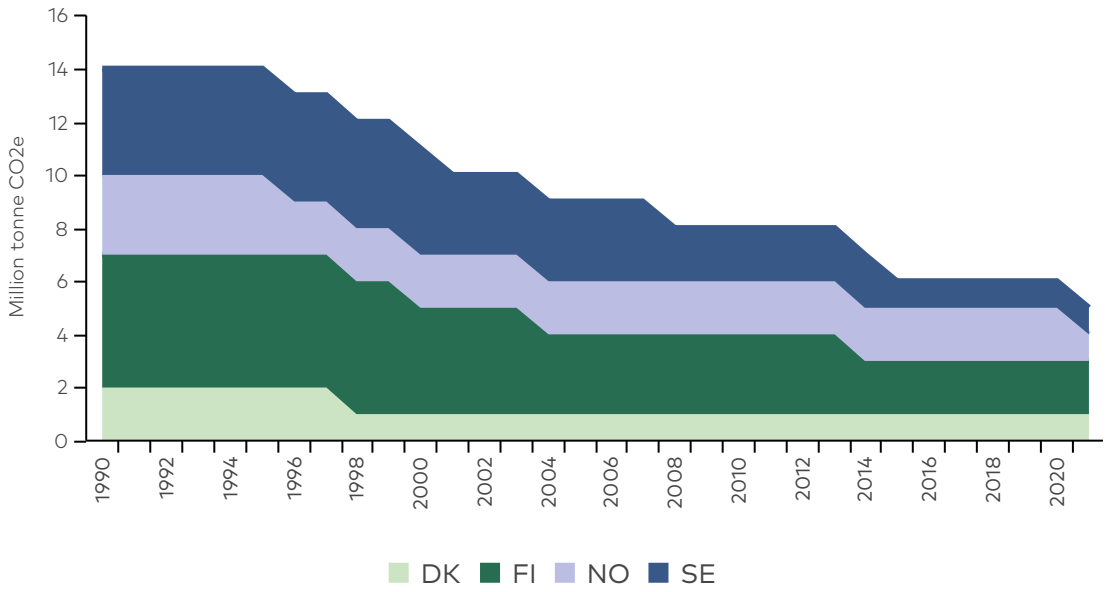


**Figure 19:** GHG emissions from the waste sector across the Nordic countries 1990-2021

*Source*: *UNFCCC. GHG data from UNFCCC. https://unfccc.int/topics/mitigation/resources/registry-and-data/ghg-data-from-unfccc*

Across the Nordic countries, previous policies have focused on reducing the emissions from landfill and increasing the level of recycling, especially in households. This has led to large GHG emission reductions across most of the Nordic countries in this sector.

Future plans in this sector include reducing the total amount of waste, increasing the recycling rate and fostering circularity.

The tables below give an overview of the emissions and emission reductions across the Nordic countries and provide a summary of the main challenge(s) facing each country.

**Table 9:** Emissions from waste management across Nordic countries – a summary

Source: UNFCCC. *GHG data from UNFCCC.* (https://unfccc.int/topics/mitigation/resources/registry-and-data/ghg-data-from-unfccc).

| | Denmark | Finland | Iceland | Norway | Sweden |
|---|---|---|---|---|---|
| **Emissions, 1990** *Mt $CO_2e$* | 2.0 | 5.2 | 0.2 | 2.7 | 4.1 |
| **Emissions, 2010** *Mt $CO_2e$* | 1.1 | 2.8 | 0.3 | 2.0 | 2.1 |
| **Emissions, 2021** *Mt $CO_2e$* | 1.3 | 1.8 | 0.3 | 1.4 | 1.0 |
| **Development, 1990-2021** | -37.0% | -65.1% | +10.2% | -45.9% | -76.0% |
| **Development, 2010-2021** | +16.9% | -35.9% | -19.7% | -28.7% | -53.5% |

**Table 10:** The waste management sector across the Nordic countries – a summary of main challenges

| Country | Summary of main challenge(s) |
|---|---|
| Denmark | • Increasing the recycling rates of waste<br>• Moving to a circular economy |
| Finland | • Increasing the recycling rates of municipal waste<br>• Moving to a circular economy |
| Iceland | • Insufficient waste management infrastructure and lack of cost-effective options<br>• Engaging businesses and consumers in reducing waste and enhancing circularity<br>• Technical and cost-related challenges to mitigation of sewage |
| Norway | • Insufficient systems and incentives for recirculation of many waste categories |
| Sweden | • The emissions from this sector are decreasing. Related challenges in other sectors, such as from incineration of plastic fractions of waste, are significant. |

Across the Nordic countries, reductions can still be made in the emissions from the waste sector. There is a need for both a reduction in the amount of generated waste, and a better handling of waste through increased reusing and recycling. Among other things, this will require investments in new recycling plants.

## 14.2. Status of the waste management sector across the Nordic countries

According to the DEA, the waste management sector in **Denmark** emitted a total of 0.78 million tonnes of $CO_2$e in 2021 (excluding incineration of waste – accounted for in the energy sector - and methane leakage from biogas facilities[160]), accounting for 1.7% of Denmark's total $CO_2$e emissions. In 1990 the sector emitted 1.96 million tonnes of $CO_2$e, and thus from 1990 to 2021 the total $CO_2$e emissions from the waste management sector had been reduced by 60%[161]. There are no binding reduction targets specifically for the waste management sector. However, the waste agreement from 2020 presents a vision of a climate neutral waste sector in 2030[162]. In the Danish Energy Agency's scenarios for 2050, the sector is expected to emit 0.6 million tonnes of $CO_2$e.[163]

In **Finland**, waste management covers about 3.8% of total emissions. Waste treatment emissions have decreased steadily and are down by 63% compared to 1990 levels, and by 38% compared to 2005 levels. Waste treatment emissions are expected to further decrease by 40% of 2019 levels by 2030 with measures already in place. The main reason is the decrease of methane emissions from landfilling biodegradable waste and increased use of waste for energy. Landfill gas recovery has contributed as well. This trend will continue due to the EU ban on landfilling organic waste, effective since 2016.[164]

The **Icelandic** waste sector was responsible for 2% of total emissions in Iceland, including emissions from LULUCF, but 6% if excluding emissions from LULUCF. Total emissions from the sector have increased by 5.4% since 1990. However, emissions have been on a downward trend since 2007 due to both actions in waste management, such as enhanced recycling, and changed consumption patterns after the financial crash of 2008[165], leading to a decline in emissions by 18.6% between 2010 and 2021.

Waste currently accounts for 4% of **Norwegian** GHG emissions, mainly methane from (de-commissioned) land fills and $CO_2$ from waste-to-energy plants[166]. The waste

160. The accounting is thus different from the IPCC Guidelines and explains the difference between the numbers presented in the table earlier in this chapter at the 0.78 million tonnes of $CO_2$e.
161. Energistyrelsen (2023, April). *Klimastatus og -fremskrivning, 2023*. Retrieved from, https://ens.dk/sites/ens.dk/files/Basisfremskrivning/kf23_hovedrapport.pdf
162. Regeringen (2020, June 16). *Klimaplan for en grøn affaldssektor og cirkulær økonomi*. Retrieved from, https://www.regeringen.dk/media/9591/aftaletekst.pdf
163. Energistyrelsen (2022, September 23). *Resultater for KP22-scenarier*. Retrieved from, https://ens.dk/sites/ens.dk/files/Basisfremskrivning/resultater_for_kp22-scenarier_23-09-2022.pdf
164. Ministry of the Environment Finland (2022, July 11). *Medium-term Climate Change Policy Plan.* Publications of the Ministry of the Environment 2022:20. Retrieved from, https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/164274/YM_2022_20.pdf?sequence=1&isAllowed=y
165. Keller, N., Helgadóttir, Á.K., Einarsdóttir, S.R., Helgason, R., Ásgeirsson, B.U., Helgadóttir, D.,Helgadóttir, I.R., Barr, B. C., Thianthong C. J. Hilmarsson, K.M., Tinganelli, L., Snorrason, A., Brink, S.H. & Þórsson, J. (2023, April 14). *National Inventory Report. Emissions of Greenhouse Gases in Iceland from 1990 to 2021. Environment Agency of Iceland.* Retrieved from, https://ust.is/library/Skrar/loft/NIR/ISL_NIR%202023_15%20april_on_web.pdf
166. Miljøstatus (2023). *Norske utslipp og opptak av klimagasser*. Norwegian Environment Agency. Retrieved from,https://miljostatus.miljodirektoratet.no/tema/klima/norske-utslipp-av-klimagasser/ [Accessed 20.05.2023].

generated per capita in Norway is among the highest in Europe[167]. This means that the potential to recycle should also be high.

In total, **Swedish** emissions from the waste sector, with the exception of incineration of (non-hazardous) waste reported under the electricity and district heating sector, were 1 million tonnes in 2021. Emissions from waste treatment have decreased by around 75% compared to 1990 and by just over 50% compared to 2010. Two-thirds of the emissions come from waste landfills[168].

## 14.3. Pathways towards climate neutrality in the waste management sector

In **Denmark**, the DEA expect that national initiatives for reducing GHG emissions in the waste management sector will lead to an 8% reduction amounting to 0.06 million tonnes of $CO_2e$ between 2021 and 2030. In this scenario, the waste management sector will make up 2.4% of the expected emissions in 2030[169]. Furthermore, the DEA expects adopted regulation of methane leakage from biogas facilities to reduce emissions in the sector by 0.45 million tonnes in 2023. However, this is not included in the current projection as the effects are not yet fully documented[170]. Overall, the emissions are relatively small and expected to decrease further. Emissions reduction should still be encouraged but it is not clear how much emissions can be reduced in terms of what is technically and economically feasible. Thus, it may be necessary to accept, and thus compensate for, a minor residual emission in order to reach climate neutrality.

In the waste management sector, the overall target of 50% reduction by 2030 compared to 2005 levels set for the **Finnish** effort sharing sector by the EU will be achieved and overtaken due to measures already taken. The new Finnish waste law has strict obligations for separate collection of municipal waste and will also increase recycling thus reducing emissions of the sector in the long term. Additional measures include a Green Deal voluntary agreement under negotiation on emissions reduction from waste incineration, and a pilot project on CCUS technologies in waste incineration.[171]

167. Miljøstatus (2023). *Avfall.* Norwegian Environment Agency. Retrieved from,https://miljostatus.miljodirektoratet.no/tema/avfall/ [Accessed 20.05.2023].
168. Swedish Environmental Protection Agency (2023, April 6). *National Inventory Report Sweden 2023.* Retrieved from, https://unfccc.int/documents/627663
169. Energistyrelsen (2023, April). *Klimastatus og -fremskrivning, 2023.* Retrieved from, https://ens.dk/sites/ens.dk/files/Basisfremskrivning/kf23_hovedrapport.pdf
170. Klimarådet (2023). *Sektorvurderinger, Baggrundsnotat til Klimarådets Statusrapport 2023, kapitel 3.* Retrieved from, https://klimaraadet.dk/sites/default/files/paragraph/field_download/Baggrundsnotat%20Sektorvurderinger.pdf
171. Ministry of the Environment Finland (2022, July 11). *Medium-term Climate Change Policy Plan.* Publications of the Ministry of the Environment 2022:20. Retrieved from,https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/164274/YM_2022_20.pdf?sequence=1&isAllowed=y

In **Iceland**, the overall strategy for mitigation from the waste sector has two pillars: to reduce food waste and to change waste management methods. The climate action plan includes three initiatives: a landfill tax, an EU mandated ban on landfilling organic waste and reduced food waste. The landfill tax was repealed by the Parliament citing lack of coordination with municipalities and thus has not been implemented. The ban on landfilling organic waste is in progress and a 24-item action plan has been set to reduce waste throughout the entire food value chain, resulting in 30% reduction by 2025 and 50% reduction in food waste by 2030[172]. The Environmental Agency expects emissions in the sector, with current mitigation measures, to be 17% and 24% lower than 2021 emissions in 2030 and 2040, respectively[173].

In **Norway** in 2021, 73% of the common waste fractions were recycled, but more than half of this was incinerated. The construction sector is responsible for the largest waste share, whereas the volume of household waste has been stable. New landfilling with biogenic waste became illegal in 2009, but existing landfills can remain, where methane emissions should be handled.

In many municipalities, plastics is a separate waste fraction for households and businesses, but more than half of the materials from households end up as residual waste and is not being recycled. 40% of the plastics materials in the waste have been used for packaging. A sizeable share of the plastics waste is exported to Germany and Sweden. Recycling of bottles for soft drinks is a success story, where 90% are being recycled and used for new bottles or other plastic products. There is a risk that most of the plastics materials are incinerated in the next use sequence.

Food waste in Norway is at 75 kg per capita and year (2020), out of which 40% is from households. 70% of the households can separate out food waste. From 2023, renovation companies will make waste separation into plastics and food categories available to households. Municipalities must achieve 70% recycling of food waste by 2035. Food waste is used for biogas production and compost, where the latter is used as fertilizer in agriculture.

In **Sweden**, the reduction in waste management emissions is mainly due to the fact that deposited organic waste has been reduced to low levels. This is in turn due to the landfill bans that were introduced at the beginning of the 2000s, at the same time as landfill gas recovery at the landfills continued and also increased in scope during the time period. Gas recovery volumes are now decreasing due to decreasing landfill gas generation at landfills.

172. Umhverfis-, orku og loftslagsráðuneytið (2022). Stöðuskýrsla aðgerðaáætlunar í loftslagsmálum 2022. Retieved from, https://www.stjornarradid.is/library/02-Rit--skyrslur-og-skrar/URN/Stoduskyrsla_Adgerdaaaetlun_2022.pdf
173. Helgadóttir, Á.K., Einarsdóttir, S.R., Keller, N., Helgason, R., Ásgeirsson, B.U., Helgadóttir, I.R., Barr, B.C., Hilmarsson, K.M., Thianthong, J.C., Snorrason, A., Tinganelli, L. & Þórsson, J. (2023, March 15). *Report on Policies, Measures, and Projections. Projections of Greenhouse Gas Emissions in Iceland until 2050.* Environment Agency of Iceland. Retrieved from, https://ust.is/library/Skrar/loft/NIR/0_PaMsProjections_Report_2023_WITH%20BOOKMARKS.pdf

Emissions from the waste sector are projected to continue to decrease, which is primarily due to the landfill bans for combustible waste and organic waste that have been introduced previously.

## 14.4. Challenges in the waste management sector on the way towards climate neutrality and opportunities for Nordic collaboration

Emissions from the waste management sector have declined significantly across the Nordic countries. The largest remaining issues are thus not related directly to emissions but instead other waste management issues such as waste generation, sorting and circularity.

**Denmark** is among the countries in Europe that generate the most household waste per capita[174] although Denmark's total waste generation is below the EU average[175]. Emissions from the treatment of waste is minimal compared to the rest of the sector, but the production and use of materials consumed in Denmark have a major climate and resource footprint[176]. Therefore, a main challenge for all types of waste is to reduce the amount of waste generated and at the same time increase recycling rates of sorted waste. A recent report concluded that Denmark is 4% circular and could increase circularity by applying a range of methods including opting for more resource-efficient lifestyles, minimising waste in the building sector and shifting to more resource-efficient diets with less waste[177].

In **Finland**, the main challenge in further reducing emissions lies in the relatively low recycling rate of household waste: 37% in 2020.[178] Despite increasingly strict requirements for separating and collecting recyclable municipal waste streams, reaching recycling targets is challenging. The broader transition to a circular economy would require a large range of policies and measures, but few of them are being actively considered.

In **Iceland**, emissions from the waste sector have declined in recent years, in particular due to improved management of waste. Opportunities exist in more holistic treatment of waste, focusing not only on the management side but also on the amount of waste produced in addition to fostering circularity. The challenges to ensure effective mitigation from the waste sector include: i) the need to improve the waste

174. Eurostat (2023, August). *Municipal waste statistics*. Retrieved from, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Municipal_waste_statistics
175. Eurostat (2023, January). *Waste statistics*. Retrieved from, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Waste_statistics#Waste_generation_excluding_major_mineral_waste
176. Circle economy foundation (2023). *The Circularity Gap Report Denmark*. Retrieved from, https://www.circularity-gap.world/denmark
177. Circle economy foundation (2023). *The Circularity Gap Report Denmark*. Retrieved https://www.circularity-gap.world/denmark
178. Finnish Environment Instiute (2022, December 15). *The recycling of household waste has become more efficient in many municipal areas in Finland.* https://www.syke.fi/en-US/Current/The_recycling_of_household_waste_has_bec(64499)#:~:text=The%20recycling%20rate%20of%20municipal,65%20per%20cent%20by%202035

management infrastructure, ii) engaging both business and consumers to reduce waste amounts and iii) to enhance circularity.  This requires, for example, better access to information, prevention of planned obsolescence and enhanced access to repair services. Finally, there are technical and cost-related challenges linked to mitigation from sewage and challenges related to cost effective treatment of solid waste in general.

For **Norway** a main challenge for reducing waste-related GHG emissions are insufficient systems for recirculation of many waste categories, including repair and re-use, leading to unnecessary resource use and high life cycle GHG emission. More recirculation requires that less waste ends up in the residual category. Since landfills are not allowed anymore, waste is incinerated in many plants in urban areas to produce energy for district heating. Due to capacity and cost conditions, a sizeable share of Norwegian waste is exported to Germany and Sweden, where GHG emissions depend on emissions reduction measures at these waste facilities. Given government support to CCS facilities and the high cost, $CO_2$ emissions from waste-to-energy plants can be reduced, and possibly $CO_2$ removal from biogenic waste generated.

In **Sweden** there has been a reduction of emissions from landfills, as more waste is being sorted to not end up in landfill and landfill gas recovery has increased. Emissions from landfills are, however, still the main contributor of emissions in the waste sector. The recovery of landfill gas is declining as the quantity of waste at deposits is going down.

It is important that policy instruments, as far as possible, reward circular carbon flows. Therefore, it can be seen as questionable to, e.g., equip waste facilities with CCS. This is because around 30% of what is burned up in waste incineration plants consists of various plastics produced from fossil raw materials. Solutions for recycling plastics in refineries are being developed where the plastic – unlike today's recycling processes – is returned to its original monomers (and such a recycling process would mean that new plastics can be manufactured that have not lost their properties). This would enable a fully circular system to be achieved[179].

The treatment of sewage water and sludge also contributes to a large part of the emissions from this sector, accounting for 25% of emissions from waste treatment in 2021[180].

179. Cañete Vela, I., Berdugo Vilches, T., Berndes, G., Johnsson, F., Thunman, H. Co-recycling of natural and synthetic carbon materials for a sustainable circular economy (2022) *Journal of Cleaner Production*, 365, art. No. 132674, DOI: 10.1016/j.jclepro.2022.132674
180. Naturvårdsverket (2023, June 15). *Avfall, utsläpp av växthusgaser.* Retrieved from, https://www.naturvardsverket.se/data-och-statistik/klimat/vaxthusgaser-utslapp-fran-avfall/ [Accessed 20.05.2023].

**Across the Nordic countries**, reductions can still be made in the emissions from the waste sector. There is a need for both a reduction in the amount of generated waste and a better handling of waste through increased reuse and recycling. This will, among other things, require investments in new recycling plants. All five Nordic countries have some degree of separate biowaste collection, which is an effective way to be able to recycle more. There is, however, still a challenge in increasing the recycling of biowaste further in all countries as there is still biowaste that ends up in mixed residual waste. Furthermore, there is also a challenge in developing the infrastructure for recycling and biowaste treatment, to ensure that there is a capacity to treat all sorted waste, so it does not end up in incineration.

According to the Circularity Gap Report there is generally a low degree of recycling materials in the Nordics. Norway, Sweden and Demark all score low on the Circularity Metric, meaning that only between 2.4-4% of all consumed materials make it back into the economy as recycled materials in these countries. Moving towards a more circular economy is also a topic being discussed at an EU level with a new Circular economy action plan[181] setting out to ensure less waste and create more sustainable products in the EU. The need for a more circular economy is a cross-sector challenge, in terms of increasing the use of sustainable materials, extending maintenance and improving resource recovery.

Unlike the other sectors, there are no major shared Nordic challenges in reducing emissions in the waste management sector. The issues described above touch broader environmental issues and are thus outside the scope of this report.

181. European Comission (n.d.) *Circular economy action plan*. Retrieved from, https://environment.ec.europa.eu/strategy/circular-economy-action-plan_en [Accessed 20.05.2023].

# 15. Agriculture, forestry and other land use

## 15.1 Introduction and summary

In 2021, the entire agriculture, forestry and other land use sector (AFOLU) absorbed 14.4 million tonnes of $CO_2e$ across the Nordic countries. The greenhouse gas inventory splits this sector into two different categories, the agricultural sector (as part of the effort sharing sector) and the land-use, land-use change and forests sector (LULUCF). Methane and nitrous oxide are calculated in the agricultural sector, and carbon dioxide in the land-use sector. In addition, agricultural energy use (fuels, electricity) is accounted for in the energy sector.

Net emissions from the Nordic **agricultural sector** were 30 million tonnes of $CO_2e$ in 2021, corresponding to 20% of the total Nordic emissions, including the LULUCF sector. Excluding the LULUCF sector, the agriculture sector is responsible for 16% of total emissions in the Nordic region. From 1990 to 2021, the GHG emissions from the Nordic agriculture sector have been reduced by 4 million tonnes of $CO_2e$, corresponding to a 12% emissions reduction in the sector.

The Nordic countries have followed approximately the same reduction path in the agricultural sector from 1990 to 2021, with reductions of 13% in Denmark, Finland and Sweden, 11% in Iceland, and 5% in Norway. Denmark, however, has contributed almost half of the overall Nordic agricultural emission reductions in the period, because Denmark is the country that accounts for most of the total Nordic emissions from this sector.

Figure 20 provides an overview of the Nordic agricultural sector's GHG emissions.

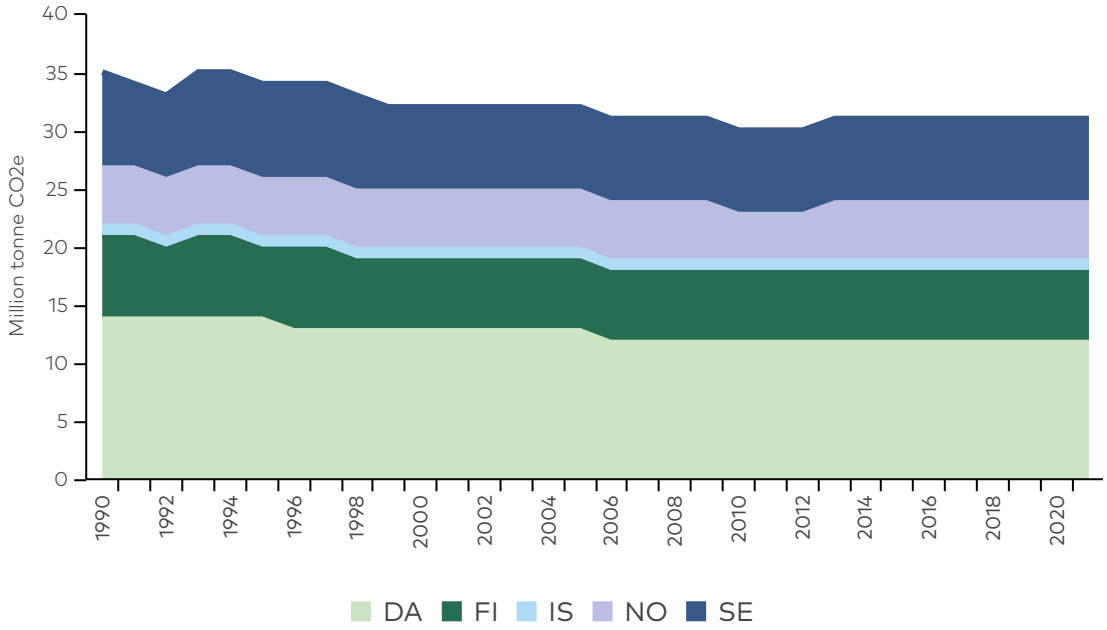


**Figure 20:** GHG emissions from agriculture across the Nordic countries 1990-2021

*Source: UNFCCC. GHG data from UNFCCC. https://unfccc.int/topics/mitigation/resources/registry-and-data/ghg-data-from-unfccc*

The Nordic **LULUCF** sector absorbed 45 million tonnes of $CO_2e$ in 2021, reducing the total Nordic emissions by 23%. From 1990 to 2021, the GHG absorption from the Nordic LULUCF sector decreased by 21 million tonnes of $CO_2e$, corresponding to a 31% reduction in the sector's GHG absorption. This was mostly due to the reduction of the forestry sink in Finland from absorbing, on a net basis, almost 26 million tonnes of $CO_2e$ in 1990 to emitting around 0.5 million tonnes of $CO_2e$ in 2021. Sweden experienced a slight reduction of 10% in their forest sink in this period, while Norway increased their forest sink by 58%. Denmark and Iceland both have net emissions from their LULUCF sector but have reduced these emissions by 65% and 2%, respectively, from 1990 to 2021 (see Figure 21, below).

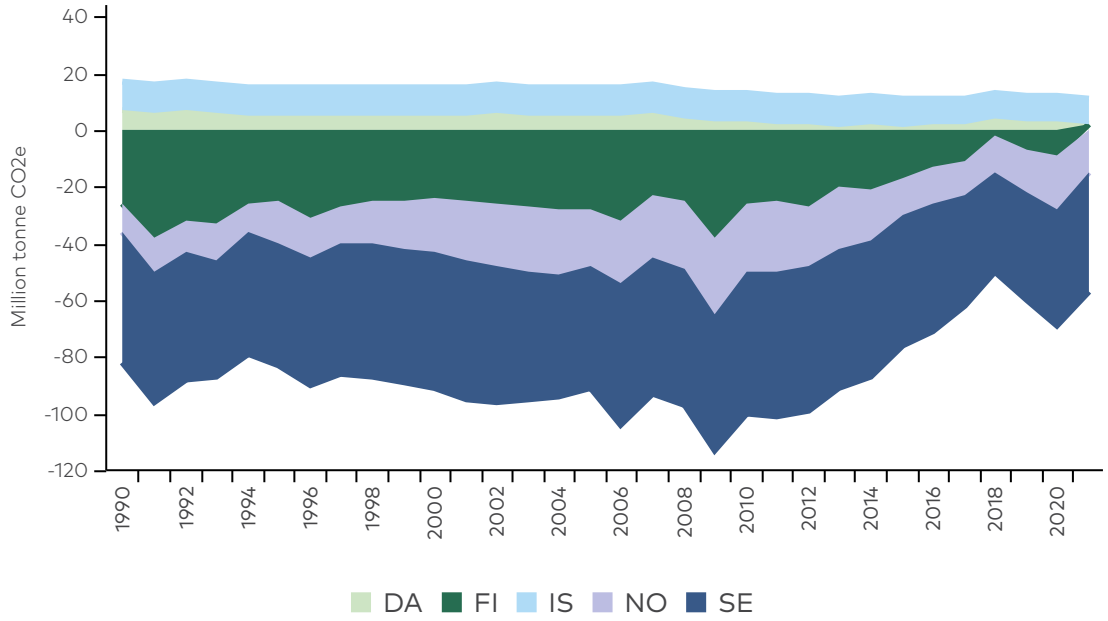


**Figure 21:** Net $CO_2$ emissions from the LULUCF across the Nordic countries 1990-2021

Source: UNFCCC. *GHG data from UNFCCC.* *https://unfccc.int/topics/mitigation/resources/registry-and-data/ghg-data-from-unfccc*

In *Nordic Economic Policy Review 2023,* the implications of targets outlined in the Fit for 55 is explored for Denmark, Finland, Norway and Sweden. The review concludes that despite the Nordic countries having more ambitious abatement targets than the EU, EU requirements for increasing the removal of carbon in the LULUCF sector are not necessarily satisfied under current national targets[182].

Across the Nordic countries, very little has been achieved with regards to reducing the emissions from agriculture, as evidenced in Figure 21, above. Most initiatives have focused on reducing emissions from agriculture by targeting the activities on the farm and, despite talk about more demand-side initiatives, these have still to be implemented. For the forestry and land-use part of this sector, initiatives have been targeted at the rewetting and/or afforestation of wetlands and peatlands, but progress is slow.

Emissions and main country challenges from the following sections are summarised in the table below.

182. Flam, H. & Hassler, J. (2023). *EU versus national climate policies in the Nordics. Nordic* Council of Ministers. Retrieved from, https://pub.norden.org/nord2023-001/introduction-eu-climate-policy-and-fit-for-55.html

**Table 11:** Emissions from agriculture across the Nordic countries – a summary

*Source*: *UNFCCC. GHG data from UNFCCC. https://unfccc.int/topics/mitigation/resources/registry-and-data/ghg-data-from-unfccc*

| | Denmark | Finland | Iceland | Norway | Sweden |
|---|---|---|---|---|---|
| **Emissions, 1990** *Mt $CO_2e$* | 14.0 | 7.2 | 0.7 | 4.9 | 7.6 |
| **Emissions, 2010** *Mt $CO_2e$* | 12.2 | 6.4 | 0.6 | 4.5 | 6.7 |
| **Emissions, 2021** *Mt $CO_2e$* | 12.2 | 6.3 | 0.6 | 4.7 | 6.7 |
| **Development, 1990-2021** | -13% | -13% | -10.8% | -5% | -12.7% |
| **Development, 2010-2021** | -0.1% | -1.8% | -4.1% | +4.6% | 0.9% |

**Table 12:** Net emissions from the LULUCF sector across the Nordic countries – a summary

| | Denmark | Finland | Iceland | Norway | Sweden |
|---|---|---|---|---|---|
| **Emissions, 1990** *Mt $CO_2e$* | 6.9 | -25.8 | 9.6 | -9.8 | -46.3 |
| **Emissions, 2010** *Mt $CO_2e$* | 2.6 | -26.0 | 9.6 | -23.8 | -50.3 |
| **Emissions, 2021** *Mt $CO_2e$* | 2.5 | 0.5 | 9.4 | -15.5 | -41.7 |
| **Development, 1990-2021** | -64.6% | +101.9% | -2.2% | -57.7% | +10.0% |
| **Development, 2010-2021** | -3.8% | +101.9% | -2.1% | +35.0% | +17.1% |

**Table 13:** The agriculture, forestry and land-use sector across the Nordic countries – a summary of main challenges

| Country | Summary of main challenge(s) |
|---|---|
| **Denmark** | • Reducing emissions from beef and dairy production<br>• Rewetting cultivated wetlands |
| **Finland** | • Decline of the forest sink<br>• Agriculture on peatland soils<br>• Reducing livestock emissions |
| **Iceland** | • Reducing livestock emissions<br>• Effective engagement with landowners in terms of restoration of wetlands and improved grazing conditions<br>• Improving baseline and monitoring data and need for formal third-party certification |
| **Norway** | • Lack of high-quality land and arduous climate conditions for agriculture production<br>• Methane emissions from grazing sheep and cattle |
| **Sweden** | • Reducing GHG emissions from agricultural production<br>• Emission reductions need to be balanced by the need to have domestic food production and the risk of emissions leakage<br>• Tradeoffs with other environmental and social objectives |

Political concerns such as carbon leakage, regressive effects, food security and rural development have led to only small emission reductions in the agricultural sector across the Nordic countries. Furthermore, a combination of climate change, demand for land for growing farms, and an increased demand for biomass, is challenging the forest sinks in the Nordic countries.

Across the Nordic countries, the following two main challenges need to be addressed:

- emissions from organic soils and securing a future net removal in the LULUCF sector
- transforming the agricultural sector in the Nordic countries.

In the agriculture, forestry and land-use sector, we see the following opportunities for creating added Nordic value through collaboration:

- knowledge sharing on carbon pricing in agriculture – risks and incentive structures
- Nordic research on climate accounting on farms and improving knowledge on ways to reduce emissions on the farm from livestock, such as manure management – including biogas production, crop cultivation and fodder additives to reduce methane releases from ruminants
- studies on examples of how to improve the conditions for producers of plant-based proteins, both in terms of research, education and regulatory frameworks
- targetting Nordic research and innovation funds towards plant-based production.

Challenges and opportunities are described in further detail later in the chapter.

## 15.2. Status of the agriculture, forestry and other land use sector across the Nordic countries

In **Denmark**, and according to the DEA, the agriculture and forestry sector emitted a total of 15.9 million tonnes of $CO_2$e in 2021, accounting for 34% of Denmark's total $CO_2$e emissions. Agricultural processes alone emitted 12.1 million tonnes of $CO_2$e, while land use for forest resulted in a removal of -3 million tonnes of $CO_2$e. In 1990 the sector emitted 23.2 million tonnes of $CO_2$e, and thus from 1990 to 2021 the total $CO_2$e emissions from the sector was reduced by 32%[183]. In the DEA's projection, net-emissions will only be reduced by a further 0.5 million tonnes by 2030.

The Danish parliament has set a political target for the agriculture and forest sector at a 55-65% reduction of GHG emissions in 2030 compared to 1990 levels, not including emissions related to the energy consumption in the sector[184]. This corresponds to emissions of 9.4-7.3 million tonnes of $CO_2$e in 2030[185], and reductions of 6.5-8.6 million tonnes of $CO_2$e between 2021 and 2030.

Furthermore, EU targets require reductions in emissions from Denmark's agriculture and forest sector. According to EU's Effort Sharing Regulation, Denmark must reduce emissions by 50% by 2030 compared to 2005 levels. The DEA estimates that Denmark has an accumulated additional reduction demand of 16 million tonnes between

183. Energistyrelsen (2023, April). *Klimastatus og -fremskrivning, 2023*. Retrieved from, https://ens.dk/sites/ens.dk/files/Basisfremskrivning/kf23_hovedrapport.pdf
184. Regeringen (2021, October 4). *Aftale om grøn omstilling af dansk landbrug*. Retrieved from, https://fm.dk/media/25302/aftale-om-groen-omstilling-af-dansk-landbrug_a.pdf
185. Energistyrelsen (2023, April). *Klimastatus og -fremskrivning, 2023*. Retrieved from, https://ens.dk/sites/ens.dk/files/Basisfremskrivning/kf23_hovedrapport.pdf

2021-2030. Additionally, the DEA expects Denmark's obligation in the LULUFC sector to be 9 million tonnes short in the period 2026-2029 and 2 million tonnes short in 2030.[186]

In the DEA's scenarios for reaching climate neutrality by 2050, emissions from the agricultural and forest sector account for up to 80% of residual emissions. Depending on the scenario, agriculture and land-use emit 11.1-3.3 million tonnes of $CO_2e$, while forests emit 0.5 to -3.4 million tonnes of $CO_2e$[187]. Reaching climate neutrality by 2045 in accordance with the new ambition of the government, would require greater reductions from the agricultural and forest sector.[188]

About a quarter of all emissions in **Finland** come from agriculture[189]. The emissions from agriculture have remained rather stable for several years. In Finland, about 75% of the total emissions from agriculture are soil emissions, which include nitrogen oxide from agriculture and carbon dioxide from land use according to the inventory. Emissions from organic lands were more than half (about 8 million tonnes of $CO_2e$) of the total emissions from agriculture (more than 15 million tonnes of $CO_2e$).[190]

186. Energistyrelsen (2023, April). *Klimastatus og -fremskrivning, 2023*. Retrieved from, https://ens.dk/sites/ens.dk/files/Basisfremskrivning/kf23_hovedrapport.pdf#page=26
187. Energistyrelsen (2022, September 23). *Resultater for KP22-scenarier*. Retrieved from,https://ens.dk/sites/ens.dk/files/Basisfremskrivning/resultater_for_kp22-scenarier_23-09-2022.pdf
188. Statsministeriet (14. december 2022). *Regeringsgrundlag 2022*, *Ansvar for Danmark*. Statsministeriet. Retrieved from, https://www.stm.dk/statsministeriet/publikationer/regeringsgrundlag-2022/
189. Note that this includes all agricultural emissions - not only those under the Effort Sharing Regulation categorized as "Agriculture".
190. Lehtonen, H., Saarnio, S., Rantala, J., Luostarinen, S., Maanavilja, L., Heikkinen, J., Soini, K., Aakkula, J., Jallinoja, M., Rasi, S., Niemi, J. (2020). *Maatalouden ilmastotiekartta – Tiekartta kasvihuonekaasupäästöjen vähentämiseen Suomen maataloudessa*. Maa- ja metsätaloustuottajain Keskusliitto MTK ry. Helsinki. Retrieved from, https://www.mtk.fi/documents/20143/310288/MTK_Maatalouden_ilmastotiekartta_net.pdf/4c06a97a-c683-1280-65ba-f4666132621f?t=1597055521915

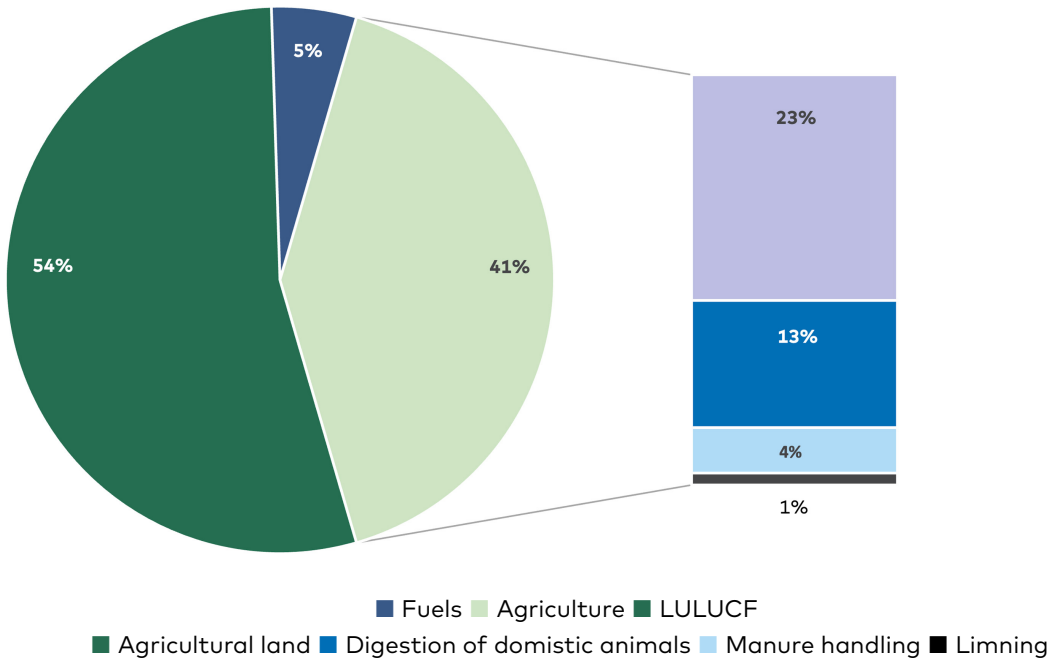


**Figure 22:** The distribution of agricultural emissions in LULUCF, effort sharing and energy sectors (2021)

*Source: Ympäristöministeriö Helsinki (2022). Ilmastovuosikertomus 2022. https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/164392/YM_2022_24.pdf?sequence=1&isAllowed=y*

The **Icelandic** agricultural sector was responsible for 4% of total emissions in Iceland if including emissions from LULUCF, but 13% if excluding emissions from LULUCF. Total emissions from the sector have declined by 10.7% since 1990, trending slowly downwards largely due to a reduction in the number of livestock (sheep) in the country [191].

The LULUCF sector is instrumental in reaching climate neutrality but is also the culprit for significant GHG emissions, as the sector was responsible for 67% of net emissions in 2021. Forestry sequestered 509 thousand tonnes in 2021 with slowly increasing sequestration quantities since 1990 as more has been planted and older plantations mature to higher sequestration stages. Emissions have remained somewhat stable in other land-use categories since 2010[192]. The sector is subject to the EU LULUCF regulation, that is, the "no-debit rule" from 2021 to 2025 and later will be subject to a

191. Keller, N., Helgadóttir, Á.K., Einarsdóttir, S.R., Helgason, R., Ásgeirsson, B.U., Helgadóttir, D.,Helgadóttir, I.R., Barr, B. C., Thianthong C. J. Hilmarsson, K.M., Tinganelli, L., Snorrason, A., Brink, S.H. & Þórsson, J. (2023, April 14). National Inventory Report. Emissions of Greenhouse Gases in Iceland from 1990 to 2021. Environment Agency of Iceland. Retrieved from, https://ust.is/library/Skrar/loft/NIR/ISL_NIR%202023_15%20april_on_web.pdf
192. Keller, N., Helgadóttir, Á.K., Einarsdóttir, S.R., Helgason, R., Ásgeirsson, B.U., Helgadóttir, D.,Helgadóttir, I.R., Barr, B. C., Thianthong C. J. Hilmarsson, K.M., Tinganelli, L., Snorrason, A., Brink, S.H. & Þórsson, J. (2023, April 14). National Inventory Report. Emissions of Greenhouse Gases in Iceland from 1990 to 2021. Environment Agency of Iceland. Retrieved from, https://ust.is/library/Skrar/loft/NIR/ISL_NIR%202023_15%20april_on_web.pdf

country-specific mitigation (sequestration) target in 2030 which has not yet been determined. In 2035 the LULUCF and agriculture sectors will, together in a "land" sector, be subject to net zero targets according to updated EU climate legislation. The inclusion of the LULUCF sector in the climate neutrality target has not been clarified, but sequestration in the sector is necessary to mitigate hard-to-abate emissions, for example in the agricultural sector.

Agriculture was responsible for 9% of **Norwegian** GHG emissions in 2021, where the main sources are methane and nitrous oxide from ruminants and fertilizer use[193]. These emissions have been relatively stable since 1990. Figure 23 shows GHG emissions in agriculture and necessary reductions until 2030 to fulfill the intentional agreement on emissions mitigation between the farmers' federations and the government.

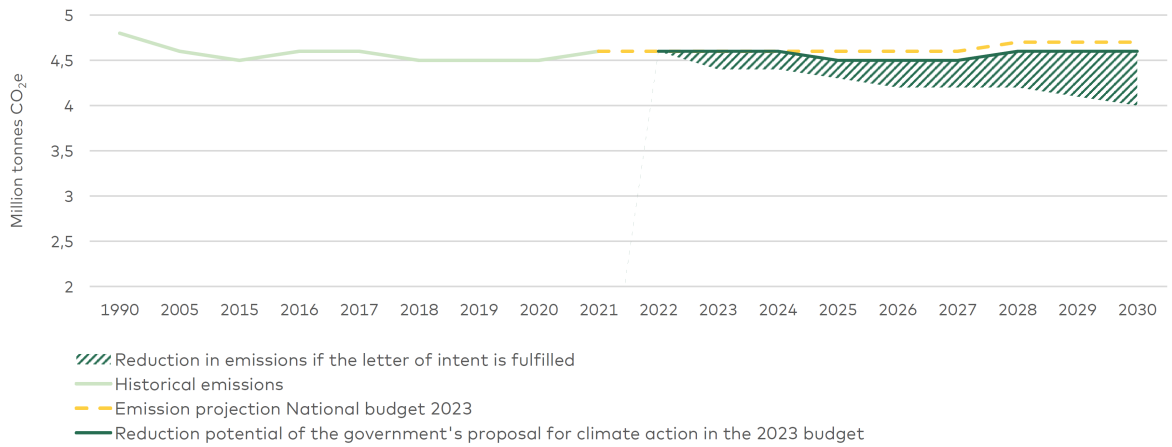


**Figure 23:** Historical GHG emissions from agriculture 1990-2021, with projections and mitigation effect of measures until 2030, million tonnes of CO2eq. (Norwegian Ministry of Climate and Environment, 2022)

*Source: Regeringen (2022). Regjeringens klimastatus- og plan.*
*https://www.regjeringen.no/no/dokumenter/regjeringens-klimastatus-og-plan/id2931051/*

193. Miljøstatus (2023). *Norske utslipp og opptak av klimagasser.* Norwegian Environment Agency. Retrieved from, https://miljostatus.miljodirektoratet.no/tema/klima/norske-utslipp-av-klimagasser/ [Accessed 20.05.2023].

Removal and release of GHG (mostly $CO_2$) from land-use and land-use changes are included in Norway's GHG accounting and reporting to the UNFCCC. Forest growth has generated a sizeable $CO_2$ sink, which has increased since 1990, even after $CO_2$ emissions from other land-use changes that release carbon are subtracted. In the '50s and '60s major tree planting campaigns led to a growing forest biomass over the last decades (some 70% of the carbon is contained in the soil). On the other hand, more land-use for infrastructure such as buildings and roads, and new agricultural land, such as draining of swamps, have contributed to emissions of GHG. Altogether, the net removal (the sink) of GHG from forest and other land-use was estimated at 20 million tonnes of $CO_2e$ in 2020.

In **Sweden**, GHG emissions from the agricultural sector were 6.7 million tonnes in 2021. The emissions, which mainly consist of methane and nitrous oxide from animal feed digestion, manure handling and nitrogen conversion in agricultural land, have remained at about the same level since 2005 but have decreased by 13% since 1990.[194] The main reasons why emissions have fallen since 1990 are increased productivity and reduced animal husbandry of mainly dairy cows and pigs and, to a lesser extent, reduced use of mineral fertilisers. The agricultural sector's emissions are estimated to decrease slightly as a result of a reduced number of animals and reduced cultivated area, assumptions about increased productivity and lower product prices are explanations behind the result. The sector contributes significantly to the remaining emissions in 2045.

During the period 1990–2021, the land-use sector reported an annual net removal of between 35 and 50 million tonnes of $CO_2e$, with a decreasing trend in the last decade mainly linked to a reduced growth in living biomass on forest land. According to the tightened LULUCF regulation, the net removal in the Swedish LULUCF sector must end up at a level that is approximately 4 million tonnes of $CO_2e$ higher in 2030 compared to the average level during the base period (2016–2018), which means a total net removal of 44 million tonnes in 2030.

The largest net removals occur through the storage of carbon dioxide in trees on forest land (25 million tonnes in 2021), mineral soil (16 million tonnes in 2021) and the storage of carbon in harvested wood products (9 million tonnes).

The development of net removal is associated with very large uncertainties. A 2023 assessment by Swedish EPA includes four different scenarios for the LULUCF sector, with different assumptions about harvesting levels and biomass growth, illustrating the sensitivity of the results[195]. The different assumptions give results with a relatively

194. Agriculture's emissions from the use of fossil fuels in tractors and other work machinery, fossil fuels for heating premises, for stationary equipment such as grain dryers and changes in carbon stocks linked to agricultural land use are reported in other sectors.
195. Naturvårdsverket (2023). *Underlag till regeringens kommande klimathandlingsplan och klimatredovisning*. NV-08102-22. Retrieved from, https://www.naturvardsverket.se/499a4f/contentassets/4c414b0778e9409fb2836fc4d3dc6259/underlag-till-regeringens-kommande-klimathandlingsplan-och-klimatredovisning-2023-04-13.pdf

wide spread; the net removal varies between 20–45 million tonnes of $CO_2e$ in total for the LULUCF sector on average during the period 2020–2050.

The largest net emissions in the LULUCF sector occur from peatlands with drainage ditches on forest land, arable land and land exploited for buildings and infrastructure. Peatlands with drainage ditches on forest and agricultural land are estimated to cause an annual emission of just over 9 million tonnes of $CO_2e$.

## 15.3. Pathways towards climate neutrality in the agriculture, forestry and other land use sector

Initiatives already implemented for reducing the GHG emissions in the **Danish** agriculture and forestry sector are limited. Projections from the DEA estimate that the current agreed policies will lead to a reduction of 0.5 million tonnes of $CO_2e$ between 2021 and 2030 when implemented. In this projection the agriculture and forestry sector will make up 52% of the expected emissions in 2030[196]. The Climate Council, on the other hand, expects the implemented political initiatives to have only a limited reduction potential in the sector of 0.07 million tonnes of $CO_2e$ in 2025 and no reduction potential in 2030. Predominantly, the current politically planned efforts are at the level of strategies, analyses and technical potentials, which the Climate Council estimates to have a total reduction potential of 8.99 million tonnes of $CO_2e$ in 2030 [197].

The agricultural agreement passed in 2021 contains a strategy to implement a carbon tax for the agricultural sector. The intention to introduce a tax on GHG from agriculture and land-use is included in the Government's Coalition Agreement, but the concrete design is still to be decided on the grounds of an expert group's recommendations, which are expected to be presented in the autumn of 2023. The tax is estimated to potentially reduce GHG emissions from the sector by 5 million tonnes of $CO_2e$ in 2030. However, as the concrete design of the carbon tax remains unknown, it is not possible to estimate which reduction potentials the tax will realise.[198]

With the currently planned policies, the Danish Energy Agency estimates that GHG emission from the agriculture and forest sector are expected to reduce by 31% in 2030 compared to 1990 levels. This leaves a 24-34 percentage points residual in order to reach the 2030 target of 55-65% reduction[199].

196. Energistyrelsen (2023, April). *Klimastatus og -fremskrivning, 2023*. Retrieved from, https://ens.dk/sites/ens.dk/files/Basisfremskrivning/kf23_hovedrapport.pdf
197. Klimarådet (2023). *Sektorvurderinger, Baggrundsnotat til Klimarådets Statusrapport 2023, kapitel 3*. Retrieved from, https://klimaraadet.dk/sites/default/files/paragraph/field_download/Baggrundsnotat%20Sektorvurderinger.pdf
198. Klimarådet (2023). *Sektorvurderinger, Baggrundsnotat til Klimarådets Statusrapport 2023, kapitel 3*. Retrieved from, https://klimaraadet.dk/sites/default/files/paragraph/field_download/Baggrundsnotat%20Sektorvurderinger.pdf
199. Energistyrelsen (2023, April). *Klimastatus og -fremskrivning, 2023*. Retrieved from, https://ens.dk/sites/ens.dk/files/Basisfremskrivning/kf23_hovedrapport.pdf

The Climate Council finds the current policies and strategies highly inadequate and untimely if Denmark is to reach its reduction targets for the agriculture and forestry sector. The Council estimates that implementation of further policies with a reduction potential of 5.4 million tonnes of $CO_2$e are needed in order to meet the 2030-target of 55-65% reduction[200].

The reduction potential of 5 million tonnes of $CO_2$e from the strategies of the agricultural agreement are assessed to be sufficient to meet the overall target of 70% GHG emission reduction in 2030.

The Climate Council consider the strategies to be based on immature technologies and to be limited by several political conditions, in particular that the business sectors competitive capacity must not be reduced[201].

Furthermore, even if Denmark's national targets for GHG emission reduction in the agriculture and forest sector are met, the reductions are inadequate for meeting Denmark's EU commitments. The DEA estimates a residual need for emissions reduction of around 9 million tonnes of $CO_2$e in the period 2026-2029, and 2 million tonnes of $CO_2$e in 2030 in terms of the LULUCF-commitment. In terms of the Effort Sharing Regulation, the DEA estimates a residual need for emissions reduction of around 16 million tonnes of $CO_2$e in the period 2021-2030.[202]

In 2021, the then **Finnish** Government agreed a 29% reduction target for agricultural emissions by 2035 (-4.6 million tonnes of $CO_2$e), compared to 2019 (when emissions totaled 16 million tonnes of $CO_2$e).[203] There are several initiatives aiming at reducing emissions from agriculture, such as the afforestation of peatlands and wetlands. Agricultural processes are slow, so the effects of the projects are visible with a delay. [204] Also, the new government has withdrawn some of the funding allocated to climate measures in agriculture.

The Climate Change Plan for the Land Use Sector (LULUCF) sets a target for a net carbon sink to be at least -21 million tonnes of $CO_2$e per year for Finland to reach carbon neutrality by 2035.[205] The LULUCF sector has traditionally been a net sink: the carbon sinks in forests have been larger than emissions in the LULUCF sector. The year

200 Klimarådet (2023). *Sektorvurderinger, Baggrundsnotat til Klimarådets Statusrapport 2023, kapitel 3.* Retrieved from, https://klimaraadet.dk/sites/default/files/paragraph/field_download/Baggrundsnotat%20Sektorvurderinger.pdf

201. Møllgaard, P., Jacobsen, J.B., Kristensen, N.B., Elmeskov, J., Halkier, B., Heiselberg, P., Knudsen, M.T., Morthorst, P.E. & Richardson, K. (Febuary 2023). *Statusrapport 2023.* Klimarådet. Retrievde from, https://klimaraadet.dk/sites/default/files/node/field_file/Klimaraadet_statusrapport23.pdf

202. Energistyrelsen (2023, April). *Klimastatus og -fremskrivning, 2023.* Retrieved from, https://ens.dk/sites/ens.dk/files/Basisfremskrivning/kf23_hovedrapport.pdf

203. Ministry of Agriculture and Forestry (2023, May 5). *Government Report on the Climate Plan for the Land Use Sector.* Retrieved from, https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/164927/MMM_2023_12.pdf?sequence=1&isAllowed=y

204. Ympäristöministeriö Helsinki (2022). *Ilmastovuosikertomus 2022.* Retrieved from, https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/164392/YM_2022_24.pdf?sequence=1&isAllowed=y

205. Ministry of Agriculture and Forestry (2023, May 5). *Government Report on the Climate Plan for the Land Use Sector.* Retrieved from, https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/164927/MMM_2023_12.pdf?sequence=1&isAllowed=y

2021 was a turning point, when the LULUCF sector turned into a net emission source for the first time. The net sink of forest land in 2021 (-8.3 million tonnes of $CO_2e$) was lower than ever before in the period starting from 1990. The decrease in the net sink is explained by increased logging, decreasing tree growth and an increase in emissions from drained peatlands in the forest land[206]. This is a significant change since the Finnish climate policy has relied on carbon sinks. It means that Finland now needs to identify additional emission reductions in other sectors and the LULUCF sector, as well as to take measures to maintain and increase forest carbon sinks to reach carbon neutrality by 2035.

Finland's sink challenge, i.e. increasing the LULUCF net sink and creating technological sinks, is significant. The net sink would need to be increased by at least 19 million tonnes by 2035 compared to the 2021 level. The land-use sector's climate plan (MISU) strengthens the sink by an estimated 5 million tonnes. The difference to the sink target, 14 million tonnes, would have to be implemented with additional measures. Cost-effectiveness would justify the reduction of soil emissions from agriculture, the reduction of forest loss to a minimum and the increase of continuous cover forest management on peatland forests, where it is suitable in order to reduce the need for maintenance of the ditch network.

Even if these measures were implemented, there would remain a significant gap, according to a preliminary estimate, of about 8 million tonnes. The net sink gap could be filled by regulating the amount of logging, which immediately increases the LULUCF net sink. In addition, a complementary option is to produce negative emissions from biogenic flue gases with the help of technological sinks. The state can encourage the reduction of felling of forests either by applying measures to reduce supply (e.g. amendments to the Forestry Act and positive incentives to extend the cycle time) or to regulate demand (e.g. a carbon tax on the use of wood or an emissions trading system). Voluntary contractual arrangements between the state and the forest industry are also possible[207].

In **Iceland**, the overall strategy for mitigation in the agricultural sector is to enable farmers to reduce the climate footprint in all of their operations, to improve data collection and to enhance research in efforts that reduce emissions, such as improved feed or use of fertilisers. The climate action plan includes five initiatives geared towards agriculture: climate friendly agriculture which aims at helping farmers reduce emissions from their own operations, including sequestration, carbon neutral beef production, increased domestic vegetable production, improved handling of fertilisers

206. Natural Resources Institute Finland (Luke) (2023, March 15). *Kasvihuonekaasuinventaario 2021: Maataloussektorin ja maankäyttösektorin nettopäästöihin ei merkittäviä muutoksia verrattuna joulukuussa 2022 julkaistuihin ennakkotietoihin.* Retrieved from, https://www.luke.fi/fi/seurannat/maatalous-ja-lulucfsektorin-kasvihuonekaasuinventaario/kasvihuonekaasuinventaario-2021-maataloussektorin-ja-maankayttosektorin-nettopaastoihin-ei-merkittavia-muutoksia-verrattuna-joulukuussa-2022-julkaistuihin-ennakkotietoihin

207. The Finnish Climate Change Panel. (2023). *Suuntaviivoja Suomen ilmastotoimien Tehostamiseen.* Retrieved from, https://www.ilmastopaneeli.fi/wp-content/uploads/2023/02/ilmastopaneelin-julkaisuja-1-2023-suuntaviivoja-ilmastotoimien-tehostamiseen.pdf

and improved feeding of livestock to reduce enteric fermentation. Four of the five initiatives are implemented, but the action "improved feeding of livestock" has gone through preliminary testing. According to the Environmental Agency the results from these tests are not promising[208]. Other initiatives that affect emissions from agriculture include initiatives to reduce food waste that have already been mentioned. Despite these initiatives, the Environmental Agency expects emissions from the agricultural sector to decline by 2% in 2030 and 5% in 2040, compared to emissions in 2021.

The strategic focus in the climate action plan is to emphasize mitigation and sequestration in the LULUCF sector beyond specific baseline emissions, acknowledging the physical difficulty in transforming the sector to a net negative state. In this regard, the climate action plan defines 6 actions related to the sector that are all being implemented. The actions are: enhanced planting efforts in forestry that are to be enhanced further in 2025; expanding revegetation efforts; restoration of wetlands; wetland conservation; improved mapping of grazing land and land-use; and improved bookkeeping. Efforts in soil reclamation/revegetation have shifted towards reclaiming key native ecosystems such as birchwood and wetlands. National plans for forestry and land/soil reclamation have been devised and benchmarks for sustainable land-use are being introduced. However, setbacks have been experienced in wetland restoration as GHG credits created are not formally certified by third party. Changes in the expected reduction in net emissions from the LULUCF sector in 2030 and 2040, according to the Environmental Agency[209] and given current mitigation measures, is 2.8% and 4.4% in 2030 and 2040, respectively, compared to 2021 levels.

**Norway** has some programmes where farmers can get support for environmental measures to increase biodiversity on their land. In 2020 a new law that prohibited cultivation of swamps for agricultural purposes was adopted. In 2019 the farmers' federations made a broad agreement with the government to reduce GHG emissions by 5 million tonnes of $CO_2$ by 2030, including GHG emissions related to land-use changes, transportation and energy use. The most important measures are improved animal feed and breeding practices in addition to carbon storage, such as through biochar use. The government will also support measures to change peoples' diet in a more climate-friendly direction. There are fewer plans after 2030, but more attention given to self-sufficiency and sustainability challenges. This includes changing crops to more cereals and legumes and using more land for grazing. The dependency on soy imports for animal feed will be reduced.

208. Helgadóttir, Á.K., Einarsdóttir, S.R., Keller, N., Helgason, R., Ásgeirsson, B.U., Helgadóttir, I.R., Barr, B.C., Hilmarsson, K.M., Thianthong, J.C., Snorrason, A., Tinganelli, L. & Þórsson, J. (2023, March 15). *Report on Policies, Measures, and Projections. Projections of Greenhouse Gas Emissions in Iceland until 2050.* Environment Agency of Iceland. Retrieved from, https://ust.is/library/Skrar/loft/NIR/0_PaMsProjections_Report_2023_WITH%20BOOKMARKS.pdf
209. Helgadóttir, Á.K., Einarsdóttir, S.R., Keller, N., Helgason, R., Ásgeirsson, B.U., Helgadóttir, I.R., Barr, B.C., Hilmarsson, K.M., Thianthong, J.C., Snorrason, A., Tinganelli, L. & Þórsson, J. (2023, March 15). *Report on Policies, Measures, and Projections. Projections of Greenhouse Gas Emissions in Iceland until 2050.* Environment Agency of Iceland. Retrieved from, https://ust.is/library/Skrar/loft/NIR/0_PaMsProjections_Report_2023_WITH%20BOOKMARKS.pdf

In recent years, nature restoration has gained more attention. Additional measures to safeguard more carbon storage and nature conservation benign forestry practices are planned.[210] In 2022 Norway signed the UN's Kunming-Montreal Global Biodiversity Framework, with one of the goals being restoration of 30% of impacted nature by 2030. At Hjerkinn (the Dovre Mountain area; at an altitude of around 1100 meters) an area was used for defense training (infantry, artillery, tanks and the air force) until 2008. In 2020 the restoration of the area for civilian use was finalised.

There are currently relatively few policy instruments in **Sweden** that directly aim to reduce GHG emissions in the agricultural sector. The most central management takes place via the EU's common agricultural policy. For the 2014–2020 programme period in Sweden (which was extended until 2022) support has gone mainly to the environmental area, aimed at biological diversity and preservation of landscape.

Similarly, there are few policy instruments that aim to directly effect emissions and uptake in the LULUCF sector in Sweden. EU legislation is having an increasing impact on land use in Sweden, and the LULUCF sector is of great importance for both Sweden's and the EU's goals for climate and biodiversity to be reached. The European Commission's proposal for a new regulation on nature restoration may impose additional requirements, including passive restoration of forest land and rewetting of agricultural land on drained peatland.

Support for increased carbon storage in agricultural land via the EU's common agricultural policy and within the so-called wetlands initiative, which is mainly carried out within the local nature conservation initiative but also through special funds being transferred to the Swedish Forestry Agency, is the policy instrument that has been introduced in Sweden so far with the clear objective of contributing to a reduced climate impact. In addition, there is also relatively extensive regulation in The Forestry Act which indirectly affects uptake of carbon dioxide and the release of greenhouse gases in the LULUCF sector.

The current CAP program period applies to 2023–2027. In the strategic plan for the new period, Sweden has also partially prioritised measures to strengthen the environmental and climate focus in line with the EU's higher ambitions in the area. The new orientation involves, inter alia, the introduction of new one-year environmental and climate support for intermediate crops for increased carbon storage. Designated funds for investments in measures that reduce emissions of ammonia from manure management were introduced, that can also reduce nitrous oxide emissions.

Outside of the strategic plan, it is also possible for farmers to apply for support for investment to produce biogas based on manure which leads to reduced emissions of

210. Klima- og miljødepartementet (2022, October 16). *Særskilt vedlegg til Prop. 1 S (2022–2023), Regjeringas klimastatus og -plan.* https://www.regjeringen.no/contentassets/fad4e2d774cf45ac8ad0e8cbb1ea093f/no/pdfs/kld_regjeringas_klimastatus_og_-plan.pdf

methane mainly, but also of nitrous oxide. There is also production support. More and more biogas is produced from manure and the increase is projected to continue[211]. The Swedish government is preparing a climate action plan to be delivered by the government in the autumn of 2023 and which will describe how the climate goals are to be achieved.

The latest projections indicate that emissions from the agricultural sector will decrease slightly as a result of, inter alia, a reduced number of livestock and reduced cultivated area[212]. The future net removal in the LULUCF is associated with large uncertainties. In four scenarios, with different assumptions, it varies between 20–45 million tonnes of $CO_2e$ annually in total for the LULUCF sector on average during the period 2020–2050.

## 15.4. Challenges on the way towards climate neutrality and opportunities for Nordic collaboration

In **Denmark**, worries about beef and dairy production moving abroad is a major challenge. If demand for beef and dairy remains high or increases, a decrease in production in Denmark will have a leakage of production and thus GHG emissions. However, GHG emissions from agriculture, including beef and dairy, must decrease while productivity increases in order to achieve the Paris Agreement and securing food for a growing population.

Furthermore, net emissions from land-use were 5.1 million tonnes in 2021, mostly from cultivating wetlands. As a part of the agricultural agreement from 2021, it was decided to take 100,000 ha wetlands out of production. The DEA expects emission from land-use to decrease by 1.4 million tonnes from 2021-2030, which is driven mainly by taking wetlands out of production. However, this process of taking out wetlands has proven to be more difficult and slower to implement than planned.[213] Thus, a major risk to the climate target in 2030 is the efficiency of taking out wetlands. Moreover, there is also uncertainty about the possible speed of taking out wetlands and the climate benefit from this, which is subject to more research and might be revised during the coming years.

211. Naturvårdsverket (2023). *Underlag till regeringens kommande klimathandlingsplan och klimatredovisning*. NV-08102-22. Retrieved from, https://www.naturvardsverket.se/499a4f/contentassets/4c414b0778e9409fb2836fc4d3dc6259/underlag-till-regeringens-kommande-klimathandlingsplan-och-klimatredovisning-2023-04-13.pdf
212. Naturvårdsverket (2023). *Underlag till regeringens kommande klimathandlingsplan och klimatredovisning*. NV-08102-22. Retrieved from, https://www.naturvardsverket.se/499a4f/contentassets/4c414b0778e9409fb2836fc4d3dc6259/underlag-till-regeringens-kommande-klimathandlingsplan-och-klimatredovisning-2023-04-13.pdf
213. Klimarådet (2023). *Sektorvurderinger, Baggrundsnotat til Klimarådets Statusrapport 2023, kapitel 3*. Retrieved from, https://klimaraadet.dk/sites/default/files/paragraph/field_download/Baggrundsnotat%20Sektorvurderinger.pdf

Emission reductions in **Finnish** agriculture face several challenges. Finnish agricultural production is predicted to remain the same as today or, with growing climate impacts, increase, as production may shift to Northern Europe. On the other hand, agriculture suffers from low profitability, which makes the take-up of new measures by farmers less probable.

Another challenge is that in some parts of the country organic peatland soils are very common and some farms are almost entirely on organic land. This makes it difficult to reduce the number of peatlands under cultivation. The structural change going on in Finnish agriculture leads to larger animal farms and regional concentration of animal production. For example, the number of cows on a milk farm has increased by 5-6% per year[214]. This leads to a lack of fields for spreading the manure, which is one of the most important drivers for clearing fields. Clearing fields, especially on peatlands, significantly increases emissions from agriculture.

Livestock production accounts for almost 90% of the agricultural emissions (excluding land-use and energy emissions). Reducing livestock emissions is thus one of the main challenges for the agricultural sector to contribute to climate targets. Without major technological breakthroughs, a substantial GHG reduction will require a reduction in livestock production[215].

Lastly, there is a huge challenge in increasing the net sink of the LULUCF sector. 2021 was a turning point as the LULUCF sector became a net source rather than a net sink. Significant additional measures would be needed to regain the sink potential to meet the target set in the Climate Change Plan, but the political acceptability of the required steps is contested.

**Iceland** aims to significantly increase mitigation and sequestration in this sector by reducing emissions and enhancing sequestration.  Emissions, however, dwarf sequestration which are in part legacy effects from former land management in the country. Coordinated plans in forestry and land restoration/revegetation acknowledge the need for careful planning, biodiversity protection and focus on restoring wetlands and native vegetation such as birch. The challenges to ensure effective mitigation and sequestration in the LULUCF sector include: i) **effective engagement with landowners:** such engagement is needed to ensure effective restoration of wetlands and improved grazing conditions for livestock; ii) **possible impact on biodiversity** from forestry and land-reclamation plans; iii) **lack of formal third-party certification** of avoided GHGs from wetland reclamation plans; iv) **lack of baseline and monitoring data: t**o ensure

214. Lehtonen, H., Saarnio, S., Rantala, J., Luostarinen, S., Maanavilja, L., Heikkinen, J., Soini, K., Aakkula, J., Jallinoja, M., Rasi, S., Niemi, J. (2020). *Maatalouden ilmastotiekartta – Tiekartta kasvihuonekaasupäästöjen vähentämiseen Suomen maataloudessa*. Maa- ja metsätaloustuottajain Keskusliitto MTK ry. Helsinki. Retrieved from, https://www.mtk.fi/documents/20143/310288/MTK_Maatalouden_ilmastotiekartta_net.pdf/4c06a97a-c683-1280-65ba-f4666132621f?t=1597055521915
215. Møllgaard, P., Jacobsen, J.B., Kristensen, N.B., Elmeskov, J., Halkier, B., Heiselberg, P., Knudsen, M.T., Morthorst, P.E. & Richardson, K. (Febuary 2023). *Statusrapport 2023*. Klimarådet. Retrievde from, https://klimaraadet.dk/sites/default/files/node/field_file/Klimaraadet_statusrapport23.pdf

effective mitigation and sequestration and to enable certification of efforts, enhanced nationwide baseline and monitoring data collection is needed.

The pathway for the agricultural sector towards lower emissions is challenging and will require simultaneous change in diets and reduction of livestock. This creates significant challenges, including: i) the impact on **rural development** and farming communities, ii) the need to safeguard **food security** and iii) emissions **leakage** as domestic self-sufficiency in meat and dairy production could be challenged.

For **Norway,** the main challenges for climate change mitigation for agriculture are scarce availability of high-quality land as well as arduous climate conditions for agriculture production. A large share of agricultural land is only suitable as grazing land for sheep and cattle, generating a sizeable methane emission given ruminants' digestion system. Reducing imports of animal feed can reduce sustainability concerns in exporting countries and increase self-sufficiency but may lead to more methane emissions. Norway spends substantial public money on various support arrangements for agriculture (e.g. through negotiated prices on agricultural products and tariffs on competing imports). Support for farmers is also motivated by the importance of agriculture for rural settlements and for preserving culture landscapes.

The net $CO_2$ sink of Norway's forested areas is, for the time being, large but will be substantially reduced over the next decades due to aging trees. Avoiding many forest areas going from a $CO_2$ sink to source is doable but will require large and long-term programs of afforestation to replace old trees and harvested wood.

There is a need for more measures in the agricultural sector in **Sweden** to enable the sector to contribute to reaching the climate targets for 2030 and 2045[216].

The main challenges in reducing emissions in agriculture are that they are difficult to measure, trade-offs with other environmental objectives, consideration of food security, as well as the sector's exposure to international competition and the risk of emission leakage. The challenges mean, among other things, that it can be difficult to introduce policies that target sources of emissions directly[217]. The need to balance emission reductions in this sector with the need for domestic food production is an issue that is becoming increasingly pertinent in times of geopolitical unrest. This has made it politically difficult to implement stringent policy instruments in the agricultural sector. Changing food preferences from meat and dairy products may reduce emissions in the long-term.

216. Naturvårdsverket (2023). *Underlag till regeringens kommande klimathandlingsplan och klimatredovisning*. NV-08102-22. Retrieved from, https://www.naturvardsverket.se/499a4f/contentassets/4c414b0778e9409fb2836fc4d3dc6259/underlag-till-regeringens-kommande-klimathandlingsplan-och-klimatredovisning-2023-04-13.pdf
217. Swedish Environmental Protection Agency and Swedish Board of Agriculture. (2022). *Jordbrukssektorns klimatomställning*. Rapport 7060. Retrieved from, https://www.naturvardsverket.se/publikationer/7000/978-91-620-7060-1/

EU legislation is having an increasing impact on land use in Sweden, and the land-use sector is of great importance for achieving Sweden's and the EU's goals for climate and biodiversity. With regards to LULUCF, how the state, through various policy instruments, can ensure that the market allocates the forest resource in order to achieve the greatest possible societal benefit[218] has been identified as the biggest challenge. For the implementation of measures on forest land to achieve this purpose, there are several important conflicting interests to consider. Climate goals must be weighed against goals for biodiversity, forest production goals and goals for other forest ecosystem services, such as recreation. Another major challenge to consider is the risk of emissions leakage by increased felling forests in other countries to compensate for reduced felling in Sweden. The potential extent of emissions leakage is surrounded by uncertainty. Another risk factor is that net removal may continue to decline due to drought, storms and insect infestations. The drought and forest fires that occurred in 2018 and the attacks of spruce bark beetles in recent years, which developed as a result of the situation around 2018, may have a major impact on the development of the net intake in future years as well. The National Forest Assessment's measurements indicate that the reduced growth is mainly due to how weather conditions have developed in recent years. Failure to recover from the recent poorer growth could lead to a reduced annual net removal from living biomass in the order of 10 million tonnes of carbon dioxide.

**Across the Nordic countries**, only small emission reductions have been achieved in the agricultural sector and strategies and initiatives are hard to implement due to political concerns such as carbon leakage, regressive effects, food security and rural development. This proves to be a major challenge in decarbonising the sector. A closely connected cross-Nordic issue for forestry and land-use, is the taking out of organic soils, peatlands and wetlands. Rewetting these areas, despite plans in place in some of the Nordic countries, has proven difficult and with much slower progress than originally envisioned. Furthermore, a combination of climate change, demand for land for growing farms and an increased demand for biomass is challenging the forest sinks in the Nordic countries.

Below, we have focused on two main cross-Nordic challenges for the agriculture, forestry and land-use sector:

- addressing emissions from organic soils and securing a future net removal in LULUCF
- transforming the agricultural sector in the Nordic countries.

These are described in further detail below.

218. Swedish Environmental Protection Agency, Swedish Forest Agency, and Swedish Board of Agriculture. (2022). *Förslag för ökade kolsänkor i skogs- och jordbrukssektorn*. Rapport 7059. Retrieved from, https://www.naturvardsverket.se/publikationer/7000/978-91-620-7059-5/.

### 15.4.1. Addressing emissions from organic soils and securing a future net removal in the LULUCF sector

*The challenge*

There is a cross-Nordic challenge in reducing emissions from LULUCF, but also in strengthening the sink potential in this sector. This includes reducing emissions from degraded wetlands, such as cultivated peatlands and improving the sink potential of forests.

Restoring degraded wetlands is a large challenge in many of the Nordic countries, in particular Denmark, Sweden and Finland, where reducing emissions from cultivated peatlands requires giving up agricultural land.

In **Finland**, since the farmed organic soils are geographically clustered, this makes taking the areas out of production politically sensitive, and with potential adverse regional social consequences. In **Denmark,** the goal of taking out 100,000 ha of peatland has also been challenging, taking longer than expected[219]. In **Sweden** emissions from drained organic soils on forest- and cropland are highlighted as primary emitters in LULUCF sector in their National Inventory Report[220].

In Sweden, Norway and Finland, forests play an important role as carbon sinks. However, there has been a decrease in the sink potential in both Sweden and Finland. In **Sweden** this is mainly due to changing weather conditions (droughts, storms) and insect infestations, and in **Finland** to increased logging. Furthermore, **Norway** also expects a decrease in the sink due to aging trees with lowering sequestration potentials. This poses a challenge in terms of using this sector to balance out emissions in the future.

*Opportunities*

- Knowledge sharing and research co-operation on addressing emissions from organic soils

This research could include investigations into the climate benefit of restoring wetlands, providing important knowledge for future political decisions and prioritisation of efforts. It could also cover the cost-efficiency and social acceptability of various policies to address organic soil emissions.

The research could further be expanded to alternatives to conventional farming on peatlands, e.g. paludiculture.

219. Klimarådet (2023). *Sektorvurderinger, Baggrundsnotat til Klimarådets Statusrapport 2023, kapitel 3.* Retrieved from, https://klimaraadet.dk/sites/default/files/paragraph/field_download/Baggrundsnotat%20Sektorvurderinger.pdf
220. Swedish Environmental Protection Agency (2023, April 6). *National Inventory Report Sweden 2023.* Retrieved from, https://unfccc.int/documents/627663

### 15.4.2. Transforming the agricultural sector in the Nordic countries

*The challenge*

Reductions in emissions from the agricultural sector is, as mentioned earlier, a challenging task, due to concerns about food security and growing demand from a growing global population. Across all Nordic countries there is a challenge in reducing emissions from agriculture on a farm level, in terms of emissions from handling manure, methane emissions from livestock and crop cultivation.

So far, technical solutions to the challenges listed above have been the main focus in the abatement of emissions from agriculture across the Nordic countries[221]. More and different efforts are needed for this sector to contribute to the climate neutrality targets.

In many of the Nordic countries, livestock production accounts for a big portion of the GHG emissions in the agricultural sector due to their methane emissions. For example, in **Finland,** livestock production accounts for almost 90% of the agricultural emissions (excluding land-use and energy emissions). So far, there has been little development in decreasing these emissions besides increasing the productivity of the animals.

In recent years, more attention has been given to combining technical efforts with consumer-based dietary shifts, but policies are still lacking in this area across the Nordic countries. One of most promising ways to address the climate challenges in the agricultural sector is replacing the consumption of animal-based food with plant substitutes such as legumes, grains, algae and vegetables[222].

*Opportunities*

- Knowledge sharing on carbon pricing in agriculture – risks and incentive structures
- Nordic research on climate accounting on farms and improving knowledge on ways to reduce emissions on the farm from livestock, such as manure management – including biogas production, crop cultivation and fodder additives to reduce methane releases from ruminants
- Studies on examples on how to improve the conditions for producers of plant-based proteins, both in terms of research, education and regulatory frameworks

The recommendations above have also previously been recommended in Nordic Food Transition: Low Emissions Opportunities in Agriculture (2021)[223].

- Target Nordic research and innovation funds towards plant-based production

221. Nordic Council of Ministers (2021, June 23). *Nordic Food Transition, Low emission opportunities in agriculture.* Retrieved from, https://norden.diva-portal.org/smash/get/diva2:1571866/FULLTEXT03.pdf
222. Nordic Council of Ministers (2021, June 23). *Nordic Food Transition, Low emission opportunities in agriculture.* Retrieved from, https://norden.diva-portal.org/smash/get/diva2:1571866/FULLTEXT03.pdf
223. Nordic Council of Ministers (2021, June 23). *Nordic Food Transition, Low emission opportunities in agriculture.* Retrieved from, https://norden.diva-portal.org/smash/get/diva2:1571866/FULLTEXT03.pdf

# 16. Further opportunities for Nordic collaboration towards climate neutrality in the Nordic region

In addition to the opportunities identified in the previous sector chapters addressing the main sector challenges across the Nordic countries, we recommend increased Nordic collaboration in the following:

- a study on Nordic scenarios for climate neutrality (at the Nordic level).

In this stock-take report, we have given an overview of the five Nordic countries' pathways towards climate neutrality in the different sectors. As shown in the report, many of the challenges are shared across countries, calling for knowledge-sharing and collaboration across the Nordics. Moreover, regarding topics such as CCS, cross-Nordic collaboration is imperative to fully realise the potential of the full value-chain.

To identify all the areas of high value for further Nordic collaboration, a natural follow-up to this project is a Nordic-level study on scenarios for climate neutrality, aligned with previous work done by Nordic Energy Research (Nordic Clean Energy Scenarios, 2021[224]). The central research questions of this study could be:

o Ignoring national borders, what combination of initiatives in the different sectors achieves climate neutrality in the Nordic region by 2040/2050?

o What are the consequences for national climate policy?

The study would be a theoretical/hypothetical exercise, but it could highlight areas of high value for Nordic collaboration and pinpoint areas where Nordic solutions are more efficient/better/less costly, compared to national solutions. It could also support a regional Nordic target year for climate neutrality, pushing national governments to implement more ambitious policies and adopt more ambitious targets.

- Knowledge-sharing on efficient climate policy collaboration between government levels

In the chapter on *Domestic transport*, one of the recommendations is about analysing and comparing multi-level governance frameworks. That recommendation is not only relevant for the transport sector but also for all the other sectors. Many government levels are involved in the implementation of climate policy initiatives in the Nordic

224. Wråke, M., Karlsson, K., Kofoed-Wiuff, A., Bolkesjø, T.F., Lindroos, T.J., Hagberg, M., Simonsen, M.B., Unger, T., Tennbakk, B., Jåstad, E.O., Lehtilä, A., Putkonen, N. & Koljonen, T. (2021). *Nordic Clean Energy Scenarios: Solutions for Carbon Neutrality*. Nordic Energy Research. Retrieved from, https://norden.diva-potal.org/smash/get/diva2:1589875/FULLTEXT02.pdf

countries, and cooperation between them is key to efficient and effective implementation. In some of the Nordic countries, e.g. Denmark, municipalities are formulating their own climate targets and strategies, in some cases setting more ambitious targets than the national government[225]. In this case, without efficient collaboration between municipalities and the national government, municipalities' efforts might be hindered by national regulation and/or strategies.

The Nordic Council of Ministers could commission a study on collaboration between government levels on climate policy initiatives and strategies. The study should result in best-practice examples and recommendations for efficient collaboration across government levels on climate policy initiatives/strategies.

- Coordination and transparency on assumptions for climate neutrality strategies and pathways in the Nordic countries

National strategies and pathways towards climate neutrality depend on and rely on assumptions about the development in other countries. If these assumptions are incorrect, the viability of national plans changes. For example, this report has described the challenges related to overreliance on the Norwegian hydropower battery (see the chapter on energy). To avoid these issues, the Nordic Council of Ministers could help further transparency in assumptions in climate neutrality strategies across the Nordic countries by, for example, maintaining an updated list of key experts in climate and energy ministries across the Nordic region. Due to issues such as language differences, it can be hard for government employees to find, access and understand their neighbouring countries' strategies and plans. Having access to an updated list of experts in government that they can reach out to, could alleviate these issues.

- Coordination of value chains on waste, CCS and bioenergy across the Nordics to enhance efficiency and economies of scale yields in terms of money, energy and GHG emissions
- Increased knowledge-sharing ("best practice") and collaboration on addressing consumption-based emissions in the Nordic countries

Across the Nordic countries, there are few policies and strategies targeting consumption-based emissions. Addressing these emissions is important not just for reaching climate neutrality in the Nordic region but also for contributing to global emission reductions.

225. Ea Energianalyse (2023, April 17). *Analyse af kommunernes CO2-reduktionsbidrag til 70%- målsætningen i 2030.* Retrieved from, https://concito.dk/files/media/document/Rul%201%20kommunernes%20bidrag%20til%2070%25%20m%C3%A5let_05_04_2023.pdf

The Nordic Council of Ministers could further this agenda by commissioning comparative studies on how consumption-based emissions are addressed in the different countries and provide best-practice examples and cases of what such policies could look like and what their impact on emissions have been. Such a study should also address the issue of a fair and just transition – e.g. how to develop such policies in a way that does not have adverse social consequences.

- Collaboration on a just and fair transition, incl. more research on making carbon taxes and pricing fair

Finally, there is a need for pooled resources on, and further investigation into, ensuring a just and fair transition across the Nordic region. As all the Nordic countries must intensify their efforts towards reaching climate neutrality, the risks of adverse and regressive effects of policies and initiatives multiply, for example policies that affect low-income more than high-income groups. Research/studies funded by the Nordic Council of Ministers could, for example, consider how to develop and implement fair and just carbon taxation without regressive effects.

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# About this publication

## Nordic Stocktake – Pathways to Climate Neutrality

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### Disclaimer



## About the project

As part of the Nordic Stocktake and Visions project funded by the Nordic Council of Ministers, CONCITO, CICERO, IVL Swedish Environmental Research Institute, University of Iceland and Reykjavik University, and Tyrsky Consulting have taken stock of greenhouse gas (GHG) emissions in the Nordic countries, assessed national pathways, and identified ways forward towards climate neutrality in the Nordic region. The project is a part of the initiative "Climate transition in the Nordics" to support the Nordic Vision 2030. The overall aim of the Nordic Vision is to become the most sustainable and integrated region in the world by 2030.

The Nordic region aims to be the world's most sustainable and integrated region by 2030 (Our Vision 2030[226]). The most recent status report[227] (2023) shows that Nordic green ambitions are challenged and points to a need for greatly accelerated efforts. The report, *Nordic Stocktake*, reaches a similar conclusion.

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