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What impact do climate change policies have on Nordic economies, industries, and households?

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Executive Summary

In August 2019, the Nordic Prime Ministers adopted a new steering document for Nordic co-operation, entitled 'Our Vision 2030'. The document states that the Nordic Region aims to become the most sustainable and integrated region in the world by 2030. Working towards a carbon-neutral society is one of the specific priorities of the strategy.

A new generation of European and Nordic climate policies sets ambitious goals to reach carbon neutrality by or before 2050. The new policies place emphasis on sectors that have proven more challenging to de-carbonise in the past, including: (a) the process industry (e.g. steelmaking, cement, aluminium smelting, petrochemicals); (b) land, air, and maritime transport; and (c) agriculture and animal husbandry. The new climate policies may have both positive and negative impacts on Nordic economies and societies:

- Economic impacts may arise from technology substitution processes steered by said climate policies. Some technologies, in particular those based on fuel combustion, will be phased out and replaced by cleaner alternatives. That will lead to mixed economic effects, depending on the ability of the various sectors to adapt to carbon-neutral production and consumption systems.
- Distributive impacts of climate policies will depend on how household finances are affected in terms of income, i.e. quantity and quality of jobs, as well as spending, i.e. cost of living.
- Regional impacts of climate policies may also be significant. Some regions may be impacted more than others due to their economic dependence on disrupted sectors or, conversely, their overall economic resilience.

This report contains a quantitative analysis of the possible effects of selected climate policies on the Nordic economies in terms of: (a) macroeconomic costs, i.e. impacts on GDP and other macroeconomic variables; (b) labour markets, i.e. employment effects by industry, occupation, wage band, required educational level, age, and subnational region; (c) cost of living, i.e. effects on various types of households, by degree of urbanisation (urban/intermediate/rural) and income decile.

The analysis focuses on a selection of greenhouse policies and their possible impacts for 2019[1] to 2030:

1. Our policy scenario looks at the 2020-2030 period. However, our simulations take 2019 as the base year because 2020 was an atypical period due to the global economic disruption caused by the COVID-19 pandemic.

- attainment of targets for a higher biofuel share of motor fuels (see Table 3);
- attainment of targets for a higher share of electric vehicles in passenger car fleets (see Table 4); and
- phasing-out of remaining coal-fired electricity.

The analyses in this report are based on a newly developed, multi-regional, computable general equilibrium (CGE) model called Nordic-TERM. It is a model with a high level of regional and sectoral disaggregation that identifies: the five Nordic countries and Rest of Europe; 25 NUTS2 regions within the Nordic countries; 53 industries; 39 occupations together with several occupational characteristics, such as wage bands; and 30 types of households classified by income decile and urban, intermediate, and rural location. That level of detail makes Nordic-TERM an ideal tool for looking at the distributional and structural effects of policies in the Nordic Region. The Nordic-TERM model is the first CGE model to be developed for the Nordic Region and allows for analyses at the national and subnational level.

Using Nordic-TERM, we compute the effects of greenhouse policies by comparing baseline and policy runs of the model for 2019 to 2030. In the baseline run, we assumed no new greenhouse policies beyond those implemented by 2019. The baseline run incorporates macro forecasts and data from the OECD and the World Bank, as well as assumptions concerning productivity differences between broad sectors (agriculture, mining, manufacturing, and services). The policy run estimates the effects of the three greenhouse policies mentioned above.

The shocks in the policy run take account of:

- increases in the cost of motor fuels for industries (mainly the road transport industry) in connection with the attainment of biofuel targets in diesel;
- increases in the cost of motor fuels for households in connection with the attainment of biofuel targets;
- changes in the composition of inputs in the production of motor fuels (substitution of oil with biomaterials);
- increases in the use of electricity by households in connection with the attainment of targets for electric vehicles as a share of the passenger car fleet;
- reductions in the use of motor fuels by households in connection with the reduction in internal combustion vehicles as a share of passenger cars;

- increased expenditure by households on charging stations for electric vehicles; and
- loss of physical capital through scrapping of remaining coal-fired electricity generation, and its replacement by other forms of generation.

The results of the simulation indicate that the attainment of targets for biofuels and electrification of car fleets, together with phasing-out of the remaining coal-fired electricity generation, will be sufficient to meet the 2030 emission reduction target in Sweden, but not in the other Nordic countries (Table 7).

Implementation of these greenhouse policies will have moderate macroeconomic costs. With the policies in place, simulated GDP in the least affected Nordic country, Iceland, is 0.18 per cent less in 2030 than according to the no-policy baseline. In the worst affected Nordic country, Sweden, the GDP cost of the policies in 2030 is a reduction of 1.31 per cent compared to baseline growth over the 11-year period, see Table 8.

The employment deviations in 2030 for the 25 NUTS2[2] Nordic regions caused by the greenhouse policies are all less than one per cent in absolute terms (Table 16). Norra Mellansverige shows the largest positive deviation (0.37%) while Vestlandet shows the largest negative deviation (-0.49%). With regard to greenhouse policies, Norra Mellansverige has a favourable industry mix (namely a dependence on forestry activity) compared to other Swedish regions. By contrast, Vestlandet has an unfavourable industry mix (namely a particular focus on oil) compared to other Norwegian regions.

In all the Nordic countries, greenhouse policies have negative employment effects on occupations that are used intensively for the provision of private and public consumption services. Those include occupations such as *Health professional* and *Personal care worker* (see Table 12). The effects on employment in *Scientific and engineering professional*, *Metal machine trade*, and *Electrical trade* are uniformly positive. For other occupations there are mixed effects across countries. The biggest negative employment deviation across the 39 occupations in the Nordic countries is -2.6% (*Handicraft and printing*, in Sweden).

As was to be expected, due to a relatively high share of consumer spending on motor fuels, greenhouse policies increase living costs for rural households relative to those in urban and intermediate regions. There is no systematic pattern across deciles: high-income families are just as likely to suffer relative cost-of-living

2. The NUTS classification (Nomenclature of territorial units for statistics) is a hierarchical system for dividing up the economic territory of the EU and the UK. The nomenclature is produced by Eurostat for the purpose of the collection, development, and harmonisation of European regional statistics.

increases as low-income families. However, the relative effects for all family types are very small (Table 17).

The results in this report allow an optimistic conclusion to be drawn. They suggest that significant reductions in greenhouse emissions can be achieved at moderate macroeconomic cost with almost no structural disruption (Table 19). In terms of adjustment, we consider the occupational and subnational regional results to be of prime relevance. It is reassuring that the greenhouse policies do not generate any large negative employment deviations in these two respects. It means that these policies are unlikely to cause skill-related or locational mismatches on the Nordic labour markets.

Sammenfatning

I august 2019 vedtog de nordiske statsministre et nyt styredokument for det nordiske samarbejde med titlen 'Vores vision 2030'. Dokumentet fastslår, at Norden sigter mod at blive den mest bæredygtige og integrerede region i verden i 2030. Arbejdet hen imod et CO2-neutralt samfund er en af strategiens specifikke prioriteter.

En ny generation af europæiske og nordiske klimapolitikker sætter ambitiøse mål for at nå kulstofneutralitet inden eller før 2050. De nye politikker lægger vægt på sektorer, der tidligere har vist sig mere udfordrende at afkarbonisere, herunder: (a) procesindustrien (stålfremstilling, cement, aluminiumssmeltning, petrokemikalier); (b) land-, luft- og søtransport; og (c) landbrug og dyrehold. De nye klimapolitikker kan have både positive og negative konsekvenser for nordiske økonomier og samfund:

- Økonomiske påvirkninger kan opstå fra teknologisubstitutionsprocesser styret af nævnte klimapolitikker. Nogle teknologier, især dem, der er baseret på brændstofforbrænding, vil blive udfaset og erstattet af renere alternativer. Det vil føre til blandede økonomiske effekter, afhængigt af de forskellige sektorers evne til at tilpasse sig CO2-neutrale produktions- og forbrugssystemer.

- Fordelingseffekterne af klimapolitikker vil afhænge af, hvordan husholdningers økonomi påvirkes med hensyn til indkomst, dvs. antallet og kvaliteten af job, samt udgifter, dvs. Leveomkostninger.

- Regionale virkninger af klimapolitikker kan også være betydelige. Nogle regioner kan blive påvirket mere end andre på grund af deres økonomiske afhængighed af forstyrrede sektorer eller omvendt deres generelle økonomiske modstandskraft.

Denne rapport indeholder en kvantitativ analyse af mulige konsekvenser af udvalgte klimapolitikker på de nordiske økonomier i form af: (a) makroøkonomiske omkostninger, dvs. påvirkninger på BNP og andre makroøkonomiske variabler; (b) arbejdsmarkeder, dvs. beskæftigelseseffekter efter branche, erhverv, lønklasse, påkrævet uddannelsesniveau, alder og subnational region; (c) leveomkostninger, dvs. virkninger på forskellige typer husholdninger, efter urbaniseringsgrad (by/mellemliggende/landdistrikt) og indkomstdecil.

Analysen fokuserer på et udvalg af drivhuspolitikker og deres potentielle konsekvenser fra 2019 til 2030:

- opnåelse af mål for en højere biobrændstofandel af motorbrændstoffer (se tabel 3);
- opnåelse af mål for en højere andel af elektriske køretøjer i personbilflåder (se tabel 4); og
- udfasning af resterende kulfyret el.

Analyserne i denne rapport er baseret på en nyudviklet, multiregional, beregnelig generel ligevægtsmodel (CGE) kaldet Nordic-TERM. Det er en model med et højt niveau af regional og sektoropdeling, der identificerer: de fem nordiske lande og Resten af Europa; 25 NUTS2-regioner i de nordiske lande; 53 brancher; 39 erhverv sammen med flere erhvervskarakteristika, såsom lønintervaller; og 30 typer husstande klassificeret efter indkomstdecil og by, mellemliggende og landlig beliggenhed. Den detaljeringsgrad gør Nordic-TERM til et ideelt værktøj, til at se på fordelingsmæssige og strukturelle effekter af politikker i Norden. Nordic-TERM-modellen er den første CGE-model, der er udviklet for Norden og giver mulighed for analyser på nationalt og subnationalt niveau.

Ved hjælp af Nordic-TERM beregner vi effekten af drivhuspolitikker ved at sammenligne baseline- og politikkørsler af modellen for 2019 til 2030. I basiskørslen antog vi ingen nye drivhuspolitikker ud over dem, der er implementeret i 2019. Basiskørslen omfatter makroprognoser og data fra OECD og Verdensbanken, samt antagelser vedrørende produktivitetsforskelle mellem brede sektorer (landbrug, minedrift, fremstilling og service). Politikkørslen estimerer effekterne af de tre ovenfor nævnte drivhuspolitikker.

Chokkene i politikkørslen tager højde for:

- stigninger i omkostningerne til motorbrændstof for industrier (hovedsageligt vejtransportindustrien) i forbindelse med opnåelsen af biobrændstofmål i diesel;
- stigninger i udgifterne til motorbrændstof for husholdninger i forbindelse med opnåelsen af biobrændstofmålene;
- ændringer i sammensætningen af input i produktionen af motorbrændstoffer (erstatning af olie med biomaterialer);
- stigninger i husholdningernes brug af elektricitet i forbindelse med opnåelse af mål for elbiler som andel af personbilsflåden;
- reduktioner i husholdningernes brug af motorbrændstof i forbindelse med reduktionen af forbrændingskøretøjer som andel af personbiler;
- øgede husholdningers udgifter til ladestandere til elektriske køretøjer; og

- tab af fysisk kapital gennem skrotning af resterende kulfyret elproduktion og erstatning heraf med andre former for produktion.

Resultaterne af simuleringen peger på, at opnåelsen af mål for biobrændstoffer og elektrificering af bilflåder sammen med udfasning af den resterende kulfyrede elproduktion vil være tilstrækkeligt, til at opfylde 2030-emissionsmålet i Sverige, men ikke i de øvrige nordiske lande (tabel 7).

Gennemførelsen af disse drivhuspolitikker vil have moderate makroøkonomiske omkostninger. Med de politikker, der er på plads, er simuleret BNP i det mindst berørte nordiske land, Island, 0,18 procent mindre i 2030 end ifølge basislinjen uden politik. I det hårdest ramte nordiske land, Sverige, er BNP-omkostningerne ved politikkerne i 2030 en reduktion på 1,31 procent sammenlignet med basisvæksten over den 11-årige periode, se tabel 8.

Beskæftigelsesafvigelserne i 2030 for de 25 NUTS2 Nordiske regioner forårsaget af klimapolitikkerne er alle mindre end én procent i absolutte tal (tabel 16). Norra Mellansverige viser den største positive afvigelse (0,37 %), mens Vestlandet viser den største negative afvigelse (-0,49 %). Med hensyn til drivhuspolitikker har Norra Mellansverige et gunstigt industrimix (nemlig afhængighed af skovbrugsaktivitet) sammenlignet med andre svenske regioner. Derimod har Vestlandet et ugunstigt industrimix (nemlig særligt fokus på olie) sammenlignet med andre norske regioner.

I alle de nordiske lande har klimapolitikkerne negative beskæftigelseseffekter på erhverv, der bruges intensivt til levering af private og offentlige forbrugstjenester. Disse omfatter erhverv som sundhedsprofessionel og personlig plejemedarbejder (se tabel 12). Effekterne på beskæftigelsen inden for videnskabelige og ingeniørfaglige, metal- og elektrikerhandel er ensartet positive. For andre erhverv er der blandede effekter på tværs af landene. Den største negative beskæftigelsesafvigelse på tværs af de 39 erhverv i Norden er -2,6 % (Håndværk og trykkeri, i Sverige).

Som det kunne forventes, øger klimapolitikkerne leveomkostningerne for landhusholdningerne på grund af en relativt høj andel af forbrugernes udgifter til motorbrændstoffer i forhold til dem i by- og mellemområder. Der er ikke noget systematisk mønster på tværs af deciler: højindkomstfamilier er lige så tilbøjelige til at lide under relative stigninger i leveomkostninger som lavindkomstfamilier. De relative effekter for alle familietyper er dog meget små (tabel 17).

Resultaterne i denne rapport gør det muligt at drage en optimistisk konklusion. De antyder, at betydelige reduktioner i drivhusemissioner kan opnås til moderate makroøkonomiske omkostninger, med næsten ingen strukturel forstyrrelse (tabel

19). Med hensyn til tilpasning, anser vi de erhvervsmæssige og subnationale regionale resultater, for at være af største relevans. Det er betryggende, at drivhuspolitikkerne ikke genererer store negative beskæftigelsesafvigelser i disse to henseender. Det betyder, at det er usandsynligt, at disse politikker vil forårsage kompetencerelaterede eller lokaliseringsmæssige uoverensstemmelser på de nordiske arbejdsmarkeder.

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1. Introduction

All Nordic countries have ambitious climate goals and are endeavouring to become carbon-neutral before or by 2050. Finland aims to achieve carbon neutrality by 2035. Iceland strives to reach the same goal before 2040, while Sweden and Denmark seek to be carbon-neutral or even climate-neutral by 2045 and 2050, respectively. Norway aims to become a 'low-emission society' by 2050. These national goals are all enshrined in climate laws in the various Nordic countries (Tapia et al. 2022).

By working towards their nationally defined climate goals, Nordic countries also contribute towards achieving international and European climate ambitions as formulated e.g. by the UN Framework Convention on Climate Change (UNFCCC) in the Paris Agreement and at the level of the European Union (EU) in the European Green Deal and the European Climate Law. Moreover, Nordic climate policies are also key enablers for Our Vision 2030, the shared Nordic strategy to become 'the most sustainable and integrated region in the world' by actively working towards carbon neutrality (Nordic Council of Ministers 2023).

Attainment of the ambitious climate goals calls for a systematic overhaul of societies and economies. This process is commonly referred to as the 'green transition' (Cedergren et al. 2022). The way we produce, heat, travel, use available resources and address waste products all have to undergo fundamental rethinking. Some have described the green transition as 'revolutionary' and as one of 'the most significant social and economic transitions in world history', with potentially major implications for households, communities, industries, and regions (Clark II and Cooke 2014).

Against that backdrop, this report explores the macroeconomic and socioeconomic implications of three specific types of climate policies in the Nordic Region: the electrification of car fleets, the implementation of ambitious biofuel goals, and the phasing-out of all remaining coal-fired energy. Unlike existing studies, which generally focus modelling on an individual country, this report covers the majority of the Nordic Region, including the five Nordic countries Denmark, Finland, Iceland, Norway, and Sweden, as well as the autonomous territory of Åland. The report is guided by the following research questions:

1. How do the three key climate policies mentioned above affect the income and consumption of various household types across the Nordic Region?
2. How do the policies affect major macroeconomic variables in the Nordic countries, as well as industry outputs and employment across sectors?
3. How do such impacts differ across subnational regions within each country?

1.1. Background to the report

In policy debates and academic discussions, there has long been a focus on understanding how various climate policies contribute to reaching climate goals, as well as on estimating their macroeconomic impacts (Flam and Hassler 2023, Calmfors and Hassler 2019). The Nordic countries have developed climate models that are equipped to produce these types of estimates, including the Norwegian SNOW model (Fæhn et al. 2020, Bye, Fæhn, and Rosnes 2018) and the Danish GreenREFORM and IntERACT models (Beck and Dahl 2020, Naturvårdsverket 2022). In Sweden, Konjunkturinstitutet bases its analyses on the EMEC model (Carlén and Sahlén Östman 2015, Klevnäs, Stefansdotter, and von Below 2016) while in Finland the FINAGE model has been used to estimate the impact of climate policy measures on macroeconomic trends and emissions (Honkatukia 2019). Somewhat less attention has often been devoted to how the impact of climate policy measures differs across regions and households with different income levels in the Nordic countries. Nonetheless, it is essential to consider such effects since they may influence public support for climate policies and the green transition.

In recent years, however, this field has increasingly been a focal point of policy-making and research. That process has been fuelled by developments at the EU level, where the social impacts of climate policies have attracted increasing attention. Most importantly, the European Green Deal includes the pledge that no person and no place shall be left behind in the transition to low-carbon economies and societies (European Commission 2023a). The European Green Deal also includes a Just Transition Mechanism, which provides financial and technical support to regions that will be most affected by the shift to a low-carbon economy, including support for vulnerable groups and communities (European Commission 2023b). That mechanism is designed to ensure that the impacts of the transition to carbon neutrality will not hit some groups or regions harder than others. It is also intended to ensure that public support for the green transition and the European Green Deal can be maintained.

Responding to the increasing focus on socio-economic and geographical implications of the green transition, a growing number of projects and studies have analysed the distributional and household effects of climate policies. In Finland, Statistics and Research Åland (ÅSUB) has worked together with its partners to analyse the economic costs of climate policy measures, such as an emissions tax, and how they affect household incomes (Alimov et al. 2020; see also Tamminen et al. 2019). In Sweden and Norway, recent studies with a similar focus have also been produced (von Below et al. 2023, Fæhn and Yonezawa 2021, Brännlund and Kriström 2020, Andersson and Atkinson 2020). The Danish Economic Councils have estimated the impact of a CO2 tax on regional employment in industry and agriculture (De Økonomiske Råd 2021). Most of these existing studies, however, analyse policy impacts for individual countries and have not compared impacts across the Nordic Region.

Nonetheless, some recent studies have taken a broader macroregional perspective and have, for example, discussed the distributive effects of EU climate mitigation policies (Chen et al. 2020, Pye et al. 2019). In addition, the OECD and other actors have published extensive literature reviews for the purpose of summarising current knowledge on the distributive effects of climate policy measures (OECD 2014 and 2017, McInnes 2017, Mackie and Haščič 2018, Zachmann, Fredriksson, and Claeys 2018). Similarly, the Nordic Council of Ministers has recently published a report that analyses current Nordic practices for assessing the distributional effects of environmental and energy taxes (Gravers Skygebjerg et al. 2020).

In addition, two research projects by the Nordic Council of Ministers, namely ‘A socially sustainable green transition in the Nordic Region’ (Høst, Lauritzen, and Popp 2020), and ‘Not just a green transition’ (Tapia et al. 2022), focus on how the green transition in the Nordic countries can be implemented without increasing socio-economic inequalities. By and large, existing studies find that climate policy measures can have varying impacts on household finances; moreover, these impacts may be regressive in character, i.e. hit low-income households harder than high-income households (OECD 2014). Nonetheless, many of those studies conclude that it is possible to counteract such effects by redistributing revenues back to households (see e.g. Chen et al. 2020, Fragkos et al. 2021, Zachmann, Fredriksson, and Claeys 2018). Moreover, some recent studies also report progressive impacts of climate policies (see e.g. Fæhn and Yonezawa 2021, Tamminen et al. 2019).

All of these studies underline the importance of analysing the impact of climate policies on household finances and differentiating between households with varying income levels and locations of residence. It is only with sound knowledge of the impact of climate policies on various types of households and regions that adequate mitigation measures can be designed. Such measures are crucial to preserve social justice and to maintain public support for the green transition and progress towards ambitious climate policy goals.

1.2. Goal and approach

This report contributes to a socially fair green transition in the Nordic Region by analysing the impact of three key climate policy measures on household income and household consumption and by comparing impacts at the subnational level and by location of residence. The policies that come under the scope of the report are:

1. The attainment of national targets for a higher biofuel share of motor fuels;
2. The attainment of national targets for a higher share of electric vehicles in passenger car fleets; and
3. The phasing-out of all remaining coal-fired electricity.

The analyses in this report are based on a newly developed computable general equilibrium (CGE) model called Nordic-TERM. The Nordic-TERM model distinguishes between 53 industries, 39 occupations, eight wage bands, and 30 types of households, differentiating by income decile and rural, intermediate, and urban location of residence. This detailed setup allows for analyses of the impact of climate policies on employment and wages – a key source of household income – as well as impacts on consumption patterns. In addition, analyses using the Nordic-TERM model allow us to investigate the impacts of climate policies on macroeconomic variables, CO2 emissions, and industry outputs.

The Nordic-TERM model is the first model to cover almost the entire Nordic Region. It encompasses the five Nordic countries Denmark, Finland, Iceland, Norway, and Sweden, as well as the autonomous territory of Åland. However, Greenland and the Faroe Islands – which also form part of the Nordic Region – could not be included in the model due to data limitations. Within each Nordic country, the Nordic-TERM model identifies subnational regions at the NUTS-2 level. The impact of the three abovementioned climate policies can therefore be compared across the Nordic countries, as well as across subnational regions within and across countries.

Overall, this report aims to contribute to the growing academic and policy-based discussion on how the green transition in the Nordic countries will affect different population groups in different regions, and how climate policy measures can be designed to ensure that the transition will be as just as possible in terms of social and regional impacts.

The remainder of the report is structured as follows: Chapter 2 provides an overview of the overall climate policy framework in the Nordic Region and how it has contributed to cutting carbon emissions and transforming energy mixes since the 1990s. Chapter 3 delves into the multi-level nature of the climate policy framework and explains the mechanisms leading to social and economic impacts at the household level. Chapter 4 introduces the key analytical tool used in this research and presents the main modelling assumptions and scenarios. Chapter 5 presents simulation results for the effects of the greenhouse policy shocks on the Nordic economies. Chapter 6 presents a number of conclusions and key lessons learned in this study.

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2. Long-term strategies for reducing greenhouse gas emissions

While not all Nordic countries are members of the European Union (EU), all of them are committed to EU climate policies and targets. This chapter describes the key climate goals and policy instruments at the EU level and their implications for climate policy-making at the national level in the Nordic countries. The chapter continues with a description of current climate goals in the Nordic countries and illustrates the success of those policies in curbing Nordic greenhouse gas emissions and greening the energy mixes of the Nordic countries.

2.1. The EU climate and energy policy framework

EU-wide climate targets and policy objectives for the period from 2021 to 2030 are defined in the 2030 Climate and Energy Framework that was introduced by the European Council on 23/24 October 2014 (EU Council 2014). Under this framework, the EU as a whole is committed to:

- cutting territorial greenhouse gas emissions by at least 40% by 2030 and by 80-95% by 2050 (compared to 1990 levels).
- achieving at least 27% renewable energy as a share of EU-wide gross final energy consumption.
- attaining an improvement in energy efficiency of at least 27%.

In December 2018, the EU made the latter two targets more ambitious. The amended Renewable Energy Directive ((EU) 2018/2001) established a new binding renewable energy target for the EU for 2030 of at least 32%. The amended Energy Efficiency Directive ((EU) 2018/2002) defined a headline EU energy efficiency target for 2030 of at least 32.5%, compared to projections of the expected energy use in 2030. Both targets were set to be revised upwards in a revision planned for 2023 (EU 2018a, 2022).

In December 2019, the newly elected European Commission proposed to increase the ambition level and presented a set of policy proposals, commonly referred to as the 'European Green Deal'. It defined the goal of making the EU climate-neutral by 2050 and argued for the need to tighten the intermediate targets for 2030. In line with the European Green Deal, in December 2020 the European Council endorsed a target of a net domestic reduction in emissions of at least 55% by 2030, as compared to 1990. A new European Climate Law (Regulation (EU) 2021/1119) was adopted and published in the Official Journal of the European Union in July 2021. It established the legally binding target for the EU institutions and member states of reducing emissions by 55% by 2030 and the goal of achieving climate neutrality in 2050 (EU 2021).

In 2021, the European Commission adopted a series of legislative proposals called the 'Fit for 55' legislative package (EC 2021a). It aims to set Europe on a realistic path to becoming climate-neutral by 2050, including the following proposals for the period until 2030:

- Attaining the EU greenhouse gas emission reduction target of 55% compared to 1990 levels.
- Increasing the share of renewable energy in the Union's gross final energy consumption to 40%.
- Increasing the target for improvement in energy efficiency to 36% for final energy consumption and 39% for primary energy consumption.

The war in Ukraine prompted European actors to increase ambition levels still further. In May 2022, the European Commission launched the REPowerEU plan. Its goals are to save energy, diversify sources, and speed up the transition to a fully renewable energy system. Among other targets, the REPowerEU plan aims to raise the EU-wide renewable energy production target for 2030 even further from 40% to 45% of gross final energy consumption (EC 2022a).

The Fit for 55 package and its policy components are currently in the final stages of negotiation between the European Council and the European Parliament. Trilogues got underway in July 2022 and concluded with a provisional political agreement on 18 December 2022. The first parts of the Fit for 55 package were formally adopted in March 2023 (European Council 2023a, European Parliament 2023).

Overall, the EU and its member states have tightened the targets for curbing greenhouse gas emissions and the overall ambition level for EU climate policies by adopting the European Climate Law and the most recent policy packages. Due to the legally binding character of the 2030 and 2050 targets that were enshrined in the European Climate Law, the EU institutions and member states are bound to take necessary action. That includes the Nordic countries. Norway and Iceland are not member states of the EU but have aligned their national climate goals to the EU, meaning that their national climate policies will contribute to achieving EU climate targets too.

2.2. The structure of EU climate policy

European climate policies are implemented through three key instruments, namely the EU Emissions Trading System (ETS), the Effort Sharing Regulation (ESR), and the Land Use, Land Use Change and Forestry (LULUCF) Regulation.

2.2.1. The EU Emissions Trading System

The EU Emissions Trading System (EU ETS) is the world's first and largest carbon market, on which emission rights are traded across international borders (EC 2022b). The ETS is a market-based scheme designed to make large industrial facilities pay for the greenhouse gases emitted by their installations. Currently, the EU ETS covers power plants, large industrial factories, and CO2 emissions from aviation within the European Economic Area (EEA). It represents roughly 40% of all CO2 emissions within the EU and the EEA.

The EU ETS is regulated under Directive 2003/87/EC and operates in all EU member states, as well as Iceland, Liechtenstein, and Norway. The EU ETS operates as a cap-and-trade system. That means that installations under the EU ETS are subject to a Community-wide emissions limit that decreases over time (a *cap*), and that economic actors can buy or receive emissions allowances, which can also be traded on the market (a *trade*). The limit on the total number of available allowances ensures that they have a value. After each year, a given installation must surrender enough allowances to cover each ton of CO2 that is actually emitted, otherwise sanctions are imposed (EC 2022b). In practice, if an installation reduces its emissions, it can keep the spare allowances to cover its future needs or else sell them to another installation that is short of allowances.

The EU ETS has been deployed in various phases (Figure 1). The first two phases (2005-2008 and 2008-2013) were marked by a large number of free allowances and demand-and-supply mismatches. That caused permit prices to remain at low levels deemed inconsistent with the EU's long-term vision for a climate-neutral economy by 2050 (Carlén and Kriström 2020). The two more recent phases (2013-2021 and 2021-2024) were accompanied by an increase in the share of auctioned rather than allocated allowances and by several other changes of rules, in particular the creation of a Market Stability Reserve (MSR) to absorb unused allowances. That led to a substantial reduction in the emissions allowance surplus and a subsequent surge in permit prices, as clearly shown in Figure 1 (Carlén and Kriström 2020; Bua et al. 2021).

Figure 1. Historical changes in ETS allowance prices (Carbon Emissions Futures)
Source: Fusion Media Limited

Since the introduction of the EU ETS in 2005, emissions under the scheme have decreased by 41%. In the Nordic countries alone, ETS emissions have declined by around 42% in Denmark, 35% in Sweden, and 33% in Finland between 2012 and 2020 (Figure 2). Emissions increased in Iceland and Norway during this period due to a recovery in international oil prices – which affected oil-related activity in Norway – and an increase in aluminium production in Iceland. As part of the Fit for 55 Package, the EU institutions have adopted a new target to reduce emissions from the EU ETS sectors by 62% by 2030, compared to 2005 levels. To reach this target, the European Commission proposed a one-off reduction in the overall emissions cap by 117 million allowances, and a steeper annual emission reduction of 4.2%, instead of 2.2% per year under the current system (EC 2021b). All Nordic countries must contribute by speeding up the reduction of greenhouse gas emissions to reach this goal.

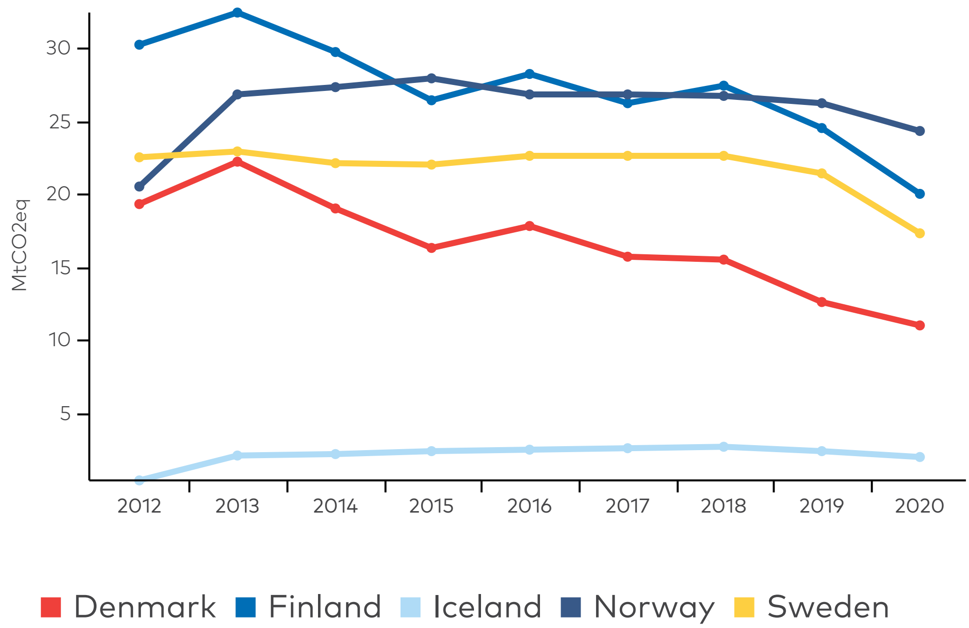


Figure 2. Verified greenhouse gas emissions under the ETS Directive (2003/87/EC)
Source: Own, based on EU ETS Union Registry databasex

Under the new Fit for 55 framework, the Council and European Parliament also agreed to include maritime shipping emissions within the scope of the EU ETS, with a gradual introduction of obligations for shipping companies to surrender allowances, namely 40% for verified emissions from 2024, 70% for 2025, and 100% for 2026. Moreover, the Council and European Parliament agreed to gradually end free allowances for sectors vulnerable to carbon leakage covered by the new Carbon Border Adjustment Mechanism (CBAM) – cement, aluminium, fertilisers, electric energy production, hydrogen, iron, and steel, as well as some precursors and a limited number of downstream products.

Targets have also been tightened for the aviation sector. Under the EU ETS, all airlines operating intra-European flights (including departing flights to the United Kingdom and Switzerland), are required to monitor, report, and verify their emissions, and to surrender allowances against those emissions. Like any other installation registered in the ETS system, airlines receive tradeable allowances covering a certain level of emissions from their flights per year. However, the system has involved a large share of free allowances (>82%) since its adoption. Under the Fit for 55 Package, EU institutions agreed to gradually phase out free emission allowances for the aviation sector as follows, to reach full auctioning by 2027: 25% in 2024, 50% in 2025, and 100% from 2026. The Icelandic government has reached an agreement with the EU to delay these rules for Iceland due to its geographical location and dependence on air transport. Under the agreement, Icelandic aircraft operators are to receive free emission allowances up to and including 2026.

In the scope of the Fit for 55 framework, the European Council and Parliament also decided to create a new, separate emissions trading system for specific sectors currently outside the EU ETS. The new system will start in 2027 and is to apply to distributors that supply fuels to the buildings sector, road transport sector, and certain industrial sectors where the scope of the system was extended to other fuels. While the new system forms part of the ETS legislation, in practice it affects emissions in the ESR sector (see below). Part of the revenues from auctioning under the new system will be used to support vulnerable households and micro-enterprises through a dedicated Social Climate Fund that was formally adopted in April 2023 (European Council 2023b).

The cap-and-trade setup of the ETS system – under which market actors trade a fixed and declining quantity of emission allowances defined at EU level – is intended to allow the system to find the most cost-effective solutions to reduce emissions. In principle, it requires no significant government intervention. Nonetheless, some governments of EU member states have used additional policy instruments to reduce emissions in sectors covered by the ETS system to an even greater extent than required by EU emissions targets. Norway, for example, has set a carbon tax on petroleum extraction and domestic aviation on top of the ETS quota price (Golombek and Hoel 2023). It has been argued that such national measures and instruments undermine the reasoning behind the ETS system in principle, namely letting the market find the most cost-effective way to achieve the target set by the cap (Golombek and Hoel 2023).

2.2.2. Effort Sharing Regulation

Sectors outside the EU ETS are covered by a number of policy mechanisms, the most important being the Effort Sharing Decision under Regulation (EU) 2018/842 (ESR). The EU ESR covers activities such as domestic transport, housing, agriculture, small industries, and waste management, which together account for around 60% of total territorial EU greenhouse gas emissions. All EU member states, as well as Iceland and Norway, have committed themselves to applying the ESR.

The 2030 Climate and Energy Framework of 2014 determined that sectors of the economy covered by the ESR must reduce emissions by 30% by 2030 compared to 2005 levels (European Council 2014). However, whereas the ETS sector adopts a common European target, the ESR sector relies on domestic targets. Such binding yet flexible[3] national emission limits are set by applying the principles of fairness, cost-effectiveness, and environmental integrity. The 2030 targets for greenhouse gas emissions per member state are defined in Regulation (EU) 2018/842 (EU 2018b), while the annual limits under the ESR are set out in Implementing Decision (EU) 2020/2126 for the EU member states (EU 2020), and Decision of the EEA Joint Committee No 269/2019 for the EFTA countries (EEA Joint Committee 2019).

As things stood at the time of modelling (January 2023), currently committed ESR targets for 2030 in the Nordic countries – expressed as percentage reductions from 2005 levels – are as follows:

- Denmark: -39% (EU ESR)
- Finland: -39% (EU ESR)
- Iceland: -29% (Action Plan 2020)
- Norway: -45% (Action Plan/White paper 2021)
- Sweden: -40% (EU ESR)

However, on 27 March 2023 the European Council ratified a preliminary agreement with the European Parliament to endorse more more ambitious greenhouse gas emission reduction targets (European Council 2023c). Under this recent agreement, each Nordic member will be committed to more ambitious national targets as follows:

- Denmark: -50% (EU burden sharing)
- Finland: -50% (EU burden sharing)
- Sweden: -50% (EU burden sharing)

Iceland and Norway are also likely to make their national targets more ambitious by means of a specific Decision of the EEA Joint Committee. However, at the time of writing (April 2023) the new targets have not yet been set.

Figure 3 shows the verified greenhouse gas emissions by the ESR sectors for the 2005-2020 period (solid line), as well as the annualised targets for the 2021-2030 period set out under Implementing Decision (EU) 2020/2126 and EEA Joint

3. Member states can, for example, bank and borrow part of their annual emission allocations from the following year and buy and sell allocations to other member states. In addition, countries can compensate excess annual emissions with net removals from LULUCF (up to a combined quantity of 280 MtCO2eq). Moreover, the ESR allows nine countries, including the three Nordic EU members, as well as Iceland and Norway, to use a limited amount of ETS allowances for offsetting emissions in the effort-sharing sectors for the period 2021 to 2030. The allowances are deducted from the amounts that would normally be auctioned under the EU ETS.

Committee No 269/2019 (thinner dotted line). The plot also shows a tentative reduction trajectory towards the new ESR targets agreed under the Fit for 55 package, as defined in a new Proposal for a Regulation (EU) 72/22 amending Regulation (EU) 2018/842 (thicker dashed line).[4]

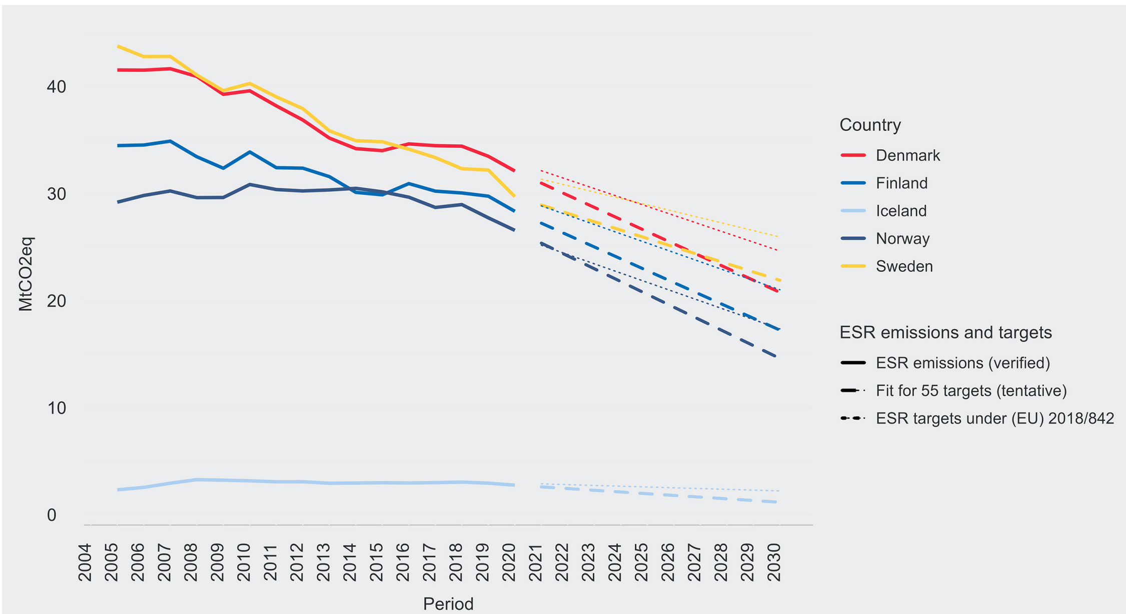


Figure 3. Total greenhouse gas emissions and targets covered by the Effort Sharing Decision

Source: Own based on EEA EU Emissions Trade System (ETS) database; Eurostat, env_air_gge (verified emissions); Implementing Decision (EU) 2020/2126; Decision of the EEA Joint Committee No 269/2019 (current targets as of March 2023); Proposal for a Regulation (EU) PE-CONS 72/22 (tentative targets under Fit for 55)

Under the Fit for 55 package, the EU member states and other participating countries are responsible for achieving the new, more ambitious national targets through domestic policy instruments and at the same time making the transition as efficient as possible while not increasing social inequalities. In other words, while the targets are fixed, national governments are responsible for adopting policies to successfully achieve them, with the rules allowing for considerable flexibility. For instance, member states can bank and borrow part of their annual ESR emission allocations from the following year, as well as buy and sell allocations to other member states.

However, ESR flexibility rules are somewhat constrained by concurrent EU-wide regulations that limit member states' ability to freely decide on the pathways to take towards reducing emissions under the ESR scheme. An important example is the new mandatory emission reduction target for new cars and vans, which will set an upper limit on the emissions produced by car manufacturers. Under the new rules set by the proposed regulation (PE-CONS 66/22), all new cars sold in the EU must be emissions-free by 2035. The regulation also sets an intermediate goal of reducing CO2 emissions from new cars by 55% by 2030, compared to 2021 levels. In addition, a legislative proposal under the Fit for 55-package establishes a new ETS system for fuels used in the building sector, road transport sector and some industrial sectors currently not covered by the EU ETS, with a suggested start date of 2027 or 2028 (see above). Such regulations place some limits on EU member states' leeway to implement national policies for reaching their ESR emission reduction targets.

2.2.3. Emissions covered by the Land Use, Land Use Change and Forestry Regulation

The Land Use, Land Use Change and Forestry (LULUCF) Regulation (EU) 2018/841 lays down the rules for the accounting of CO2 emissions and removals from all forms of natural or seminatural land cover, including wetlands but excluding agriculture (EU 2018b). This regulation was extended to Iceland and Norway by incorporation into the EEA Agreement by Joint Committee Decision No 269/2019, which entered into force on 11 March 2020 (EEA Joint Committee 2019). Under this regulation, emissions from LULUCF are to be entirely compensated by an equivalent accounted removal of CO2 from the atmosphere through targeted action in the sector. This is known as the 'no-debit' rule. Based on the no-debit commitment, the LULUCF Regulation is to generate no less than -225 MtCO2eq of net GHG removals for the EU as a whole by 2030.

In the 2030 Climate Target Plan, the European Commission proposed to increase the annual carbon removals goal through LULUCF management to -310 MtCO2eq removals by 2030, aimed at achieving 'climate neutrality' in the combined land use, forestry, and agriculture sector at the EU level by 2035 (EC 2021c). The new overall EU-level objective of 310 million tonnes of carbon dioxide equivalent (MtCO2eq) equivalent of net removals in the LULUCF was ratified by all parties and formally adopted by the Council on 27 March 2023 (European Council 2023b). For the 2026-2030 period, each member state will have a binding national target consistent with the newly agreed net greenhouse gas removal target for 2030.

Similar to the ESR system, emissions uptake obligations are defined at the EU level for the various member states, but it is up to the national governments to decide on how to reach those targets. Member states can also trade net-uptake certificates with one another and can link their work in the ESR and LULUCF sectors. As such, ESR quotas may be used to cover underperformance in the LULUCF sector and, conversely, LULFC certificates may be used to compensate for deficits in the ESR sector.

To summarise, the Fit for 55 package increases climate policy ambitions at the EU level substantially. Once the various policies and instruments become legally binding, practically all sectors and industries will be covered by an emissions trading system or other type of regulation. The goal of the various policies will be to lower greenhouse gas emissions in the EU and contribute to the goal of making the EU climate-neutral by 2050. In the context of the increasingly ambitious EU policy framework, national climate policies remain important to achieving nationally defined emission reduction targets, especially in the ESR and LULCF sectors. The following section provides a comparison of current national climate laws and goals in the Nordic countries.

2.3. The Nordic climate policy framework

All of the Nordic countries have aligned their climate change mitigation efforts with those approved at EU level. Nonetheless, the Nordic countries have a tradition of going beyond what is strictly required by EU climate goals (Flam and Hassler 2023). That is reflected clearly in current emission reduction targets approved at the national level (Table 1):

In Denmark, the Climate Act (*Lov om klima*) aims to reduce total territorial emissions by 70% by 2030, in comparison to 1990. Climate neutrality is to be achieved by 2050, i.e. remaining greenhouse gas emissions are to be absorbed by natural carbon sinks in its own territory.[5] The Climate Change Act in Finland (*Ilmastolaki*) defines the goal of achieving a 60% cut in emissions by 2030, compared to 1990 levels. By 2050, emissions are to be lowered by 90% to 95%. In addition, Finnish law states that the country is to reach carbon neutrality in 2035 and be carbon-negative thereafter. That means that the level of CO2 emissions removed from the atmosphere is to be higher than the level of emissions. In Iceland, the goal is to reduce emissions by 40% by 2030, compared to 1990 levels, while carbon neutrality is to be reached by 2040. As stated in its Climate Law (

5. Denmark's grand coalition government, led by Mette Frederiksen, has announced plans to reach climate neutrality by 2045, i.e. five years earlier than previously planned.

Lov om Klimamål), Norway strives to reduce emissions by around 55% by 2030 and by 90-95% by 2050, compared to 1990 levels, while Sweden is working towards lowering emissions by 63% by 2030, achieving carbon neutrality by 2045, and negative net emissions thereafter.

At the Nordic level, the Nordic national governments confirmed their commitment to ambitious climate goals in 2019 by adopting the Nordic Vision 2030. This key steering document for Nordic cooperation sets the goal of the Nordic Region being the most sustainable and integrated region in the world in 2030. This includes a commitment to promote the transition towards carbon neutrality.

These ambitious targets reflect how climate change mitigation ambitions remain higher than those agreed at the EU level in most of the Nordic countries, even if the new Fit for 55 targets have substantially reduced the gap between the Nordic and overall EU climate goals (Flam and Hassler 2023). Under the current national climate laws, several Nordic countries aim to achieve carbon neutrality between 2035 and 2045, whereas the EU ambition remains to become a climate-neutral continent by 2050. The more ambitious Nordic climate goals will not be reached by relying solely on EU policies and regulations (Liski and Vehviläinen 2023). Additional national instruments and policies are required to make the intended progress in curbing emissions. As described in this chapter, those measures should most usefully apply to sectors falling under the ESR and LULUCF fields.

Table 1. Climate laws and long-term targets in the Nordic countries

	Climate policy	Climate goals[6]	Responsible ministry/national authority
Denmark	Climate Act/ *Lov om klima* LOV nr 965 af 26/06/2020	• 70% reduction in 2030 compared to 1990 levels. • National indicative target for 2025: 50-54% reduction from 1990. • Climate neutrality by 2050: territorial greenhouse gas emissions are to be absorbed by natural sinks in its own territory.	Ministry for Energy, Utilities, and Climate
Finland	Climate Change Act/ *Ilmastolaki/ Klimatlag* 423/2022	• 60% reduction by 2030 compared to 1990 levels. • 80% reduction by 2040 compared to 1990 levels. • 90% reduction, but aiming for -95% by 2050 compared to 1990 levels. • Carbon neutrality by 2035: territorial CO2 emissions are to be absorbed by natural sinks in its own territory.	Ministry of the Environment (responsible for the Medium-Term Climate Change Policy Plan) Ministry of Economic Affairs and Employment (responsible for the Long-Term Climate Change Policy Plan)

6. Carbon neutrality means that the amount of emitted CO2 emissions is compensated by an equal amount of CO2 being removed from the atmosphere, e.g. through carbon sinks. Climate neutrality defines the goal of net zero emissions not only for CO2, but also for other types of greenhouse gases.

Iceland	Climate Change Act/ *Lög um loftslagsmál* 2012 nr. 70 29. júní	• 40% reduction by 2030, compared to 1990 levels. • Carbon neutrality by 2040: territorial CO2 emissions are to be absorbed by natural sinks in its own territory.	Ministry of the Environment, Energy, and Climate
Norway	Climate Law/ *Lov om Klimamål* (LOV-2017-06-116-60). Last revised 2022	• At least 55% reduction by 2030 compared to 1990 levels. • Low-emission society by 2050. Greenhouse gas emissions are to be reduced by around 90–95% compared to 1990.	Ministry of Climate and Environment
Sweden	Climate Law/ *Klimatlag* SFS 2017:720	• 63% reduction by 2030 compared to the 1990 baseline. • 75% reduction by 2040 compared to the 1990 baseline. • Carbon neutrality by 2045: territorial greenhouse gas emissions are to be absorbed by natural sinks in its own territory. The goal implies that emissions of greenhouse gases must be at least 85% lower in 2045 compared to 1990. • Negative net emissions' after 2045.	Ministry of Climate and Enterprise Swedish Environmental Protection Agency

2.4. Long-term emissions trajectories and energy mixes in the Nordic countries

Despite the coordinated climate policy action, the Nordic countries still paint a very different picture from one another when it comes to emission patterns and energy mixes. These factors shape the nature of climate ambitions, with respect to climate neutrality or carbon neutrality, and the proposed timing for reaching the agreed goals in each country. It is therefore important to shed light on differences in emission patterns and energy mixes in the Nordic countries to understand not only the purpose of climate policies in each country, but also their potential economic, social, and territorial impacts.

2.4.1. Territorial greenhouse gas emissions by source sector

This section presents an overview of the decarbonisation trajectories of each of the Nordic countries, considering emission sources. The analysis covers the 1990-2019 period and focuses on all types of territorial greenhouse gas emissions, excluding LULCF and memo items[7], but including international aviation and navigation. As shown in Figure 4, each Nordic country is undergoing a different decarbonisation process as a result of the climate goals and implementation policies described in the previous chapter. However, the specific decarbonisation trajectories are also a result of the different economic specialisations, natural endowments, and energy mixes in each country. Looking at emission levels in 2020, *fuel combustion in the transport* and *energy industries* is the single most important contributor to greenhouse gas emissions in the Nordic countries. The only exception is Iceland, where *industrial processing and product use* is the dominant sector.

7. In the gas emissions inventories submitted to the UNCCC, countries are asked to report emissions from international aviation and marine bunkers and multilateral operations, as well as CO2 emissions from biomass, under a *Memo Items* category. These are not accounted for in the calculation of total greenhouse gas emissions. For example, CO2 emissions from the combustion of biomass fuels are reported as a memo item and are therefore not included in the total emissions from fuel combustion. Calculations of these emissions are generally based on the accounting methods and emission factors set out in the EMEP/EEA air Pollutant Emission Inventory Guidebooks (EMEP/EEA, 2007, 2013, and 2019).

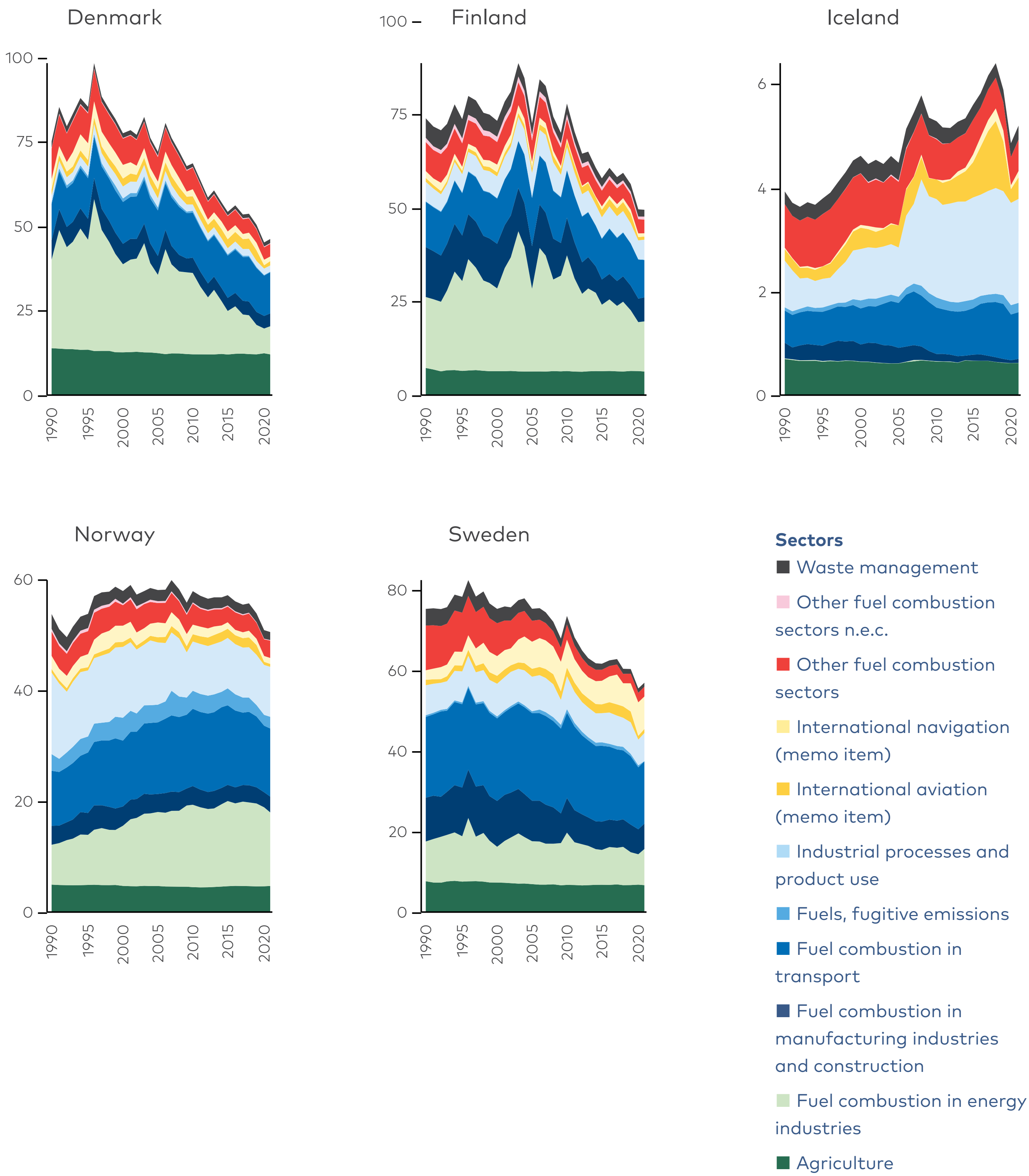


Figure 4. Greenhouse gas emissions in the Nordic countries, by source sector

Source: Eurostat (env_air_gge)

**Excluding Land-Use Change and Foestry and memo items, but including international aviation and navigation*

Most of the Nordic countries were successful in reducing industrial emissions during the 1990-2019 period. The *Fuel combustion in energy industries* sector made a leap forward in terms of emission abatement in several of the countries. In Denmark, for example, this sector reduced greenhouse gas emissions by 17.5 MtCO2eq between 1990 and 2019. That represents a 67% reduction, which was achieved mainly as result of a large increase in wind power generation, which replaced carbon-intensive coal and gas power (IEA 2017). Progress in Finland and Sweden was also substantial in this sector (-1.7 and - 2.7 MtCO2eq, equivalent to a 14% and a 17% decrease, respectively). Thanks to the abundance of renewable energy sources – mostly hydro and geothermal –, emissions in the *Fuel combustion in energy industries* sector are negligible in Iceland, where house heating was converted almost entirely from oil to geothermal during the 1970s and 1980s. In Norway, however, emissions in this sector increased by 7.8 MtCO2eq (a 108% rise) due to the toll of oil production. Upstream oil and gas activities, comprising exploration, production, transportation, processing, and vessel loading, account for a significant proportion of those emissions (Hall 2020).[8]

Emissions in the *Fuel combustion in manufacturing industries and construction* sector also declined over the 1990-2019 period in all of the Nordic countries. Emission cuts ranged from a 76% decrease in Iceland to a 15% reduction in Norway. In Iceland, the reduction was driven by the switch from oil to electricity as a power source in manufacturing industries, particularly at fish meal plants. The largest absolute reduction was in Finland (-6.8 MtCO2eq, a 51% decrease). Here, the key factors were the increased use of biofuels in the forest industry and outsourcing of power plants from industry to the energy sector (Statistics Finland 2022). In Sweden, emissions from manufacturing industries and construction fell by 37% between 1990 and 2019 (-4.0 MtCO2eq), as fossil fuels were replaced by electricity or biomass (Ministry of Environment 2019).

Progress in the *Industrial processes and product use sector* was mixed. During the 1990-2019 period, Denmark and Norway managed to reduce their emissions in this sector by 14% and 38%, respectively, while emissions in Finland (2%) and Sweden (6%) did not undergo substantial change. In Iceland, greenhouse gas emissions from industrial processes increased by 122% between 1990 and 2019, particularly during the years 2006 to 2008, when emissions from industrial processes doubled. The metal industry mainly aluminium smelting and ferroalloys production accounts for the largest proportion of those emissions. In a global

8. Due to its own financial reliance on oil production boosted by the high international demand for oil, Norway has so far prioritised nature-based solutions as its fundamental decarbonisation strategy. The strategy has been developed domestically – through its own forestry sector – and abroad – through accredited programmes in developing countries contributing to abating emissions and preserving natural carbon sinks (Hall 2020).

context, however, the absolute increase in Icelandic industrial processing emissions is modest (1.1 MtCO2eq). Moreover, as stressed by Weber and Søyland (2020), the low-carbon energy inputs used by Iceland's industry offset the more carbon-intensive processes that would occur if these processes were performed elsewhere in the world. That is because all primary energy used to produce electricity comes from renewable sources, in particular hydro and geothermal (see Section 2.4.2).

Emissions from fuel combustion in commercial, institutional, and residential buildings account for the largest share of the emissions included in the *Other fuel combustion sectors*. These emissions lessened significantly in all of the Nordic countries thanks to the increased use of district and electric heating in residential, commercial, and public buildings (Statistics Finland 2022). In Sweden, for instance, oil-fired combustion furnaces used for heating purposes in the residential sector have been replaced on a massive scale by district heating and electric heat pumps (Ministry of Environment 2019). Emission cuts in this sector range from a 78% decrease in Sweden (-8.7 MtCO2eq) to a 35% reduction in Iceland (-0.3 MtCO2eq), thanks to continued development of geothermal heating.

Looking at the development of greenhouse gas emissions in the 1990-2019 period, *agriculture* is the sector where the attainments of the countries are more similar. In Denmark, emissions declined by 13% (-1.8 MtCO2eq). In Iceland, Finland and Sweden, emission reductions in this sector were in the environment of 11% and 12%, while in Norway emissions in the primary sector declined by 6%.

Progress in *transport*, including *international aviation* and *navigation*, has been limited and unevenly distributed. In a Nordic comparison, only Sweden (-3.1 MtCO2eq) and Finland (-0.8 MtCO2eq) managed to reduce greenhouse gas emissions in the transport sector between 1990 and 2019 (-15% and 7%, respectively). In Iceland, the increase of emissions in the transport sector was as high as 71% (0.4 MtCO2eq), driven by the boom in tourism that started around the year 2013. In Denmark, domestic emissions in 2019 were 22% higher than in 1990 (2.3 MtCO2eq), while in Norway the increase during this period was 27% (2.7 MtCO2eq). The international transport memo items also show a contrasting performance. As long-distance tourism became more popular during the time period considered here, the emissions from *international aviation* increased substantially in all of the Nordic countries, ranging from a 336% rise in Iceland (0.7 MtCO2eq) to a 77% increase in Denmark (1.4 MtCO2eq). In Iceland emissions from international aviation increased particularly rapidly during the 1990-2020 period. That development was driven by tourism. In particular, international tourist visits to Iceland have increased considerably during the last two decades, resulting in more flights to and from the country. After a single unbridled period of growth during the first two decades of 21st century, the influx of international tourists to Iceland came to a full stop due to the COVID-19 pandemic (Norlén et al. 2022, Ch. 10). That resulted in a sharp decline of emissions in this sector in 2020, while the 2021 figures already anticipated a post-pandemic boom. Emissions from *international navigation* decreased in Denmark, Finland, and Norway (by 26%, 43% and 53%, respectively), but increased in Iceland (632%) and Sweden (196%).

Emissions in *Other fuel combustion sectors* that are 'not elsewhere classifiable' (*n.e.c.*) represent a very small proportion of total emissions in all countries, with Finland being the only exception. Here, the subcategory covers emissions from non-specified consumption of fuels and statistical corrections of fuel consumption, including fuels for military use and emissions from pipeline transport. These emissions decreased by 31% compared to 1990 levels (Statistics Finland 2022).

In order to reach the ambitious climate goals at national and European levels that were described in previous chapters, transport is one of the main sectors where emissions need to be reduced. Looking across the Nordic countries, this sector continues to account for a large share of emissions, meaning that progress in abating emissions would have a large impact. This sector also falls under the Effort Sharing Regulation (ESR) and is therefore a policy area where the national governments of the Nordic countries have greater influence on how to achieve European climate targets. In later sections of this report, we will therefore focus, among other things, on this sector and analyse the impacts of climate policies aimed at abating emissions originating from transport.

2.4.2. Energy consumption and energy mixes

The emissions trajectories described in the previous section are closely related to those illustrated in Figure 5, which shows the evolution of primary energy consumption[9] in each country, measured in terawatt hours (TWh). According to the trends shown in the various panels, during the 1990-2021 period, Denmark, Finland and Sweden managed to curb their primary energy consumption in absolute terms by 37.2 TWh, 19.6 TWh, and 14.9 TWh, respectively. In relative terms, the reduction was particularly marked in Denmark (-19%), compared to Sweden (-11%) and Finland (-6%). By contrast, total primary energy consumption increased in Norway (68.1 TWh; up 14%) and, particularly, in Iceland, driven mainly by the increase in aluminium production (28.2 TWh; up 133%).

9. The share is higher if primary energy is calculated using a 'direct method', which does not take account of the intrinsic inefficiencies of energy production from fossil fuels.

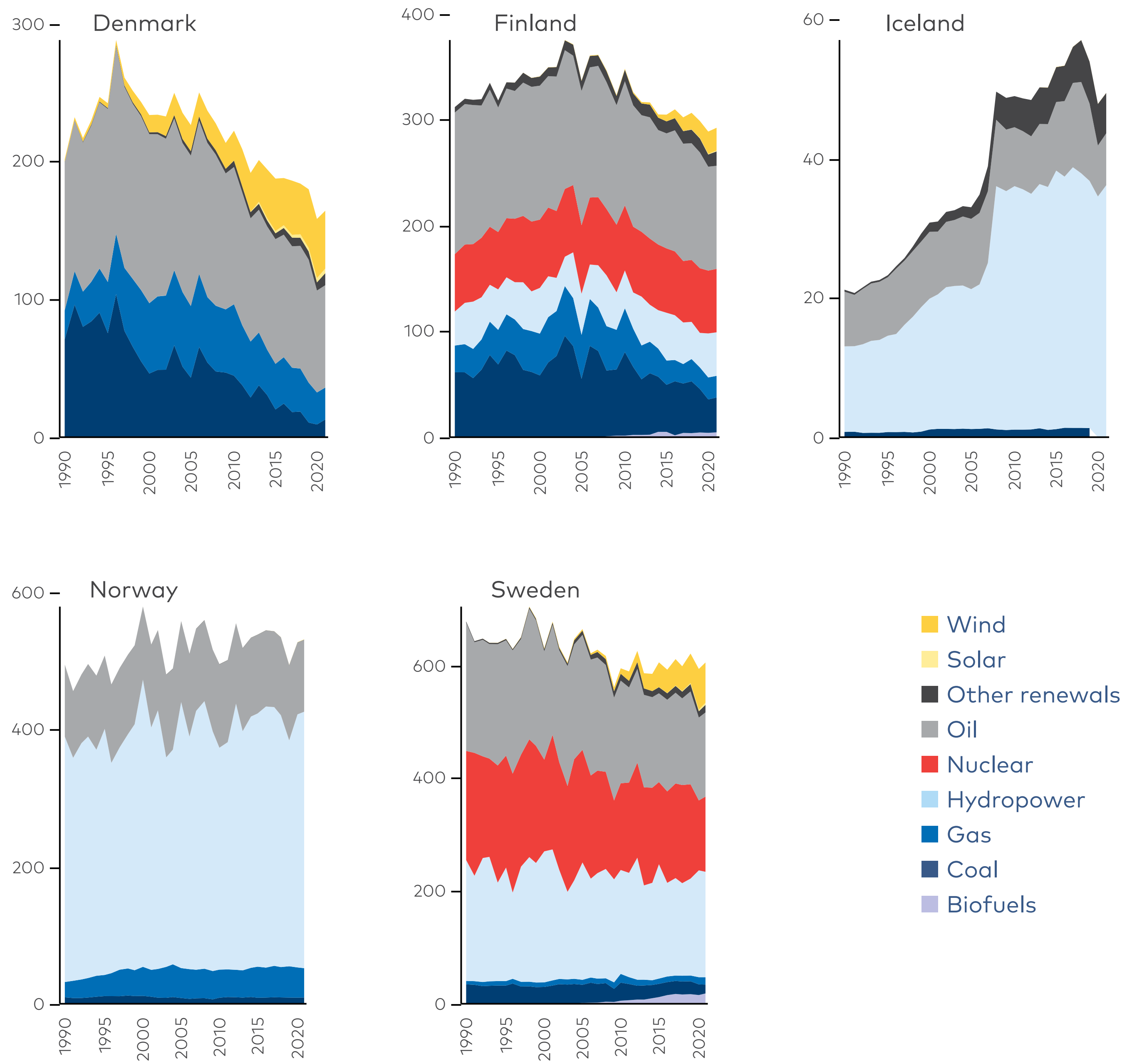


Figure 5. Primary energy consumption by source in the Nordic countries (1990-2021)

Source: Our World in data and BR Statistical Review of World Energy

**Note: "Other renewables" includes geothermal, biomass and waste energy*

As illustrated in Figure 5, since the 1990s the share of renewable and non-fossil fuels in the Nordic energy mix has increased steadily. In 2021, the largest share of the primary energy consumed in Iceland and Norway comes from renewable energy, in particular *hydropower* (73% and 67% of total electricity consumption, respectively). In Iceland *other renewables*, in particular geothermal energy, also accounted for a significant share of the primary energy consumed in 2021 (12%). In Sweden *hydropower* (31%) is supplemented by *wind* (12%), *biofuels* (3%), *solar* (1%), and *other renewables* (2%). In Denmark, the contributions of *wind* (26%), *solar* (2%), and other *renewables* (6%) are more substantial than in the other Nordic countries. In Finland *wind* (7%) and *hydro* (14%) produce the largest proportion of renewable energy consumed locally. Liquified *biofuels* represent 2% of primary energy consumption, whereas *other renewables*, in particular biomass, constitute an even larger proportion of the total primary energy consumed in Finland (5%). *Nuclear* energy plays a major role in Sweden (22%) and Finland (21% of primary energy consumption).

In most countries, the expansion of renewable energy and nuclear power has gone hand in hand with a proportional decrease in fossil fuel consumption (coal, gas, and oil). Measured in absolute terms, between 1990 and 2021 the use of fossil fuels decreased by 89.2TWh (down 45%) in Denmark, by 69.6TWh (-32%) in Finland, by 90.2TWh (-34%) in Sweden, and by 1.2TWh (-14%) in Iceland. By contrast, the amount of primary energy from fossil fuels consumed in Norway increased substantially during the same period (20.5TWh; up 15%).

Regardless of past trends, coal, oil, and gas still make a major contribution to primary energy consumption structures in the Nordic countries. That is particularly so in Denmark (oil: 45%, gas: 14%; coal: 8%), Finland (oil: 33%, gas: 7%; coal: 11%), and Sweden (oil: 25%, gas: 2%; coal: 3%), but, to a lesser extent, also in Norway (oil: 19%, gas: 8%; coal: 2%), and Iceland (oil: 15%). The figures imply that, even if major progress has been achieved in terms of renewable energy production, substantial decarbonisation challenges remain in all Nordic countries due to fossil-based energy mixes (Sweden, Finland, and Denmark), oil production (Norway), and industrial processing (Iceland). In the simulations presented later in this report, we will focus on one such decarbonisation strategy and model the macro-economic and socio-economic impacts of phasing-out all remaining coal-fired electricity in the Nordic Region.

Photo: Marcin Jozwiak, unsplash.com

3. The focal areas of this study: from climate policies to household impacts

This section describes the main focal areas that are of interest in this study. We start by defining the key policy areas that are pivotal to reaching Nordic and European climate goals and where ambitious targets have been defined in the Nordic countries. These policy areas are the focus of our modelling. In the second section of this chapter, we explain why it is important to analyse how these policies impact household finances and outline the main pathways through which climate policies may influence household income and consumption.

3.1. Key policy areas for achieving the Nordic climate goals

Finding the right balance between the EU and Nordic climate policy frameworks is a matter of policy efficiency. Analysis of the costs and benefits of having more ambitious emission reduction targets in the Nordic countries than at EU level has formed the subject of much research.

Some researchers have endorsed a normative argument in support of the ambitious climate policies in the Nordic Region. Following the Kantian principle that *moral actors should act in the same way as they would like others to act*, Greaker and colleagues (2019) argue that each Nordic country could choose to mitigate climate change and accelerate efforts to reduce greenhouse gas emissions regardless of what other countries do. Their status as climate frontrunners may bring concrete benefits for the Nordic countries, most notably in the form of international prestige as global green leaders and inspiring models for others to follow. Green technologies or products developed in the Nordic countries to curb emissions may allow them to set international standards and tap into increasingly climate-conscious consumer markets (Silbye and Sørensen 2023). The adoption of Nordic green innovations by other countries may also contribute to abating emissions at a global level (Greaker, Golombek and Hoel 2019).

On a more practical level, Golombek and Hoel (2023) investigate the role of Nordic climate policies targeting industry and their overlaps with the EU ETS. According to this research, if the proposed Nordic national climate goals described in the previous chapter are to be met, a substantial number of ETS allowances that are not used in the Nordic countries due to lower-than-expected emissions would become available for use by other EU member states. That could effectively transfer greenhouse gas emissions to other EU countries, neutralising the reductions induced by Nordic policies. On those grounds, the authors argue that the Nordic countries should avoid implementing more ambitious policies in sectors already covered by the ETS, since such policies would undermine the market-driven nature of the ETS system. In a similar vein, von Below and colleagues (2023) maintain that more ambitious goals and policies at the national level in Sweden, the largest Nordic economy, could place higher costs on households without making a substantial contribution to climate change mitigation.

Silbye and Birch Sørensen (2023) take a different view on this matter. These authors argue that ambitious climate goals in Denmark have the potential to reduce total EU-wide emissions. They point out that the ETS includes a Market Stability Reserve (MSR), which absorbs emission allowances if there is a large surplus on the market. Since the size of the MSR is limited, when too many allowances are absorbed by the system they are cancelled. The authors argue that, thanks to this mechanism, the authors argue that the 'overperforming' climate policies in Denmark and other Nordic countries could still serve to increase the effectiveness of the ETS sector at the EU level and would not necessarily lead to higher emissions in other countries. At the same time, more ambitious climate policies in the Nordic countries may also help shift the European discussion towards a tightening of ETS rules and cuts in total allowance supplies.

A general point of consensus among most of these studies is that the split between the ETS and ESR sectors affects the cost-effectiveness of climate policies. It has been widely recognised that the marginal costs of emission reductions are unlikely to be equalised between the two sectors because the ETS/ESR split is rather arbitrary (Flam and Hassler 2023). Within the ETS sector, equalisation of the marginal cost of emission reductions is facilitated. That is because businesses in this sector either have to acquire emission permits or reduce emissions to the point where the marginal cost of abatement matches the permit price. As described in Section 2.2.2, the ESR sector, on the other hand, is subject to a variety of activity-specific domestic regulations. It cannot be expected that these regulations will deliver equalisation in the marginal costs of emission reductions across the diverse activities within the ESR sector of any country or across similar ESR activities in different countries. That also implies that Nordic policy instruments to reach the national climate goals could most usefully be applied in sectors included in the ESR. Those are sectors for which the EU sets shared goals but does not prescribe policies or mechanisms to attain them; the national governments are hence expected to design and deploy country-specific strategies.

Therefore, considering that this study is primarily intended to inform policy-making in the Nordic countries, it focuses on the Nordic ESR sectors where domestic policies may have a major impact. Placing the focus on ESR policies may allow possible improvements to be pinpointed in terms of marginal cost equalisation. Moreover, many of the measures in the ESR sector directly affect households, giving rise to much of the Nordic policy debate on the effects of climate policies. We contribute to this debate by estimating the effects of ESR policies on costs of living for households in various socio-economic groups and on employment opportunities in various occupations and subnational regions in the Nordic countries.

Within the ESR sector, the main policy initiatives in the Nordic countries for the next decade, and the ones chosen for our study, focus on decarbonising the transport sector. These polices target the electrification of car fleets and an increase in the use of biofuels in the remaining internal combustion engine vehicles. Our study also considers the effects of further decarbonisation of the power sector through the phasing-out of remaining coal generation, which still plays a relevant role in the Finnish energy system (see Section 2.4.2).

3.2. Impacts of climate policies on household finances

Land transport and energy mixes remain key policy areas for the decarbonisation of the Nordic and European economies. In contrast to the previous generation of climate policies, which focused on industrial processes (ETS), the current generation of climate policies – at both the EU and Nordic levels – target sectors and technologies that may have a more direct impact on household finances (ESR). Such impacts can manifest themselves via two pathways, namely household income and household consumption (Figure 6). The following overview draws on an analytical framework developed by Zachmann, Fredriksson, and Claeys (2018).

Figure 6. The composition of household budgets

Source: Own figure based on Zachmann, Fredriksson, and Claeys (2018)

3.2.1. Sources of household income

Households generate income through earnings (including wages, salaries, and earnings from self-employment), income from capital, land or property ownership, and government transfers. Climate policies may affect household finances by impacting on these various sources. For example, some jobs in carbon-heavy industries may disappear during the green transition while new jobs in green sectors may be created, affecting the career options and earning potential of employees in such sectors. The income that households generate from capital investment, e.g. through stocks and retirement funds, may also be affected by climate policies, as the market value of various company types fluctuates. Nonetheless, the overall impact of climate policies on capital is likely to be small. Finally, climate policies may affect government transfers to households. For example, climate policies such as carbon taxes may generate government income that could be redistributed to households or could allow governments to reduce other taxes (Zachman, Fredriksson, and Claeys 2018).

Earned income is the main source of income for most households, making it particularly pertinent to analyse the effects of climate policies on this income source. Since climate policies may impact some sectors and industries more than others, any repercussions in terms of employment opportunities or salary developments will particularly affect households that generate income from work in these sectors. Given that the Nordic countries and subnational regions have differing industry mixes, impacts on employment and wages are also likely to be more keenly felt in some regions than in others.

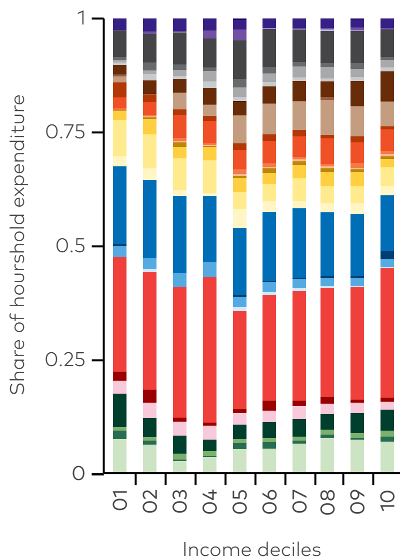
3.2.2. Household expenditure

Households can spend money on immediate consumption or invest in durables. Goods and services that are purchased for immediate consumption include food, fuels, and personal services etc. Investments in durables include goods that can be used over a longer time period, such as furniture or household appliances. In addition to goods for immediate consumption and durables, households also benefit from infrastructure and services that are provided by the government, including health care services and the use of public roads. Households use their available budget to acquire a combination of these different types of goods and services. The exact combination depends on individual and household preferences, the level of the available household budget, and borrowing constraints. Due to a lower total budget and stronger borrowing limitations, low-income households are more constrained in their consumption than high-income households.

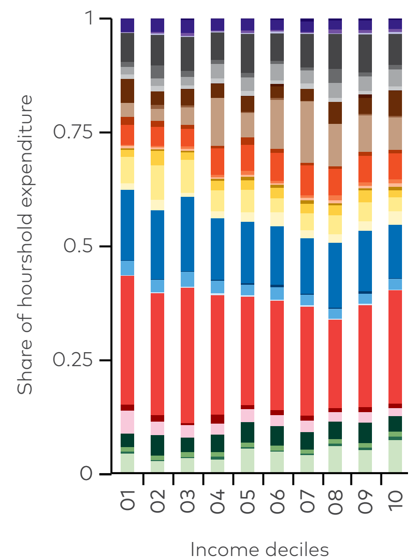
Climate policies may affect household consumption through increases in commodity prices, in particular those of energy products. As the prices of various fuels change in response to market fluctuations, households adapt their consumption habits, contributing thereby to large-scale shifts of production technologies, until a new equilibrium is met. The transition between two equilibrium points may be marked by temporary increases in the prices of key energy commodities, particularly in the presence of external shocks, like international geopolitical tensions. These processes may affect households in diverse ways, depending on their specific characteristics. Climate policies may have a disproportionally higher impact on households that are more dependent on fossil fuels and private transport. Furthermore, consumption patterns are often driven by contextual factors rather than by personal choices. For instance, households composed of older people or persons with disabilities tend to be more reliant on private transport, while households living in houses typically consume more energy to keep them at a comfortable temperature compared to those living in condominiums (Tapia 2022). Furthermore, these aspects depend on the geographical location of the dwellings. There is a close link between the degree of urbanisation and the intensity of use of private cars – in terms of a) the frequency of use and transit distance and b) the proportion of people living in houses. In general terms, rural and isolated households tend to consume more energy at home and for personal transport than urban households (Simock et al. 2021).

Figure 7 illustrates the extent to which various commodities account for household expenditure in Denmark, Finland, and Sweden, by type of household location – urban, rural, and intermediate areas – and income deciles. By convention, less affluent households are those included in low-numbered deciles (1-5) while higher income households are those in high-numbered ones (deciles 6 to 10). The values were generated using microdata from the European Household Budget Survey (Eurostat 2022). Appendix 5 summarises the various types of household data inventoried for this study, and Appendix 6 details how some of these data points were processed for analysis.

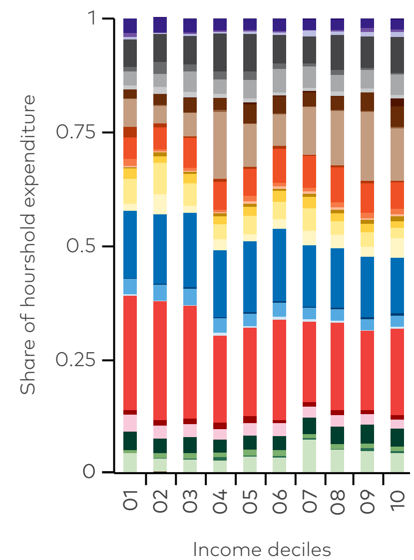
1. Urban, Denmark



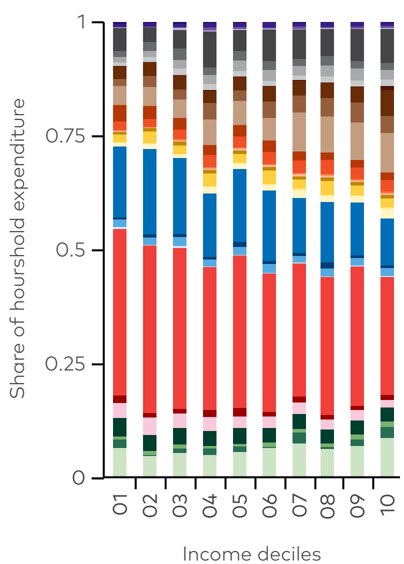
2. Intermediate, Denmark



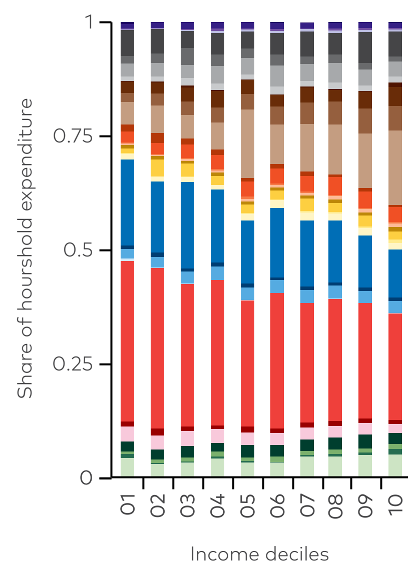
3. Rural, Denmark



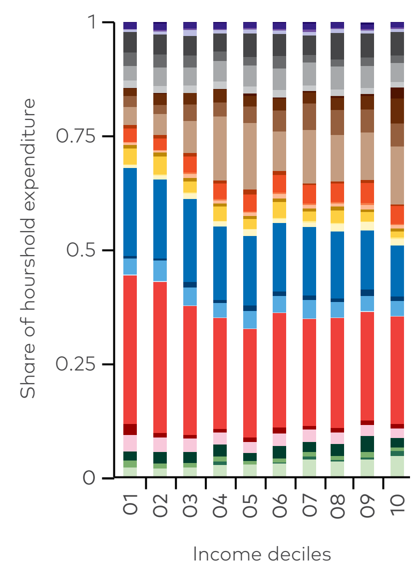
1. Urban, Finland



2. Intermediate, Finland



3. Rural, Finland



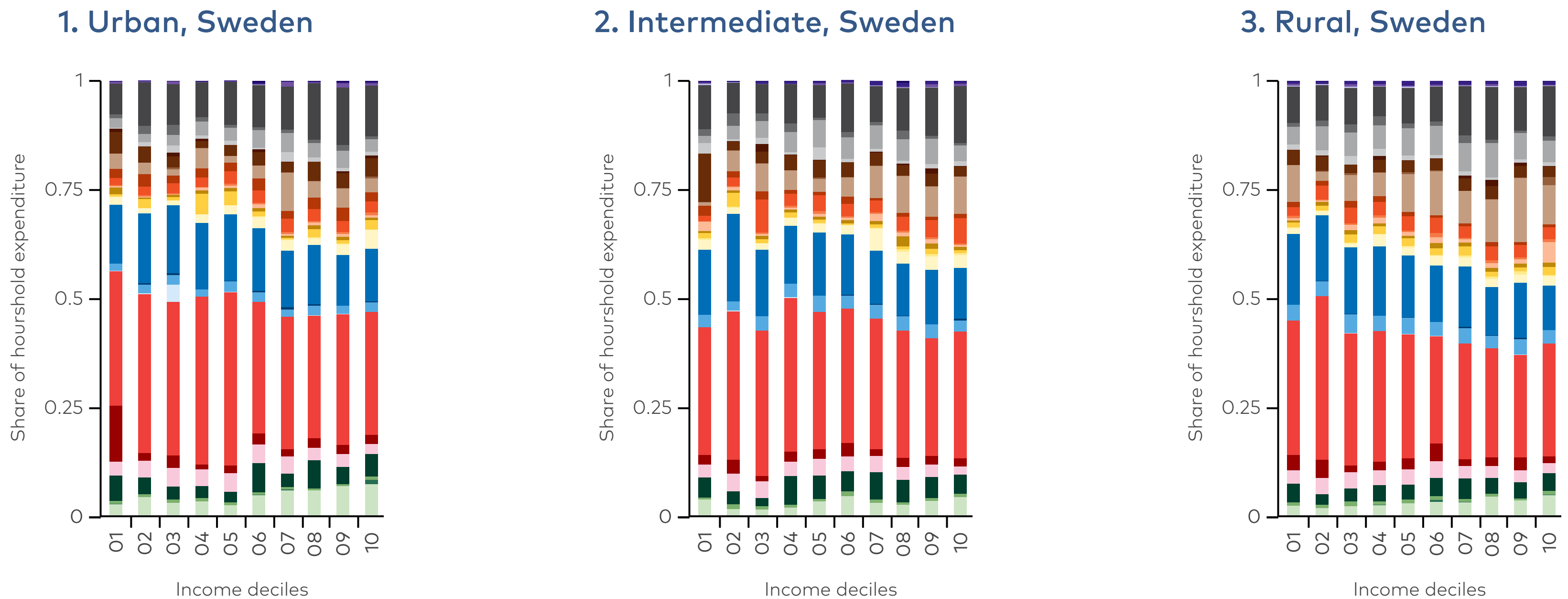
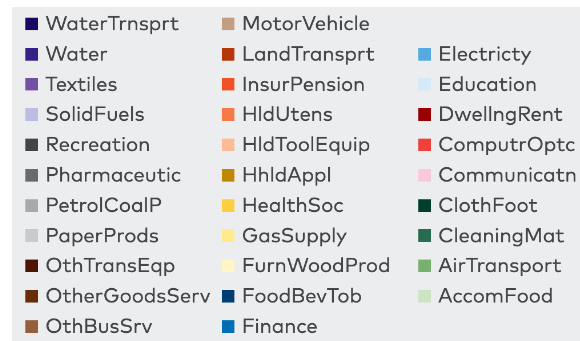


Figure 7. Household expenditure by commodity and income decile in Denmark, Finland, and Sweden (2015)

Own elaboration based on Eurostat microdata from the Household Expenditure Survey. Expenditure based on normalised household size.



As shown on the individual bar plots in Figure 7, household spending is distributed very differently across countries and types of households. In general, the main expenditure categories in most households are 1) housing, including mainly dwelling and rentals but also goods related to property maintenance, and repair (*DwellngRent*), 2) food and non-alcoholic beverages (*FoodBevTob*), 3) recreation, culture, and accommodation (*Recreation*), 4) water and sanitation (*Water*), and 5) miscellaneous goods and services (*OtherGoodsServ*). In relative terms, expenditure on housing tends to decrease with income levels (*DwellingRent*). The opposite holds true for expenditure on motor vehicles (*MotorVehicle*) and recreation, culture, and accommodation (*Recreation*), particularly in urban households. Household expenditure on fuels and lubricants, including both motor fuels and liquid fuels for domestic use (*PetrolCoalP*) and electricity (Electricity), also tends to increase with income levels and, particularly, with rurality.

Figure 7 shows that fuels and electricity costs are of considerable relevance to household finances. Combined spending on energy fuels ranges from one to six per cent of total household expenditure, depending on the country and type of household. Expenditure on electricity ranges from two to five per cent. Household expenditure on energy commodities tends to be greater in rural areas than in densely populated municipalities. That is driven by a higher dependence on private motorised transportation and greater heating requirements of household dwellings located in such areas, as argued above. Moreover, low-density municipalities in Finland and Sweden tend to be in regions with longer and harsher winters, resulting in greater heating requirements in this type of household.

Given that households differ in terms of how much they spend on items such as fuel and electricity, it is important that climate policies consider differences in household income and geographical location. That approach is not only important to prevent undesired social impacts but also to ensure people's support for climate policies. A recent Nordic survey on perceptions of climate policies and the green transition (Tapia, Sánchez Gassen, and Lundgren 2023) shows that a large majority of people in the Nordic countries (75%) consider climate change a serious or very serious problem, and roughly half of them agree that more public resources should be spent on mitigating climate change, even if that would result in tax increases. Nonetheless, one in four respondents state that climate policies already affect their own household finances in a negative way, and just as many are concerned that climate policies may put existing jobs at risk. Half of all respondents in the Nordic Region also fear that prices and cost of living will increase due to climate policies. Furthermore, respondents expressed concerns about the fairness of climate policies. Importantly, more than half of the respondents who answered the survey perceive that the impact of climate policies differs between rural and urban areas, and just as many think that impacts differ depending on personal income. In short, many people in the Nordic countries do not consider current climate mitigation efforts to be fair and just in terms of their income-related and spatial effects. It is therefore important to pay particular attention to the impacts of climate policies on these two aspects.

In the following chapters, we analyse the long-term impacts of three key climate policies on wages and household consumption: the attainment of national targets for an increased biofuel share of motor fuels and for an increased share of electric vehicles in passenger car fleets, as well as the phasing-out of coal-fired electricity. More information on these three policies is provided in the next chapter, following a brief description of the Nordic-TERM model used for the analysis.

Photo: Susan Q Yin, unsplash.com

4. Representing Nordic greenhouse policies: setting the policy shocks

This chapter introduces the Nordic-TERM model and presents the main modelling assumptions and scenarios involved in this research. These include a baseline run and a policy run and set out the effects of the greenhouse policies as deviations from the baseline.

4.1. The Nordic-TERM model

Our main analytical tool for this project is the Nordic-TERM model. It is called Nordic because it focuses on the Nordic countries and TERM because the model is in the tradition of The Enormous Regional Models initially developed at the Centre of Policy Studies at Victoria University in Melbourne, Australia (Horridge 2012; Adams, Dixon, and Horridge 2015). Information on TERM models in general and the technical details of Nordic-TERM in particular are given in Appendix 2. A brief overview is provided here.

Nordic-TERM, like all TERM models, is a multi-regional computable general equilibrium (CGE) model. Nordic-TERM, which was created for this project, identifies the five Nordic countries Denmark, Finland, Iceland, Norway, and Sweden, and the Rest of Europe (RoE). Each Nordic country is split into subnational regions at the NUTS-2 level: 5 regions in Denmark; 5 in Finland; 1 in Iceland; 7 in Norway; and 8 in Sweden. With the rest of Europe (RoE) treated as a single region, Nordic-TERM has 27 regions. The regions are treated as trading economies with strong flows of capital and labour within the regions of each country.

We chose the CGE approach for this study for four reasons:

- First, CGE models are a practical framework for representing micro-economic policies. That is because CGE models incorporate descriptions of inputs to industries and sales to users. As explained in Section 4.3, for this project we applied 'shocks' to our model by making changes to the composition of inputs for the production of motor fuels and changes to the composition of expenditures by households, including a switch from motor fuels towards increased use of electricity (associated with the adoption of electric vehicles). The quantitative details of the shocks (the extent of the reduction in motor fuels, how much extra electricity etc.) are always subject to debate. Using the CGE framework, we can identify the role of each shock in contributing to key results and the effects on those results of varying the degree of the shocks within plausible ranges.

- Second, CGE models specify explicit price-sensitive behaviour for multiple agents. Using a CGE model, we can trace how demand for various products by households, firms, exporters, and importers is affected by changes in prices. That is important for the present study, which involves policy-induced changes in commodity prices, particularly those of energy products.

- Third, CGE models incorporate links between different economic agents. The most obvious are input-output links in which one agent (such as the motor vehicle industry) is a customer for the product of another agent (such as the fabricated metals industry). However, CGE models also include macro-economic links through labour, capital, and foreign-currency markets: expansion of one industry in a CGE model generates costs for other industries through wage, interest, and exchange rate effects. With these links in place, a CGE model picks up not only effects of greenhouse policies on energy industries, but also on industries and households that depend on such directly affected activities.

- Fourth, a CGE model allows for computations at a high level of disaggregation. As mentioned already, Nordic-TERM encompasses 27 regions. Within each region there are 53 industries. At this level of disaggregation, we can identify activities most relevant to greenhouse gas emissions, including: 5 distinct types of electricity generation based on different fuels; 3 agricultural activities; 3 transport modes; 4 mining activities; oil refining; and 4 categories of metal production.

In addition to the disaggregated regional and industry results generated by the core part of Nordic-TERM, further results can be generated using downstream add-on programs. In this analysis, we have created add-on facilities to take core Nordic-TERM results and compute implications for the following: greenhouse gas emissions; employment by occupation and wage band; and living costs for households classified by income decile and location: urban (large cities);

intermediate regions (towns and suburbs); and rural areas.

CGE models can be run using various choices for the length of a period. One possibility is to perform year-on-year simulations, where the length of each period is one year. However, in this analysis, we are concerned with long-term effects. We are therefore able to simplify the simulations by using just one period of 11 years, namely 2019 to 2030. When the Nordic-Term model was developed, the latest data in the CGE database were from 2020. We selected 2019 as the reference year instead of 2020 since the global economy was disrupted by the COVID-19 pandemic in the latter year and 2020 does not therefore reflect typical economic activity patterns in the Nordic Region. Each computation starts with a database for 2019. We then apply shocks for the exogenous variables representing their movements from 2019 to 2030. The model generates results for endogenous variables showing their resulting movements from 2019 to 2030. In other words, the model starts with a picture of 2019 and generates a picture of 2030.

We conducted two types of simulation using Nordic-TERM. The first is a baseline run showing the development of the Nordic economies from 2019 to 2030 in the absence of incremental greenhouse policies. The second is a policy run showing the development of the Nordic economies with decarbonisation policies for the transport sector in place and with phasing-out of coal in the power sector. Comparison of the policy and baseline results shows the effects of anticipated policies by the Nordic countries.

4.2. Developing the baseline scenario

The baseline run shows the evolution of the Nordic economies from 2019 to 2030 in the absence of greenhouse policies beyond those already implemented by 2019. It not only excludes policies that are yet to be agreed, but also policies that have been agreed, but are yet to be implemented. The baseline simulation covers macro variables, output projections for industries by nation, employment projections for industries and subnational regions, and emissions projections by nation. The baseline also includes projections for employment by occupation, wage band, education, and age.

Table 2 shows percentage growth in macro variables for the Nordic countries and the rest of Europe. The results are for growth over the 11 years from 2019 to 2030. They were derived in the baseline simulation.

Table 2. Baseline national forecasts: 2019-2030 (percentage growth for 11 years)

	Denmark	Finland	Iceland	Norway	Sweden	RoE
Real household consumption (C)	13.6	16.0	19.1	14.4	24.6	5.9
Real investment (I)	8.3	8.8	12.9	10.3	15.1	2.1
Real government consumption (G)	13.6	16.0	19.1	14.3	24.2	5.9
Export volumes (X)	11.8	13.8	14.7	11.2	19.0	13.0
Import volumes (M)	10.8	13.1	15.1	15.2	21.4	14.8
Real GDP	11.2	13.5	16.4	12.7	21.5	3.8
Aggregate employment	-1.5	-2.0	2.2	5.5	2.7	-6.5
Average real wage	20.1	25.0	24.2	12.9	29.5	18.8
Aggregate capital stock	8.2	8.8	12.9	10.3	15.0	2.1
GDP price index	6.3	6.4	7.2	5.3	6.2	7.2
Change to Consumer Price Index (CPI)	4.1	4.1	4.8	3.9	3.7	5.1
Export price index	3.3	3.4	3.5	1.4	3.4	4.1
Import price index	3.2	2.6	3.7	1.5	1.4	0.9
Population (15-64 years)	3.5	0.1	5.2	8.9	5.0	-0.8

In the baseline simulation, GDP and employment growth were set exogenously for each of the Nordic countries and the Rest of Europe (RoE). In determining these variables, we started with historical GDP data from the OECD (2023). We used these data to derive GDP growth for the decades 2001-11 and 2011-21. We then accessed the World Bank historical data and projections for growth in the population aged between 15 and 64 (World Bank 2023). Combining the historical data for GDP and the working-age population, we derived growth in productivity for the decades 2001-11 and 2011-21, with productivity defined as GDP divided by working-age population (15-64). For the decade 2021-31, we assumed that productivity growth in each of the five Nordic countries and RoE will be the average of the productivity growths from the two earlier decades. Finally, we assumed that employment growth in the Nordic countries and RoE in the decade 2021-31 will match the World Bank projection for growth in the working-age population. With employment growth thus projected and our productivity assumption in place, we derived GDP growth. Our calculations, alongside the details of the baseline simulation and their underlying assumptions, are given in Appendix 1. Detailed results regarding forecasted industry outputs, CO2 emissions, and employment are also available in Appendix 1.

4.3. Setting the policy shocks

Our policy run shows the development of the Nordic economies with decarbonisation policies for the transport sector in place and with phasing-out of coal in the power sector. Our analysis captures:

- increases in the cost of motor fuels to industries (mainly the road transport industry) associated with the attainment of biofuel targets in diesel;
- increases in the cost of motor fuels to households associated with the attainment of biofuel targets;
- changes in the composition of inputs in the production of motor fuels (substitution of petroleum by bio-based feedstock);
- increases in the use of electricity by households associated with the attainment of targets for the electric vehicle (EV) share of the passenger car fleet;
- reductions in the use of motor fuels by households associated with the reduction in the share of passenger cars accounted for by internal combustion vehicles;
- increased expenditure by households on charging station for EVs; and
- loss of physical capital through scrapping of the remaining coal-fired electricity generation and its replacement by other forms of generation

In line with the selection criteria outlined in Chapter 3, these effects summarise the key impacts of Nordic ESR policies on households. Technical details on the formulation of the policy shocks and the calculation of welfare effects are given in Appendices 1 and 2 to this Report.

The main information sources for modelling climate policies in the Nordic countries are the National Energy and Climate Plans (NECPs) referenced at the foot of Table 3. Policy targets and some of the measures that the Nordic countries are adopting are reported in a broadly comparable fashion in these reports, which are updated every three years. We used data from the reports for 2019. The national reports differ in level of detail. For example, the Danish report contains a very detailed annex covering economic and energy assumptions, as does the Finnish report, which however relies more on references to research reports. What the reports have in common is that the detail on policy targets is richer than the detail on specific policy measures.

Table 3. Calculation of percentage increases in motor fuel costs in 2030

	Biofuel blending (percentage of motor fuels)		Biofuel blending (percentage of diesel)		Cost of diesel blend in 2030 (euro per litre)		Diesel blend	Diesel share of passenger car motor fuel use	Car fuels used by households	Average over all motor fuels
	2020	Target 2030	2020	Target 2030	with baseline shares	with target shares	Price rise as a per-centage, 2030	2020 and 2030	Price rise as a per-centage, 2030	Price rise as a per-centage, 2030
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Denmark	6	7	5.39	6.49	0.675	0.688	1.961	0.29	0.49	1.77
Finland	11.7	30	11.66	32.16	0.750	0.996	32.803	0.29	8.89	29.19
Iceland	7.6	8	7.02	7.47	0.694	0.700	0.783	0.33	0.23	0.69
Norway	20	30	20.30	30.69	0.854	0.978	14.592	0.56	8.29	14.07
Sweden	23	63	23.88	66.00	0.897	1.402	56.404	0.38	36.53	54.02

Sources for biofuel percentages in 2020 and targets for 2030:

- ***Denmark:*** *Denmark's Integrated National Energy and Climate Plan under the Regulation of the European Parliament and of the Council on the Governance of the Energy Union and Climate Action. Denmark's Ministry of Climate, Energy and Utilities, December 2019. Rapport (kefm.dk)*
- ***Finland:*** *Integrated Energy and Climate Plan. Publications of the Ministry of Economic Affairs and Employment Energy 2019:66. Finland's Integrated Energy and Climate Plan (europa.eu)*
- ***Norway:*** *National Plan related to the Decision of the EEA Joint Committee No. 269/2019 of 25. Norwegian Ministry of Climate and Environment, October 2019. national-plan-2030_version19_desember.pdf (regjeringen.no) and Climate Action Plan for 2021–2030. Norwegian Ministry of Climate and Environment, Meld St. 13 (2020–2021) (regjeringen.no)*
- ***Sweden:*** *Integrated National Energy and Climate Plan. The Ministry of Infrastructure, 2020. se_final_necp_main_en_0.pdf (europa.eu)*
- ***Iceland:*** *2020 Climate Action Plan. Ministry for the Environment and Natural Resources. 201004 Umhverfisraduneytid Adgerdaaaetlun EN V2.pdf (government.is) See also Appendix A1.2.*

4.4. Biofuels

Although important criticism has been voiced regarding the use of biofuels, particularly first-generation biofuels, as an alternative energy source for vehicles,[10] all Nordic countries have set targets to increase the renewable proportion of motor fuels (including gasoline and diesel). The first two columns in Table 3 show the actual biofuel share in motor fuels as of 1 January 2020 (column 1), and the target for 2030 (column 2). The definition of the blending target varies among the Nordic countries. In most of the countries, the biofuel blending target was expressed in terms of biofuel as a share of motor fuels.

The Danish Integrated National and Climate Plan of 2019 sets a renewable energy target for the transport sector aimed at increasing the renewable share from some nine per cent in 2020 to 19 per cent in 2030, mostly through electrification. According to the Danish legislation in place by the end of 2019, suppliers should blend at least 5.75 per cent of biofuels in the transport fuel they put on the market.[11] From 1 January 2020, this also included 0.9 per cent advanced biofuels, while the actual biofuel share in motor fuels was about six per cent in that year. The biofuel target for liquid fuels in the transport sector should be in the environment of seven per cent for 2030 (Danish Ministry of Climate and Utilities 2019).

In Finland and Norway, the targets are set explicitly: 30 per cent in 2030 in both countries. For Finland, the 2020 biofuel share in motor fuels was about 11.7 per cent (Ministry of Economic Affairs 2019). The Norwegian blending requirement for 2020 was 20 per cent, which was planned to be raised by 10 per cent; with double-counting of emission reductions for biofuels of the latest generation, that would amount to 40 per cent (Norwegian Ministry of Climate and Environment 2019, 2021).

According to the Swedish *Reduktionsplikt* policy defined by Law 2017:1201, the Swedish blending targets are expressed in terms of an emission reduction obligation, where the targets are defined in comparison with emissions from producing the same amount of energy with fossil fuels. This therefore amounts to a blending requirement, which is given separately for petrol and diesel in the law. In Sweden, the biofuel share in motor fuels in 2020 was about 23%. The emission reduction target for 2030 was 28% for petrol and 66% for diesel (Ministry of Climate and Enterprise 2017). Assuming that the petrol and diesel shares of

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10. Despite their capacity to replace fossil fuels (Malla et al. 2022), biofuels have been blamed for increasing food prices, thereby reducing food security in developing countries, and for driving global land use change, with unintended impacts on global biodiversity, potentially contributing to a net increase in greenhouse gas emissions (see Sarwer et al. 2022 for a recent review of this issue).
11. These goals have since then been tightened, and in 2021, the blending requirement for gasoline, diesel, and gas supplied for land transportation was set at 7.6%, including 0.3% advanced biofuels (more information is available here: CO2e-fortrængningskrav og regler for VE-brændstoffer til transport | Energistyrelsen (ens.dk). Nonetheless, in this report, we focus on policy goals that were in place in 2019 in the Nordic countries, before the start of the pandemic.

2020 remain unchanged until 2030, the emissions target would require an overall blending share for low-emission fuels in 2030 of about 63 per cent (Table 3, column 2). It should be noted that in 2022 the Swedish Parliament (Riksdag) decided to pause the gradual increase in the required reduction for petrol and diesel. That means that that the reduction levels for 2022 continued to apply in 2023. During the spring of 2023, the government announced that the required reduction for petrol and diesel would be lowered to six per cent from 2024 and remain at that level for the remainder of the current term of office. In our scenario, we do not take these developments into account. Instead, we analyse how the required reduction as defined in Law 2017:1201 would influence the Swedish economy, industries, and households if it were to be implemented as initially planned.

In Iceland's case, the biofuel share in motor fuels in 2020 was 7.6 per cent. The share of renewables was 11.4 per cent including electricity, and was expected to grow as EVs become more common. Electricity is to account for most of the increase in renewables in Iceland’s transport sector. Iceland’s biofuel target is not so much concerned with increasing the biofuel share per se, but rather with increasing the domestic production of fossil-free fuels. These fuels would be produced by combining carbon capturing and the production of hydrogen with renewable electricity (hence the term e-fuels).

Diesel fuels account for different fractions of motor fuel use by passenger car fleets in the five countries (see column 8 in Table 3) and for approximately 100 per cent in their road transport sectors. The bio shares in gasoline for these countries are already at about the maximum level that is technically compatible with the gasoline-using motors in the current generations of passenger cars and biofuels. We therefore assume that bio targets for motor fuels will be achieved by increasing the bio content of diesel fuels, with the main implications being for the cost of motor fuels used by industries, particularly the road transport industry.

As explained in Appendix 1, we calculated implied biofuel targets for diesel fuels, assuming no increase in bio shares of gasoline for any of the countries, except Sweden, for which we increased the gasoline bio share from 12 per cent to 28 per cent in order to account for the specific targets set by its *Reduktionsplikt*. The results of these calculations are shown in columns (3) and (4) of Table 3. The 2020 shares and the targets for 2030 expressed in terms of bio shares for diesel do not differ greatly from the bio shares expressed in terms of motor fuels, i.e., columns (3) and (4) are similar to columns (1) and (2).

4.5. Electric vehicles (EV)

The approximate targets for increasing electric vehicles (EVs) as a share of passenger car fleets are given in Table 4. There is an explicit target for growth in the number of EVs in only two of the Nordic countries. The Danish target is to have 775,000 EVs on the road by

2030,[12] whereas Finland is targeting a figure of 750,000. These targets imply an increase of 23.1 percentage points in the share of EVs in Denmark and 24.0 percentage points in Finland.

Table 4. Targets for sales of electric vehicles and effects on household motor fuel consumption in 2030

	EV share 2020-2030 (%)	Policy	Policy-induced percentage change in 2030 in household consumption of motor fuels
Denmark	1.9→25.0	775,000 EV target	-23.5
Finland	2.0→26.0	750,000 EV target	-24.8
Iceland	4.6→ 47.4	60% EV sales share	-44.9
Norway	22.1→ 62.2	70% EV sales share	-51.5
Sweden	6.2 → 48.1	60% EV sales share	-44.6

Sources:

2020 EV shares

- ***Finland:*** *Cars by driving power by Traffic use, Vehicle class, Year, Driving power and Information. PxWeb (stat.fi)*
- ***Denmark:*** *Means of transport population – Statistics Denmark (dst.dk)*
- ***Norway:*** *landtransport (ssb.no) Also IEA, Private car fleet in Norway by type of fuel, 2016-2021, IEA, Paris https://www.iea.org/data-and-statistics/charts/private-car-fleet-in-norway-by-type-of-fuel-2016-2021, IEA. Licence: CC BY 4.0*
- ***Sweden:*** *Fordonsstatistik – Transportstyrelsen*
- ***Iceland:*** *Vehicles – Statistics Iceland (statice.is)*

2030 targets

- ***Denmark:*** *https://www.reuters.com/article/us-denmark-climatechange-autos-idUSKBN28E23O on Danish government targeting 775000 EVs.*
- ***Finland:*** *Hiilineutraali Suomi 2035 – ilmasto- ja energiapolitiikan toimet ja vaikutukset (HIISI), Synteesiraportti – Johtopäätökset ja suositukset (valtioneuvosto.fi)*
- ***Sweden:*** *Sweden's Country report to UNFCCC 2021. Emissions from diesel cars fell by 21% from 2010 in the year 2020; the target is a reduction of 66% by 2030, thus a reduction of 43% from 2020. It is possible to derive the biofuel blending target from this and the share of diesel in 2020. Sweden's long-term strategy for reducing greenhouse gas emissions (unfccc.int)*

12. The Danish parliament declared a more ambitious target of a million EVs in 2020 but so far there are only policies in place for the earlier government target of 775,000 EVs by 2030.

- ***Norway's*** *Climate Action Plan for 2021–2030. Norwegian Ministry of Climate and Environment, Meld St. 13 (2020–2021) (regjeringen.no)*

For the other Nordic countries, we assume that the EV share of total sales of passenger cars in each year from 2020 to 2030 will be in line with current expectations as expressed in the sources listed under Table 4: 70 per cent in Norway and 60 per cent in Sweden and Iceland. As explained in Appendix 1, these assumptions concerning the share of sales, combined with expected scrapping rates for existing cars, imply growth in the EV share of the Norwegian passenger car fleet from 22.1 per cent in 2020 to 62.2 per cent in 2030. For Sweden and Iceland, the EV share is expected to grow from 6.2 per cent to 48.1 per cent and from 4.6 per cent to 47.4 per cent, respectively. Further details on assumptions related to household demand for electricity, costs of EV, and home charging stations are presented in Appendix 1.

4.6. Electricity generation sector

To enable a complete decarbonisation of the electric sector, we assume that by 2030 coal will have almost ceased entirely to be used in power generation in the Nordic Region. We simulate this by scrapping 90% of the capital and investment in Nordic-TERM's coal-fired generation of electricity (*ElecCoal* industry, see Appendix 1). We make a corresponding reduction in the nations' aggregate capital stock. In our simulations, coal electricity is replaced endogenously by low or zero-carbon alternatives.

Photo: Julius Ysl, unsplash.com

5. The effects of Nordic greenhouse policies: percentage deviations from the no-policy baseline

This chapter presents simulation results for the effects on the Nordic economies of the greenhouse policy shocks described in Section 4. The results are mainly expressed as percentage deviations in 2030 from the no-policy baseline described in Section 4.2. For example, the first result in Table 8 means that real household consumption in Denmark in 2030 is 1.32 per cent lower with the climate policies in place than it would be without the policies.

To present the results, we have first calculated the contribution of the Nordic policies to greenhouse abatement. We then describe macro effects and industry output effects at the national level, followed by labour-market effects at the national and regional levels. Finally, we look at effects on the costs of living for households classified by urban, intermediate, and rural location and income decile in the Nordic countries.

5.1. Carbon dioxide equivalent emission effects

Table 5 and Table 6 show differences and percentage differences between baseline (no policy) CO2eq emissions in 2030 and emissions in 2030 with the greenhouse policies in place. Looking at those tables, we see that our simulated policies generate significant reductions in emissions from combustion of coal in Denmark, Finland, and Sweden. In Denmark and Finland, the phase-out of coal and peat-fired electricity is the major contributor. In Sweden, the main factors are the reduction in the use of coal per unit of output in petroleum and coal products, and reduction in the output of petroleum and coal products.

The simulated policies generate increased emissions from combustion of gas in Denmark, Finland, and Norway. That is explained by an increase in output of gas-fired electricity (see Section 5.3, Table 10, industry 30). In Sweden, gas-fired electricity contracts, leading to reduced emissions from combustion of gas. In Iceland there is almost no use of gas.

Table 5. Policy-induced change in CO2 eq. emissions in 2030 (Kt)

	Denmark	Finland	Iceland	Norway	Sweden
Combustion of:					
Coal	-3070	-10888	20	-74	-4903
Gas	954	1934	0	338	-157
PetrolCoalPrds	-1249	-6514	-105	-3806	-17331
Activity in:					
Forestry & land	0	0	0	0	0
Other	59	-627	26	-668	-1591
Total (net)*	-3306	-16095	-59	-4210	-23982

* Includes LULUCF

Table 6. Policy-induced percentage change in CO2 eq. emissions in 2030

	Denmark	Finland	Iceland	Norway	Sweden
Combustion of:					
Coal	-80.4	-65.4	2.5	-1.6	-50.3
Gas	13.7	40.0	1.7	2.2	-7.0
PetrolCoalPrds	-5.5	-29.9	-9.2	-20.9	-58.0
Activity in:					
Forestry & land	0.0	0.0	0.0	0.0	0.0
Other	0.4	-4.0	0.8	-3.4	-8.2
Total (net)*	-6.3	-35.6	-0.4	-10.1	-97.6

* Includes LULUCF

In all countries, Tables 5 and 6 show reductions in emissions from combustion of petroleum and coal products. That is explained by two factors: increased biofuel shares of motor fuels and decreased use of motor fuels associated with uptake of EVs. We assume no change in the emissions from forestry and land use.

Policy-induced changes in emissions in the 'Other' category are relatively small. They reflect changes in the industrial composition of output. The main contributor to the positive entry for Denmark is an expansion of the output of crops (see Section 5.3, Table 10, industry 1,), which generates emissions through soil disturbance. In the case of Finland, Sweden, and Norway, the contraction in the output of petroleum and coal products reduces activity-based emissions from this industry. In Iceland, expansion of ferrous and non-ferrous metals (industries 20 and 21, Table 10) increases activity-based emissions from these industries.

The first two rows of Table 7 present index numbers for 1990 and 2019 representing gross greenhouse emissions from the Nordic countries. By gross, we mean emissions excluding carbon sequestration in forests and emissions associated with changes in land use. The third row, calculated from the first two, shows the percentage changes in emissions between 1990 and 2019. Row 4 gives baseline emission indexes for 2030, assuming no further greenhouse policies. The entries in row 4 were calculated using baseline growth projections for gross CO2eq emissions (see Appendix 1, Table 10). Row 5 shows estimated policy-induced percentage reductions in gross emissions (see Table 6). Row 6 gives the emission indexes with the simulated policies, calculated by applying the percentages in row 5 to the indexes in row 4. Row 6 can be compared with row 7, which shows emissions targets. These are either official targets for 2030 or have been interpolated from targets announced for later dates. Comparison of rows 6 and 7 indicates that attainment of the 2030 targets for Denmark, Finland, Norway, and Iceland will require policies beyond those that we have examined. In the case of Sweden, implementation of its ambitious biofuel targets would take it below its 2030 greenhouse target.

Table 7. Gross[13] CO2eq emissions: baseline; policy; and targets

		Denmark	Finland	Iceland	Norway	Sweden
1	Emissions index 1990	1	1	1	1	1
2	Emissions index 2019*	0.65	0.77	1.46	1.01	0.73
3	*Percentage change from 1990 to 2019*	-34.65	-23.29	45.74	1.36	-26.52
4	Emissions index for the no-policy baseline 2030	0.72	0.86	1.64	1.15	0.88
5	*Percentage deviations in 2030 due to greenhouse policies*	-6.72	-27.36	-1.12	-7.23	-39.12
6	Emissions index in 2030 with greenhouse policies in place	0.67	0.62	1.62	1.07	0.54
7	Emissions index target for 2030**	0.45	0.57	1.29	0.82	0.63

* Source: Eurostat (env_air_gge): https://ec.europa.eu/eurostat/web/products-datasets/-/env_air_gge

** Source: European Environmental Agency. EEA greenhouse gas projections – data viewer: https://www.eea.europa.eu/ds_resolveuid/DAS-235-en

5.2. Macro effects at the national level

Table 8 shows results for national macro variables. The big picture is that the greenhouse policies described in Section 4 will have moderate macroeconomic costs for the Nordic countries. Due to these policies, their real GDP in 2030 will be reduced by between 0.18 per cent and 1.31 per cent; their real wage rates will be reduced by between 0.68 per cent and 2.64 per cent; and their real household consumption levels will be reduced by between 0.59 per cent and 1.51 per cent. These negative macroeconomic effects should be assessed in the context of baseline growth. For example, the greenhouse-related reduction in real GDP for Sweden of 1.31 per cent means that real GDP will grow by 19.9 per cent between 2019 and 2030, rather than by 21.5 per cent (see the baseline growth projections in Table 2).

13. This measure of emissions is referred to as gross because it does not include emissions from LULUCF.

Table 8. Macro effects (%) in 2030 of greenhouse policies in Nordic countries

		Denmark	Finland	Iceland	Norway	Sweden
1	Real household consumption (C)	-1.32	-1.27	-0.59	-1.14	-1.51
2	Real investment (I)	0.11	-0.06	0.00	0.21	-0.05
3	Real government consumption (G)	-1.32	-1.26	-0.59	-0.93	-1.43
4	Real GNE (combination of C, I, G)	-1.01	-1.00	-0.49	-0.74	-1.13
5	Export volumes (X)	-1.2	-2.66	0.63	-2.61	-2.75
6	Import volumes (M)	-1.36	-2.83	0.06	-1.23	-2.34
7	Real Gross Domestic Product (GDP)	-0.73	-1.16	-0.18	-1.22	-1.31
8	Aggregate employment	0.00	0.00	0.00	0.00	0.00
9	Average real wages	-0.76	-2.15	-0.70	-0.68	-2.64
10	Aggregate capital stock	-0.65	-0.10	0.00	0.00	0.00
11	GDP price index	-0.81	-0.02	-0.59	-0.19	-0.00
12	Consumer Price Index (CPI)	-0.20	0.06	-0.18	-0.45	0.16
13	Export price index	-0.40	1.52	-0.18	1.86	1.74
14	Import price index	0.93	0.67	0.39	0.34	0.31
15	Population	0.00	0.00	0.00	0.00	0.00
16	Welfare	-0.99	-0.72	-0.29	-0.38	-0.91

As will become apparent in the detailed explanation, the results in Table 8 depend on the following assumptions:

- greenhouse policies do not affect aggregate national employment in the Nordic countries in 2030. We assume that wage rates (rather than employment) adjust in the long run to accommodate productivity and cost changes caused by greenhouse policies.
- greenhouse policies do not affect nominal exchange rates. To the extent that these policies require changes in the competitiveness of the Nordic economies, this is achieved through changes in domestic price levels. This is a technical assumption that does not affect the results for industry outputs and other real variables.

- aggregate investment in each Nordic country during the period from 2019 until the start of 2030 is not affected by greenhouse policies. That means that aggregate capital in each Nordic country at the beginning of 2030 is unaffected by greenhouse policies, apart from the early scrapping of coal-fired electricity generation capacity.

- investment/capital ratios at the aggregate level in each Nordic country in 2030 are unaffected by greenhouse policies. We therefore assume that business confidence in 2030 is independent of greenhouse policies. Together with our previous assumption concerning aggregate capital, our investment assumption for 2030 means that greenhouse policies are assumed to have very little effect on investment in 2030.

- greenhouse policies do not affect the ratio of nominal private consumption to nominal GDP in the Nordic countries or the ratio of real public consumption to real private consumption. We therefore assume that the costs of greenhouse policies are shared equally between the public and private sectors.

With these assumptions in mind, in the following points we explain these results in Table 8, starting with the real GDP deviations in row 7:

Real GDP deviations (row 7, Table 8)

The real GDP results can be understood via the stylised equation:
(4.1)

real GDP = F (NR, K, L, Tech, Eff)

In this equation, *real GDP* is determined as a function of the use of natural resources (*NR*), the use of capital (*K*), the use of labour (*L*); technology or productivity (*Tech*); and efficiency (*Eff*), which refers to the ability of the market to allocate resources in ways that optimise the aggregate value of production. Using this stylised framework, Table 9 decomposes the real GDP deviations from row 7 of Table 8 into four parts.[14] The decomposition in Table 9 quantifies the other four drivers:

- ***reduced oil production*** (reduced use of natural resources). This is important for Norway and to a lesser extent Denmark. It does not affect the other three countries.

- ***capital loss***. This arises from early scrapping of coal-fired electricity generation capacity. That effect is mainly pronounced in Denmark. By 2019, the other Nordic countries had very little coal-generated electricity so their real GDP in 2030 is barely affected by our assumption of a 90% phase-out

14. Labour (*L*) is omitted from this breakdown because we assume that the greenhouse policies have no effect on aggregate employment in 2030; see row 8 of Table 8

of remaining capacity.

- ***deterioration in production technology***. This arises from our assumption that the shift towards biodiesel increases the cost of providing motor fuels. That is simulated as a technological deterioration or a reduction in output per unit of input in creating motor fuels.

- ***efficiency or dead-weight losses***. Efficiency losses arise when consumers are induced to switch from high-taxed products to lower taxed products. That occurs in the current simulation because households switch from petroleum and coal products (very highly taxed) to electricity (taxed at lower rates than petroleum).

Table 9. Breakdown of GDP effects: percentage contributions

	Use of natural resources (oil)	Capital loss (coal)	Production efficiency (Petrol prods)	Dead-weight losses (switch to electricity)	Real GDP
Denmark	-0.24	-0.21	-0.02	-0.25	**-0.73**
Finland	0.00	-0.02	-0.80	-0.35	**-1.16**
Iceland	0.00	0.01	0.00	-0.19	**-0.18**
Norway	-0.45	-0.01	-0.38	-0.39	**-1.22**
Sweden	0.00	0.03	-0.91	-0.42	**-1.31**

Using Table 9, we can see that the real GDP loss for Iceland is small for the following reasons:

- Iceland does not produce oil and suffers no reduction in its use of natural resources;

- Iceland does not produce coal-fired electricity and suffers no capital loss;[15]

- Iceland produces very little motor fuel and consequently suffers almost no deterioration in economy-wide production technology; and

- households in Iceland allocate a relatively low budget share to petroleum products so the switch towards electricity causes a relatively small efficiency

15. Table 9 shows tiny capital contributions for Iceland, Sweden and Norway despite capital deviations of zero in row 10, Table 8. This is a numerical quirk explained by differences between the baseline and policy runs in the capital shares in GDP.

loss.

By contrast, Sweden has a relatively large GDP loss due to this country's large switch to biofuels (see columns (1) and (2) of Table 3), which is reflected in Table 9 by a high entry in the production efficiency column.

Real private and public consumption (rows 1 and 3, Table 8)

Real private and public consumption fall relative to real GDP (row 7, Table 8) in four of the Nordic countries. Norway forms an exception. In our simulation, we assume that the value of private consumption in each region changes in line with the value of the region's GDP. Consequently, the value of private consumption in each nation changes approximately in line with the value of the national GDP. In real terms, private consumption at the national level falls relative to GDP in four of the Nordic countries because the price of private consumption rises relative to the price of GDP in those countries (rows 11 and 12, Table 8). Public consumption is assumed to change in line with private consumption in real terms in each region and this relationship is approximately maintained at the national level. Real public consumption at the national level therefore falls relative to real GDP in the four countries. In Norway's case, the price of private consumption falls relative to the price of GDP. As a result, real national public and private consumption rise relative to real GDP in Norway.

Terms of trade (the movement in export prices relative to import prices, rows 13 and 14, Table 8) are a key determinant of movements in the price of private consumption relative to the price of GDP. A deterioration in the terms of trade (a reduction in the export/import price ratio) causes the price deflator for Gross National Expenditure (GNE, a combination of private consumption, public consumption, and investment) to rise relative to the price deflator for GDP. That is because GNE includes imports but not exports, whereas GDP includes exports but not imports. Within the scope of GNE, the price deflator for private consumption rises in all countries relative to the other components: both public expenditure and investment are labour-intensive and, as will be explained shortly, real wages fall. The terms-of-trade deterioration for Denmark and Iceland is driven by an increase in the price of their imported petroleum products. We assume that Nordic countries insist on environmental improvements in their imported motor fuels, causing an increase in the import price of motor fuels that broadly matches the increase in the cost of domestically produced motor fuels. Both Denmark and Iceland import considerable petroleum products relative to their exports of these products. Both countries therefore suffer a terms-of trade decline. That, together with the increase in the price of private consumption relative to the other components of GNE, is sufficient to explain the increases for these two countries in the price of private consumption relative to the price of GDP.

Finland, Sweden, and in particular Norway export more petroleum products than they import. Consequently, they each have an improvement in their terms of trade, implying a reduction in the price of GNE relative to the price of GDP. Nevertheless, in the case of Finland and Sweden the private consumption price index rises relative to the price of GDP. The explanation is that the increase in the price of private consumption relative to the other components of GNE is sufficient to leave private consumption prices elevated relative to the price of GDP, even though the price of GNE falls relative to the price of GDP. For Norway, the reduction in the price of GNE relative to the price of GDP outweighs the effect of the increase in the price of private consumption relative to the prices of the other components of GNE, leaving the price of GDP elevated relative to the price of private consumption.

Real wages (row 9, Table 8)

Real wages fall in all regions primarily because we assume a 'deterioration in technology' in the production of motor fuels, reducing the value of the marginal product of labour in terms of GDP units. The fall in real wages relative to baseline is then accentuated in all countries except Norway because we use consumer prices (rather than the GDP prices) to deflate nominal wages.

Welfare (row 16, Table 8)

In calculating changes in welfare, we include changes in most components of household consumption. However, we leave out the increase in electricity consumption and the reduction in motor fuel consumption associated with the uptake of electric cars. We also omit the increase in expenditure on electrical equipment associated with the installation of household charging stations. The reduction in expenditure on motor fuels outweighs the increase in expenditures on electricity and charging stations. Omitting these three items implies a better utility (welfare) outcome than the outcome for real household consumption.

The easiest way to explain the omission of greenhouse-related changes in expenditure on electricity, motor fuels, and electrical equipment is by way of an example. If expenditure on electrical equipment needs to increase by 25 per cent due to the installation of charging stations, then a 25 per cent increase in consumption of electrical equipment should generate no additional utility. Only consumption increases beyond those required for charging stations can be thought of as generating extra utility. The technical details of how welfare changes are calculated are set out in Appendix 1.

GDP deflator (row 11, Table 8)

The movements in price deflators for GDP are negative, indicating that the Nordic greenhouse policies cause real devaluation (it should be recalled that we assume no movement in nominal exchange rates, cf. the second bullet point at the beginning of this section). The starting point for understanding this aspect of the results is the equation:

real GDP - real GNE = X - M

i.e. the difference between real GDP and real GNE is the real trade balance (real exports less real imports).

As already described, real private and public consumption fall relative to real GDP in all Nordic countries except Norway. However, we assume that the movements in investment are small, resulting in an increase in investment to real GDP in all Nordic countries. That is sufficient to convert the decline in consumption relative to GDP for Finland and Sweden into increases in real GNE relative to real GDP. Thus, for Finland and Sweden, together with Norway, there must be a decrease in *X-M*. For Denmark and Iceland, *X-M* must increase, reflecting reductions in real GNE relative to real GDP.

In Denmark's case, there is a direct negative effect on exports through reduced international demand for Danish oil. Nevertheless, *X-M* must increase. That is facilitated by real devaluation, i.e. by a reduction in the Danish price level (price of GDP, row 11, Table 8) relative to that of the rest of the world. For Iceland, there is little direct negative effect on exports. Exports are stimulated by the small real devaluation necessary to increase *X-M*. Although imports become more expensive, there is a small positive effect on import volumes (row 6, Table 8). That arises from high use of imported inputs by export-oriented industries.

For Sweden and Norway there are direct negative effects on exports. In the case of Norway, that occurs through contraction in demand for oil. For Sweden, the diversion of forestry products into motor fuels causes cost increases and export reductions for paper and wood products. Cost increases for motor fuels are also an important direct negative for Sweden's exports. These direct negatives for Norway and Sweden's exports are sufficient to require a reduction in import volumes (M), despite the reduction in *X-M*. The required reductions in *M* are achieved via small real devaluations (small declines in the GDP price deflators for Norway and Sweden, row 11, Table 8).

In Finland's case, the export-to-import ratio rises slightly (rows 5 and 6, Table 8). That is contrary to expectations because we know that *X-M* must fall. Closer inspection of our results reveals that *X-M* does indeed fall. It emerges that for Finland, *X* is sufficiently greater than *M* that a 2.66 per cent reduction in *X* (row 5, Table 8) outweighs a 2.83 per cent reduction in M (row 6, Table 8), that is:

$$\Delta(X - M) = -0.0266*X+0.0283*M<0$$

As in Sweden's case, there is a direct negative impact on Finland's exports of paper and wood products through diversion of forestry products into motor fuels and through export-reducing cost increases in motor fuels. Although there is very little real devaluation (Finland's GDP deflator falls by only 0.02 per cent), Finland's real imports fall by 2.83 per cent, reflecting the reduction in economic activity and the import intensity of Finland's motor fuels industry. A 2.83 per cent reduction in imports, together with the direct negative export effects, is sufficient to generate the required decrease in *X-M*, with almost no real exchange rate movement.

5.3. Industry effects at the national level

Table 10 shows the effects in 2030 of the Nordic greenhouse policies on industry outputs at the national level. For some industries, the results in Table 10 stem directly from special treatments in the formulation of the policy shocks. For other industries, the results come mainly via macro effects.

Table 10. Effects on industry* output (%) in 2030 of greenhouse policies in Nordic countries

	Denmark	Finland	Iceland	Norway	Sweden
1 Crops	0.77	-3.65	-3.86	1.21	-6.12
2 Livestock	0.42	-0.34	-1.34	0.58	-0.25
3 ForestryLogs	8.30	27.29	0.48	96.02	61.55
4 FishingAqua	NA	-0.55	-1.92	1.24	-5.02
5 Coal	-78.87	-58.02	NA	-14.19	-11.92
6 Oil	-33.60	-26.87	NA	-20.81	NA
7 Gas	9.05	14.14	NA	10.23	NA
8 OthMining	1.68	-1.81	1.29	0.93	-1.23
9 FoodBevTob	0.31	-0.52	-0.97	0.53	-0.59
10 Textiles	1.32	-0.93	0.87	1.70	-3.93
11 Apparel	0.49	-0.22	-0.62	1.20	-3.85
12 LeatherPrd	0.45	-0.39	-0.08	0.54	-4.11
13 WoodProds	4.10	-4.79	0.82	-1.13	-6.63
14 PaperProds	2.40	-3.35	0.33	0.83	-5.27
15 PetrolCoalP	-5.51	-22.26	NA	-17.11	-37.58
16 ChemicalProds.	17.18	-7.83	6.69	-0.25	-15.90
17 Pharmaceutical	2.14	-1.41	-1.15	-0.32	-1.05
18 RubberPlas	3.11	-0.10	0.75	0.54	-0.85
19 NonMetMinProds	1.76	0.06	1.12	-0.23	-1.88
20 FeMetals	6.91	0.58	2.50	4.33	-2.71

21 NonFeMetals	2.61	-1.22	4.13	3.04	-0.24
22 FabriMetals	1.27	0.07	-0.19	2.48	0.39
23 Computer & optics	0.80	0.21	-0.28	0.74	0.99
24 ElectricEqp	2.00	1.59	3.09	3.90	1.36
25 MachineNEC	0.80	0.43	-0.53	1.23	0.54
26 MotorVehicle	0.52	0.42	-0.74	0.79	0.54
27 OthTransEqp	1.11	1.30	-0.69	1.79	-0.05
28 FurnitRepair	0.59	-0.58	-0.56	0.14	-0.09
29 ElecCoal	-88.72	-87.90	NA	NA	NA
30 ElecGas	65.51	4.42	NA	12.04	-18.48
31 ElecOther	102.94	-38.50	NA	18.32	-24.82
32 ElecHydro	NA	15.82	1.98	4.19	4.31
33 ElecNuc	NA	14.83	NA	NA	3.12
34 ElecDist	2.73	0.69	1.98	3.39	0.69
35 GasSupDist	1.17	NA	NA	4.99	-3.62
36 Water	-0.03	-0.73	-0.14	-0.09	-0.66
37 Construction	0.16	-0.23	0.01	0.22	-0.18
38 Wholesale & retail	0.50	-0.49	-0.13	0.18	-0.63
39 AccomFood	-1.06	-0.49	-0.31	-0.35	-0.58
40 LandTransprt	0.96	-0.67	-0.32	0.25	-1.08
41 WaterTrnsprt	-0.80	-3.16	0.75	-0.78	-6.09
42 AirTransport	0.38	-0.08	-0.11	-0.25	-0.28
43 Warehousing	0.52	-0.59	0.16	0.42	-0.95
44 Communication	0.17	-0.27	-0.12	0.44	-0.13
45 Finance	0.42	-0.12	-0.17	0.24	-0.01
46 InsurPension	0.85	-0.06	-0.38	0.52	0.35
47 RentLease	-0.21	-0.53	-0.04	0.25	-0.49
48 OthBusSrv	0.43	-0.08	-0.06	0.62	0.16
49 Recreation & pers. serv.	-0.36	-0.35	0.00	0.19	-0.52
50 PubAdm & defence	-1.14	-1.16	-0.49	-0.73	-1.31
51 Education	-0.49	-0.72	-0.31	-0.36	-0.79

52 Health & social serv.	-1.28	-1.07	-0.47	-0.71	-1.22
53 Services of dwellings	-1.23	-1.37	-0.41	-0.12	-1.33
Absorption of electricity**	0.55	0.78	1.98	3.27	0.68

NA: Not applicable because output is negligible

* The industries in Nordic-TERM are based on those used in the GTAP model, defined in https://www.gtap.agecon.purdue.edu/databases/contribute/detailedsector57.asp . However, we have performed a few aggregations. For example, our industry 1, Crops, is an aggregation of the first eight GTAP industries. We have also broken down the GTAP electricity generation industry into 5 generating industries (our industries 29-34). See Appendix 1 for further details.

** This is the use of electricity: output *plus* import *less* exports.

In this subsection, we provide explanations for a selection of industries. These explanations are divided into two sections. First, we address industries for which the results are directly related to the greenhouse policy shocks. Then we address a group of industries for which the results derive mainly from changes in the macro economy.

5.3.1. Industries with special treatments in the shocks representing Nordic climate policies

Crops (Row 1, Table 10)

This industry is stimulated in Denmark as an input for the production of motor fuels. The negative results for Finland, Sweden, and Iceland are caused by loss of international competitiveness related to increased costs of petroleum products that are used intensively as an input for crop production. Crop production in Norway gains from using relatively little petroleum products and having relatively high inputs of primary factors, particularly capital. As explained in the discussion below of *Oil*, capital in Norway becomes relatively cheap.

Forestry & logging (Row 3, Table 10)

This industry is strongly stimulated in Finland, Sweden, and Norway due to its use as an input for the production of motor fuels. We also assume that forestry and logging provide the bio input for motor fuels in Iceland. That is unimportant because Iceland does not produce significant amounts of motor fuels. Forestry and logging are stimulated in Denmark by trade effects.

Coal (Row 5, Table 10)

Output of this industry is sharply reduced in Finland, where our database shows coal is used as an input to *ElecCoal*. However, coal production is very small in Finland, where this industry mostly consists of peat production.

Oil (Row 6, Table 10)

Production is reduced in all producing countries through reduced demand for the production of motor fuels. This is significant in Norway. Under our assumption that greenhouse policies barely affect aggregate capital for each country at the start of 2030, the contraction of Norway's oil industry (a capital-intensive industry) releases considerably more capital than labour to be absorbed by other industries in Norway. That leads to a small reduction in the cost of using capital relative to the cost of using labour. As we will see, this has some minor implications for other industries.

Gas (Row 7, Table 10)

Production is stimulated in Denmark, Finland, and Norway via stimulation of *ElecGas*, see discussion of industries 29 to 33, Table 10.

Wood products (Row 13, Table 10)

This industry contracts in Finland, Sweden, and Norway due to cost increases caused by the diversion of raw materials (forestry and logging) into motor fuels. In Denmark, the industry gains a competitive advantage and expands.

Petroleum & coal products (Row 15, Table 10)

Production is reduced in all Nordic countries due to adoption of electric cars.

Electrical equipment (Row 24, Table 10)

Production is increased in all Nordic countries due to adoption of electric cars.

Electricity-generating industries (Rows 29 to 33, Table 10)

In Denmark, *ElecCoal* is phased out and replaced by *ElecGas* and *ElecOther*. *ElecOther* is a heterogeneous collection that includes solar, wind, and oil-based capacity. *ElectricHydro* and *ElectricNuc* do not operate in Denmark.

In Finland, *ElecCoal* is replaced mainly by *ElecNuc*. There are also minor contributions from *ElecHydro* and *ElecGas*. In Finland, *ElecOther* is small and dominated by oil-based generation capacity. Output of *ElecOther* contracts because the increase in the price of petroleum product inputs makes it uncompetitive.

Sweden does not have *ElecCoal*. Nevertheless, the adoption of greenhouse policies causes a reorganisation of its generation capacity. *ElecHydro* and *ElecNuc* expand while the fossil-based *ElecGas* and *ElecOther* contract.

Like Sweden, Norway has no *ElecCoal*. Norway relies heavily on *ElecHydro*, with minor contributions from *ElecGas* and *ElecOther*. Both *ElecGas* and *ElecOther* (which does not have a significant oil input) become cheap in Norway relative to the comparable products in the other Nordic countries. That enables Norway to expand its exports, which were already significant in 2019.

Iceland relies entirely on *ElecHydro* (including geothermal). Expansion of output must match expansion in Iceland's absorption of electricity.

As shown in the last row of Table 10, absorption of electricity increases in all the Nordic countries, reflecting the increased use of electric vehicles.

5.3.2. Industries for which macro and trade effects dominate

Chemical products (Row 16, Table 10)

This is a trade-exposed industry with considerable exports from all Nordic countries. In Denmark and Iceland, the industry benefits from real devaluation. In Finland, Sweden, and Norway, the benefits of real devaluation are offset by increases in the price of petroleum and coal products. The chemical products industry in Finland, Sweden, and Norway is much more intensive in its use of petroleum and coal products than in Denmark and Iceland.

Other trade-exposed manufacturing industries (Rows 9 to 28, Table 10, excluding 15 & 16)

Table 10 shows 90 results for these industries, i.e. from 18 industries in five Nordic countries. 36 of these results are negative and 54 are positive.

The industries in this group are heavily trade exposed, with high export shares in their national outputs and high import shares in their domestic markets. They benefit from real devaluation in both their ability to export and compete with imports. On the other hand, they are harmed by contraction in private and public consumption, not only in their own countries but also in their trading partners.

The largest real devaluation caused by the Nordic greenhouse policies is in Denmark, where real devaluation is dominant (see row 11 in Table 8), and all the industries in this group of 18 show a positive result in Table 10. In the case of Finland, Sweden and Norway, real devaluation is moderate, leaving a mixture of positive and negative results for these 18 tradeexposed industries.

In Iceland's case, real devaluation measured by the reduction in the price deflator for GDP is almost as great as for Denmark (0.59 per cent compared with 0.81 per cent, row 11 in Table 8). Yet, for Iceland, ten of the 18 industries in this trade-exposed group exhibit negative output deviations. The explanation is that some of Iceland's export industries, such as non-ferrous metals, are heavily dependent on imported inputs. That limits the ability of real devaluation to stimulate exports and improve the trade balance. It is also true that a major export for Iceland is food (including marine products) to the Nordic countries and the rest of

Europe. The reduction in private consumption in these countries inhibits Iceland's exports.

Public-sector and private-sector service industries (Row 38 to 53, Table 10)

In most cases, these industries show small negative deviations, arising from the contractions in real private and public consumption. However, there are a number of exceptions.

For example, industries 43 to 48 in Norway have small positive output deviations. All of these industries have non-negligible export sales, typically of 5 to 10 per cent. The competitiveness of these industries in Norway is enhanced relative to competitors in other Nordic countries, leading to export expansion and Norway's small positive output deviations. The competitiveness effect for these industries in Norway arises from the reduction in the cost of using capital relative to the cost of using labour as explained in our discussion of industry 6, *Oil*. According to our database, industries 43 to 48 in Norway are considerably more capital-intensive than the corresponding industries in the other Nordic countries and gain a significant cost advantage from Norway's reduction in the cost of using capital.

5.4. Labour market effects

In this subsection, we set out results for employment in the Nordic countries classified by industry, occupation, wage band, education requirement, age, and subnational region.

Industry employment results are generated directly using Nordic-TERM at the subnational regional level and then aggregating to the national level. Employment results follow predictably from industry output results such as those described at the national level in subsection 5.3. The occupational results are derived directly from the industry employment results under the assumption that the Nordic greenhouse policies do not affect the occupational composition of employment in each industry. The results for employment classified by wage band, education, and age are generated under the assumption that greenhouse policies do not affect the wage band, required educational level, and age composition for employment in each occupation. Details of the theory and data used in generating labour-market effects are provided in Appendix 4.

Given that occupations are spread across industries, the variation in greenhouse-related percentage deviations across occupations is damped relative to the employment variations across industries. Similarly, employment deviations by wage band, education, and age are evened out by their spread across occupations.

5.4.1. Employment by industry

Table 11 shows greenhouse-related deviations in employment by industry for the Nordic countries. In most cases, the employment deviation in Table 11 is similar to the output deviation in Table 10, but there are a number of exceptions.

Table 11. Effects on industry employment (%) in 2030 of greenhouse policies in Nordic countries

	Denmark	Finland	Iceland	Norway	Sweden
1 Crops	0.85	-3.80	-4.38	1.31	-6.28
2 Livestock	0.43	0.02	-1.52	0.57	0.18
3 ForestryLogs	9.51	32.72	0.63	121.70	74.94
4 FishingAqua	-0.86	0.13	-3.37	2.11	-7.94
5 Coal	NA	-74.26	NA	-31.10	-23.06
6 Oil	-33.53	-26.21	NA	-20.77	NA
7 Gas	14.45	36.93	NA	16.24	NA
8 OthMining	1.87	-1.36	1.57	1.06	-0.46
9 FoodBevTob	0.26	-0.02	-0.82	0.40	-0.04
10 Textiles	1.27	-0.55	0.98	1.59	-3.49
11 Apparel	0.45	0.23	-0.45	1.03	-3.31
12 LeatherProds	0.42	0.09	0.03	0.37	-4.04
13 WoodProds.	4.06	-4.44	0.89	-1.23	-6.11
14 PaperProds.	2.35	-2.83	0.49	0.72	-4.69
15 PetrolCoalP	5.70	70.23	NA	3.51	118.24
16 ChemicalProds	17.08	-7.16	6.84	-0.46	-15.13
17 Pharmaceutical	2.07	-0.58	-0.99	-0.57	-0.06
18 RubberPlas	3.05	0.34	0.86	0.43	-0.25
19 NonMetMinProds	1.72	0.46	1.18	-0.35	-1.38
20 FeMetals	6.88	0.93	2.60	4.19	-2.20
21 NonFeMetals	2.58	-0.59	4.25	2.89	0.26

22 FabriMetals	1.23	0.42	-0.14	2.39	0.86
23 Computer & optics	0.75	0.80	-0.20	0.59	1.70
24 ElectricEqp	1.95	2.11	3.19	3.77	1.98
25 MachineNEC	0.75	0.90	-0.43	1.12	1.13
26 MotorVehicle	0.46	0.78	-0.64	0.69	1.18
27 OthTransEqp	1.07	1.58	-0.66	1.75	0.61
28 FurnitRepair	0.55	-0.08	-0.45	0.05	0.49
29 ElecCoal	-85.82	-81.36	NA	NA	NA
30 ElecGas	65.38	5.42	NA	11.83	-17.67
31 ElecOther	103.34	9.96	NA	18.03	19.06
32 ElecHydro	NA	16.73	2.11	3.99	5.29
33 ElecNuc	NA	15.85	NA	NA	4.24
34 ElecDist	2.61	1.53	2.12	3.13	1.65
35 GasSupDist	1.03	NA	NA	4.74	-2.82
36 Water	-0.08	-0.39	-0.07	-0.19	-0.32
37 Construction	0.13	0.13	0.06	0.10	0.26
38 Wholesale & retail	0.46	-0.04	-0.03	0.09	-0.13
39 AccomFood	-1.10	-0.15	-0.23	-0.41	-0.21
40 LandTransprt	0.92	-0.29	-0.26	0.10	-0.54
41 WaterTrnsprt	-0.88	-2.73	0.78	-0.92	-5.66
42 AirTransport	0.34	0.51	0.03	-0.31	0.2
43 Warehousing	0.46	-0.03	0.25	0.24	-0.19
44 Communication	0.12	0.30	0.02	0.28	0.51
45 Finance	0.36	0.26	-0.04	0.00	0.57
46 InsurPension	0.83	0.53	-0.25	0.34	1.07

47 RentLease	-0.32	0.29	0.14	0.02	0.43
48 OthBusSrv	0.38	0.35	0.06	0.50	0.64
49 Recreation & pers. serv.	-0.42	0.10	0.09	0.05	0.03
50 PubAdm & defence	-1.17	-0.86	-0.44	-0.83	-1.01
51 Education	-0.51	-0.57	-0.28	-0.41	-0.65
52 Health & social serv	-1.30	-0.92	-0.44	-0.75	-1.08
53 Services of dwellings	-1.36	-0.26	-0.22	-0.42	-0.13

Output of petroleum and coal products (industry 15, Table 10) falls sharply in all countries, but employment rises (industry 15, Table 11). That follows from the 'technological deterioration' that we introduced to account for the cost increase in motor fuels caused by the switch towards biodiesel. This switch means that more inputs of labour are required in the petroleum and coal products industry per unit of output.

Employment per unit of output for coal and gas (industries 5 and 7) is affected by the presence of a fixed factor (natural resource). With a fixed factor, a given percentage reduction in output requires a greater percentage reduction in employment. That can be seen in the coal results for Finland and Norway. In Finland, coal (including peat) output falls by 58.02 per cent and coal employment falls by 74.26 per cent. In Norway, the reductions in coal output and employment are 14.19 and 31.10 per cent. For gas (industry 7), there are increases in output in all producing countries. With a fixed factor, the percentage increases in employment exceed those in output. In our model, oil (industry 6) also has a fixed factor. However, in this industry the output and employment results in Table 10 and Table 11 stay in line. That is because we assumed that the Nordic countries treat their oil reserves as though they are supplied elastically at a price which is independent of Nordic greenhouse policies. Thus, rather than adjust the price of their product in response to changes in demand, they adjust supply, allowing world prices of oil to guide their own prices.

A striking disconnect occurs between the employment and output results for *ElecOther* (industry 31) in Finland and Sweden. In both cases, output contracts but employment increases. We traced these unexpected results to the effects of aggregation across NUTS2 regions within Finland and Sweden. At the NUTS2 regional level, employment closely follows output. However, in both countries there is a sharp decline in the output of *ElecOther* in regions in which this industry is predominantly oil-based, while at the same time providing very little employment. In other regions, *ElecOther* is not oil-based, is relatively labour intensive, and expands. With regard to output, the contraction of the oil-based part of the industry dominates. With regard to employment, the expansion of the non-oil-based part dominates. However, this does not take into consideration the possibility that the oil-dependent fraction of the *ElecOther* segment can adapt to fossil-free technologies in order to retain output.

5.4.2. Employment by occupation

Table 12 shows the policy-induced deviations in employment by occupation in 2030 in the Nordic countries.

Table 12. Total growth in employment (%) between 2019 and 2030 by selected occupation

Percentage deviations, 2030	Denmark	Finland	Iceland	Norway	Sweden
4 Hospitality & retail manager	0.2	-0.2	0.0	0.0	0.0
5 Scient. & engineer professional	0.2	0.2	0.3	0.1	0.3
6 Health professional	-1.0	-0.8	-0.4	-0.7	-0.9
19 Other clerk	0.2	0.0	0.0	0.0	0.2
22 Personal care worker	-1.1	-0.8	-0.4	-0.7	-0.9
27 Metal machine trade	1.1	0.4	0.6	0.7	0.3
28 Handicraft & printing	1.6	-1.9	0.1	0.4	-2.6
29 Electrical trade	0.3	0.5	0.6	0.3	0.3
34 Cleaners & helpers	-0.1	0.1	-0.2	0.1	0.1
35 Agric., forest, fishing labourer	0.8	9.2	-1.3	7.2	25.9
37 Food prep assistant	-0.7	-0.2	0.2	-0.3	-0.2

Table 12 shows that the adoption of greenhouse policies has negative employment effects on consumption-oriented occupations such as *Health* *professional* and *Personal care worker* (occupations 6 and 22). As we saw in Table 11, employment falls in most consumption-oriented industries such as *Health &social serv* (industry 52).

For *Handicraft & printing* (occupation 28), there is a mixed picture in Table 12: positive for Denmark, Norway, and Iceland and negative for Finland and Sweden. The main employing industry for this occupation is *PaperProds* (industry 14). Paper products shows positive employment results for Denmark, Norway, and Iceland in Table 11, and negative results for Finland and Sweden.

The effects of greenhouse policies on employment in *Scientific & engineering*, *Metal machine trade* and *Electrical trade* occupations (occupations 5, 27 and 29) are positive in all Nordic countries. That reflects stimulation of employment opportunities in *Electrical equipment* (industry 24), *Construction* (industry 37), a variety of manufacturing industries, and motor fuels (it should be recalled that employment in motor fuels expands with the adoption of biodiesel). With the exception of Iceland, employment opportunities increase for *Agricultural, forestry, and fishing* labourers (occupation 35), reflecting the expansion of industries providing biomaterials for motor fuels.

5.4.3. Employment by wage band, age and education

Table 13 shows policy-induced deviations in employment by wage band in 2030. Wage bands refer to hourly wage rates in 2019: less than 25 Euro per hour; 25 to 40 Euro per hour etc. The deviation results are small and less than one per cent in all cases. They show no clear pattern. In Denmark and Iceland, the simulated greenhouse policies have small negative effects on employment in the lowest wage band and positive effects on employment in the other bands. In Sweden, the effects are slightly positive in lower wage bands and negative in high-wage bands. Finland and Norway paint a mixed picture. Overall, Table 13 indicates that greenhouse policies have a negligible impact on the distribution of jobs across wage bands.

Table 13. Total growth in employment (%) between 2019 and 2030 by wage band

Percentage deviations, 2030	Denmark	Finland	Iceland	Norway	Sweden
0_25	-0.3	0.0	-0.1	0.0	0.0
25_40	0.1	0.1	0.0	-0.2	0.2
40_55	0.2	-0.2	0.2	0.0	0.0
55_70	0.3	0.3	0.4	0.0	0.3
70_85	0.8	-0.3	0.3	-0.1	0.0
85_100	0.7	-0.5	0.0	-0.2	0.2
100_plus	0.5	0.4	0.8	-0.3	-0.4

Table 14 and Table 15 show that greenhouse policies have a negligible impact on the distribution of jobs across age and required educational level.

Table 14. Total growth in employment (%) between 2019 and 2030 by age

Percentage deviations, 2030	Denmark	Finland	Iceland	Norway	Sweden
A14-19	0.0	-0.1	-0.1	0.0	-0.1
A20-29	-0.1	0.0	-0.1	-0.0	0.0
A30-39	-0.1	0.0	0.0	0.0	-0.1
A40-49	0.0	0.0	0.0	0.0	0.0
A50-59	0.1	0.0	0.0	0.1	0.0
A60-	-0.0	0.1	0.0	0.0	0.0

Table 15. Total growth in employment (%) between 2019 and 2030 by education level

Percentage deviations, 2030	Denmark	Finland	Iceland	Norway	Sweden
Basic	0.3	0.0	-0.1	0.0	-0.2
Secondary	0.1	0.2	0.1	0.3	0.3
Tertiary, 4 years	-0.2	-0.2	-0.1	-0.3	-0.3
Tertiary, greater than 4 years	-0.2	-0.2	-0.1	-0.2	-0.7

5.4.4. Employment by region

The first two rows for each Nordic country in Table 16 show growth in employment between 2019 and 2030 at the national level and by NUTS2 region for the baseline and policy runs. The policy-induced deviations in national and regional employment in 2030 are in the third row for each country. The deviations at the national level are zero: it should be recalled from Section 5.2 that we assume that greenhouse policies do not affect aggregate national employment in 2030.

All of the regional deviations are less than one per cent in absolute terms. The largest positive deviations are 0.37 per cent for Norra Mellansverige and 0.36 per cent for Sør-Østlandet. The largest negative deviation is -0.49 per cent for Vestlandet.

As further explained in Appendix 1 (Section 2.6), regional results can be analysed by decomposing them into industry mix and industry growth effects. A region scores a positive industry mix effect from greenhouse policies if it has relatively large shares of its employment in industries that benefit from these policies at the national level and relatively low shares of its employment in industries that contract at the national level. A region scores a positive industry growth effect from greenhouse policies if the percentage impacts on employment in its industries are more positive (or less negative) than the percentage impacts on employment in the corresponding industries at the national level.

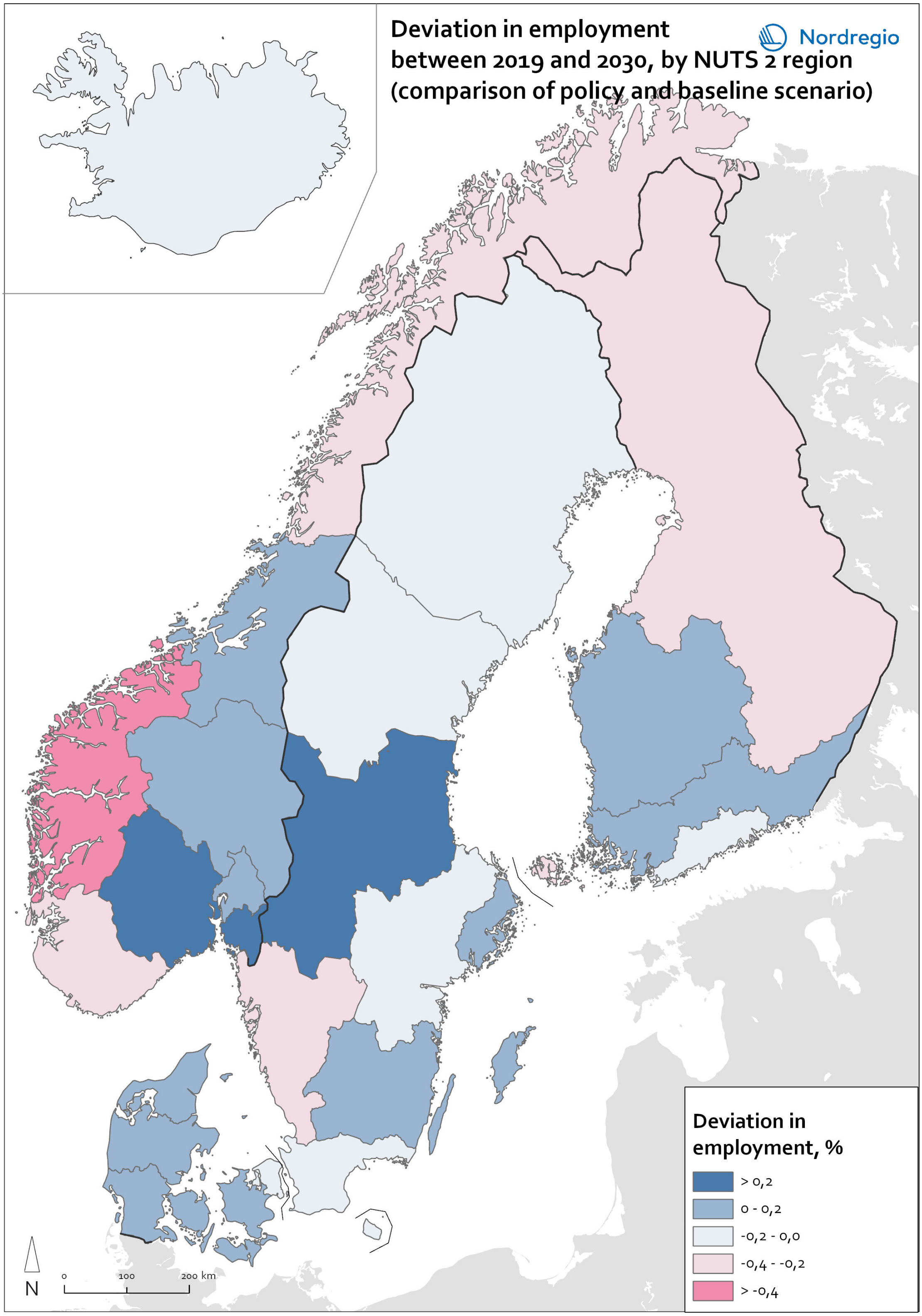
The industry mix and industry growth effects generated by greenhouse policies are positive for Norra Mellansverige. With regard to the industry mix, this region benefits from having above-average shares of its employment in *Forestry and logging* (industry 3) and *Petroleum and coal* products (industry 15). The Nordic greenhouse policies generate large increases in employment in both of these industries (74.94 per cent and 118.24 per cent, Sweden column in Table 11). *Wood* *products* and *Paper products* (industries 13 and 14) have negative employment outcomes for Sweden in Table 11 (-6.11 per cent and -4.69 per cent). These negatives mainly reflect contraction of exports caused by cost increases resulting from the *Forestry and logging* industry. However, the *Wood products* and *Paper products* industries in Norra Mellansverige have low reliance on exports. They therefore suffer less from export contraction than these industries in Sweden as a whole, giving Norra Mellansverige a positive industry growth effect.

For Sør-Østlandet, both the industry mix and industry growth effects are positive. Sør-Østlandet benefits from having almost no *Oil* (industry 6) in its employment mix. Oil is a significant employer in Norway and, as can be seen from Table 11, employment in the industry at the national level falls sharply (-20.77 per cent). Sør-Østlandet also benefits from overrepresentation in its employment mix of *Electrical equipment* (industry 24). The region's positive industry growth effect is explained mainly by relatively strong consumption demand for local products associated with its positive industry mix effect.

For Vestlandet, the story is similar to Sør-Østlandet but with the opposite sign. Oil is overrepresented in Vestlandet, giving the region a negative industry mix effect, which is reinforced by a negative industry growth effect associated with damped demand for local products.

Table 16. Total growth in employment (%) between 2019 and 2030 by NUTS2 region

	Denmark	Hovedstaden	Sjælland	Syddanmark	Midtjylland	Nordjylland			
base	-1.48	-0.80	-1.56	-1.91	-1.87	-2.01			
policy	-1.48	-0.97	-1.42	-1.84	-1.80	-1.90			
deviation	**0**	**-0.17**	**0.14**	**0.07**	**0.07**	**0.11**			
	Finland	**Länsi-Suomi**	**Helsinki-Uusimaa**	**Etelä-Suomi**	**Pohjois- ja Itä-Suomi**	**Åland**			
base	-1.98	-2.26	-1.46	-2.08	-2.27	-3.36			
policy	-1.98	-2.06	-1.54	-1.95	-2.51	-3.56			
deviation	**0**	**0.20**	**-0.08**	**0.13**	**-0.25**	**-0.20**			
	Iceland								
base	2.20								
policy	2.20								
deviation	**0**								
	Norway	**Oslo og Akershus**	**Hedmark og Oppland**	**Sør-Østlandet**	**Agder og Rogaland**	**Vestlandet**	**Trøndelag**	**Nord-Norge**	
base	5.45	6.03	5.07	5.24	4.37	6.06	5.23	5.33	
policy	5.45	6.23	5.28	5.62	4.14	5.53	5.29	5.10	
deviation	**0**	**0.19**	**0.18**	**0.36**	**-0.22**	**-0.49**	**0.05**	**-0.22**	
	Sweden	**Stockholm**	**Östra Mellansverige**	**Småland med öarna**	**Sydsverige**	**Västsverige**	**Norra Mellansverige**	**Mellersta Norrland**	**Övre Norrland**
base	2.72	2.80	2.50	1.96	2.32	4.02	2.17	1.63	1.80
policy	2.72	3.00	2.46	2.14	2.28	3.64	2.55	1.53	1.66



The baseline forecasts in Table 16 show variation in employment growth across regions in each Nordic country. For example, in Nordjylland baseline employment falls by 2.01 per cent between 2019 and 2030 whereas in Hovedstaden it falls by 0.80 per cent.

One question that we can answer from the information in Table 16 is whether greenhouse policies may help to even out regional differences in growth rates for employment or whether, on the contrary, there is a risk that climate policies may exacerbate the differences. Our simulations suggest mixed results with regard to the cohesion effects of climate policies. The example of Agder og Rogaland suggests exacerbation: This NUTS-2 region has the lowest baseline growth rate of all the Nordic NUTS2 regions in Norway (4.37 per cent) and a negative greenhouse-induced deviation (-0.22 per cent). However, exacerbation is not generally the case. Counting up the positives and negatives in Table 16 we find that over the 25 Nordic NUTS2 regions, there are only ten cases of exacerbation. Those are the cases in which the regional deviation in baseline employment growth from national employment has the same sign as the greenhouse-induced deviation. There are 15 cases of evening out. Those are the cases in which the regional deviation in baseline employment growth from national employment has the opposite sign to that of the greenhouse-induced deviation. Further research would be necessary to shed light on this matter.

5.5. Cost-of-living effects for various types of households

Table 17 and Figures 8 to 10 show cost-of-living effects in 2030 of Nordic greenhouse policies for households classified by location of residence (urban/intermediate/rural) and income decile. The effect for a particular household type is the percentage deviation in the cost of the household's consumption bundle relative to the percentage deviation in the cost of the consumption bundle for the average household in the nation. In working out the average, we gave equal weight to each household type in the nation. The details of the theory and data underlying Table 17 are set out in Appendix 6. Results are given for only three of the Nordic countries because we found no suitable data for identifying expenditure by household type for Norway and Iceland.

The main price movement in our simulations is for motor fuels. For households in Denmark and Finland, the Nordic greenhouse policies that we simulate increase the price of motor fuels by about 11 per cent, while for Sweden the price increase is about 38 per cent.[16] As can be seen from Table 18, rural households generally devote a higher share of their total expenditure to motor fuels than intermediate households, and intermediate households generally devote a higher share than urban households. In Table 17 and Figures 8 to 10, we therefore see that rural households suffer cost-of-living increases from greenhouse policies that are greater than those of intermediate households, which in turn suffer cost-of-living increases that are greater than those of urban households.

16. These price increases are a little higher than those shown in column (9) of Table 3. These are the final price increases, taking account of increases in the prices of inputs such as crops and forestry products, whereas those in Table 3 are first-round effects.

Looking along the rows of Table 17, or moving from low deciles to high deciles in Figures 8 to 10, we see no clear patterns. In most of the nine graphs in Figures 8 to 10, there is little or nothing to suggest either an upward trend or a downward trend as we move from low deciles to high deciles. It appears that with regard to costs of living, the simulated greenhouse policies do not discriminate between income categories.

Table 17. Effects in 2030 of Nordic greenhouse policies on costs of living for households classified by location and income
Percentage deviations relative to national Consumer Price Index – CPI (D01 is the lowest decile, D10 is the highest decile)

Percentage deviations, 2030	D01	D02	D03	D04	D05	D06	D07	D08	D09	D10
Denmark										
Urban	-0.22	-0.24	-0.17	-0.08	-0.09	-0.15	-0.07	-0.08	-0.17	-0.21
Inter-mediate	-0.15	-0.14	-0.10	0.02	0.00	0.08	0.00	0.06	0.03	0.07
Rural	0.07	0.03	0.21	0.07	0.15	0.28	0.26	0.11	0.18	0.21
Finland										
Urban	-0.18	-0.19	-0.11	-0.16	-0.10	-0.10	-0.16	-0.14	-0.11	-0.17
Inter-mediate	-0.05	-0.03	-0.04	0.06	0.02	0.16	0.02	0.09	-0.04	-0.05
Rural	0.01	0.12	0.11	0.14	0.15	0.15	0.18	0.18	0.17	0.05
Sweden										
Urban	-0.72	-0.88	-0.72	-0.43	-0.53	-0.09	-0.02	-0.44	-0.17	-0.50
Inter-mediate	-0.88	-0.42	-0.17	0.04	0.59	0.18	0.29	0.20	0.39	-0.28
Rural	-0.08	0.34	0.34	0.32	0.60	0.73	0.62	1.09	0.48	0.12

Table 18. Baseline percentages in 2030 of household expenditures devoted to motor fuels

Households classified by location and income decile (D01 is the lowest decile, D10 is the highest decile)

Percentage deviations, 2030	D01	D02	D03	D04	D05	D06	D07	D08	D09	D10
Denmark										
Urban	0.55	0.77	1.35	2.33	2.12	1.77	2.47	2.59	1.74	1.62
Inter-mediate	1.56	1.55	1.89	3.15	2.92	3.54	2.93	3.36	3.17	3.65
Rural	3.11	2.83	4.42	3.21	4.01	5.11	4.75	3.70	4.15	4.46
Finland										
Urban	1.28	1.33	1.90	2.06	2.23	2.39	2.07	2.43	2.54	2.11
Inter-mediate	2.85	3.01	2.92	3.78	3.62	4.58	3.74	4.27	3.45	3.25
Rural	3.19	4.07	3.94	4.50	4.60	4.69	4.95	5.12	4.84	4.16
Sweden										
Urban	2.21	1.77	2.42	3.22	2.91	4.08	4.39	3.20	3.90	2.96
Inter-mediate	1.71	3.17	3.94	4.61	6.28	5.00	5.37	5.04	5.74	3.74
Rural	4.17	5.47	5.32	5.37	6.26	6.79	6.46	7.85	6.04	4.98

The lack of a clear pattern in the movement of the cost-of-living results as we move between deciles is explained by the lack of a clear pattern in Table 18 in the movement of the motor fuel expenditure shares as we move between deciles.

Overall, our cost-of-living results reveal disadvantage to rural households relative to urban households, but neither progressive nor regressive effects. However, the most important feature of the results is that they are very small. That was to be expected. For Denmark and Finland, they reflect a 11 per cent increase in an item accounting for between 0.55 and 5.12 per cent of household budgets. For Sweden, the cost-of-living effects are more significant: a 38 per cent increase in an item accounting for between 1.71 and 7.85 per cent of household budgets. Nevertheless, even for Sweden the results indicate that our simulated greenhouse policies are unlikely to cause major relative cost-of-living disadvantage to any broadly identified group of households.

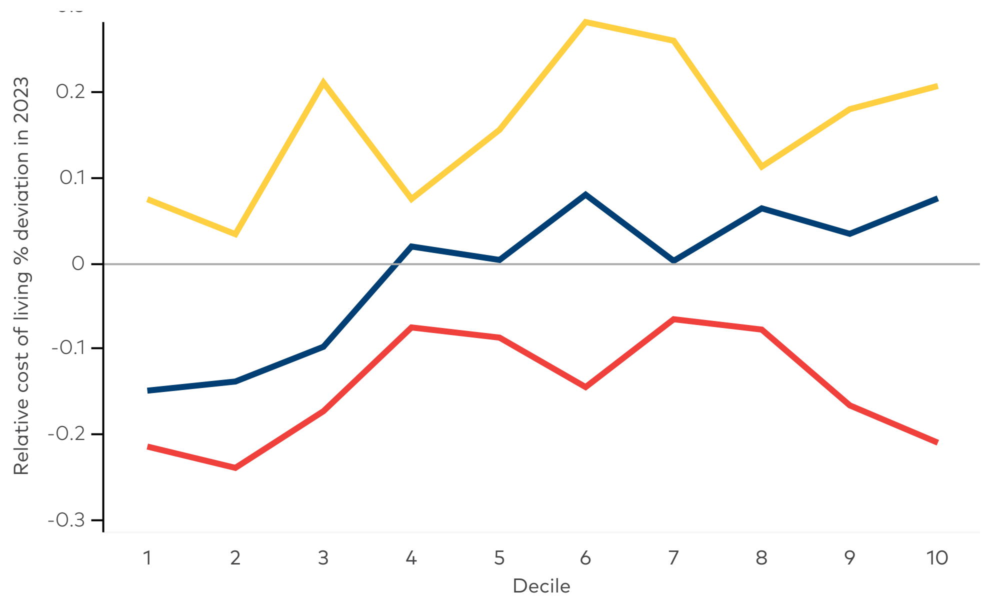


Figure 8. Cost-of-living effects (%) from Table 17: DENMARK

- Rural
- Intermediate
- Urban

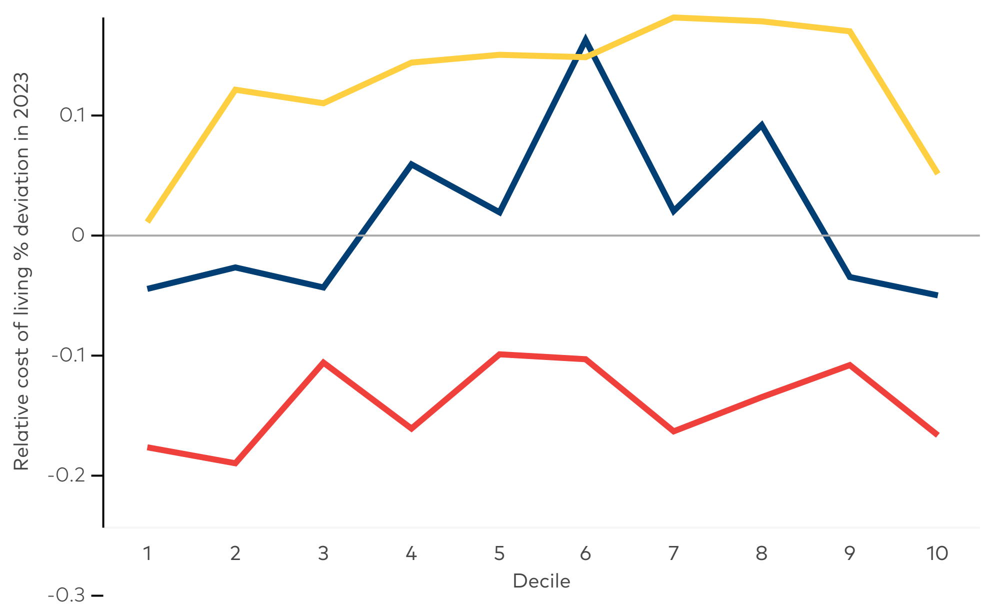


Figure 9. Cost-of-living effects (%) from Table 17: FINLAND

- Rural
- Intermediate
- Urban

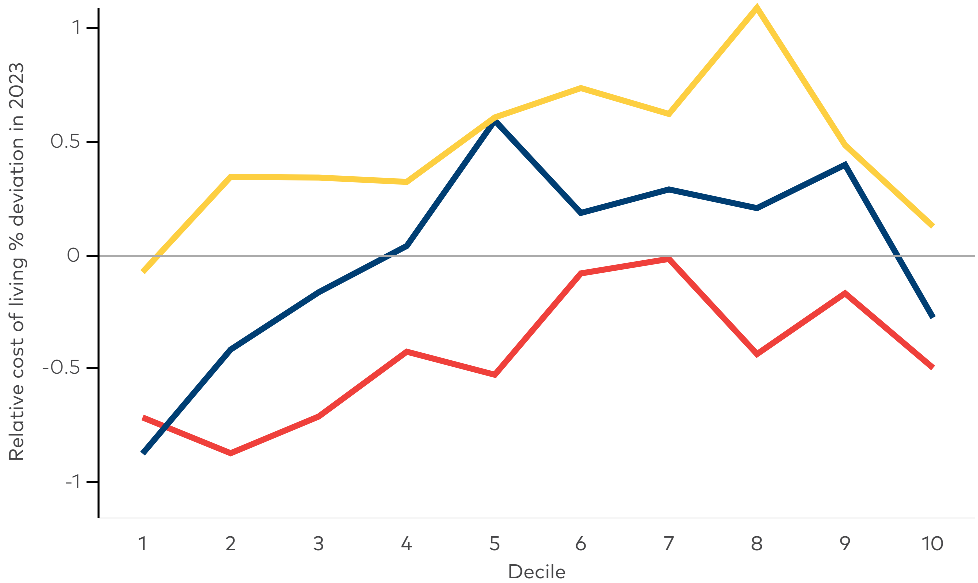


Figure 10. Cost-of-living effects (%) from Table 18: SWEDEN

- Rural
- Intermediate
- Urban

Photo: Karsten Wurth, unsplash.com

6. Conclusions

The Nordic countries have been leading global efforts towards a post-carbon society since the discussions that led to adoption of the first international agreements to reduce the emission of gases contributing to global warming. Efforts to reduce greenhouse gases in the Nordic countries can been traced back to the 1990s. Nonetheless, emission cuts have so far been concentrated on large combustion plants in manufacturing and energy industries. Emissions in agriculture, transport, and industrial processing – including, e.g. aluminium smelting, steel, and cement production – have proven much more difficult to abate. That is due to a range of technical, legal, and financial obstacles of varying nature, including vested economic interests.

A critical obstacle for the deployment of carbon abatement policies is the lack of international consensus establishing shared goals and industrial standards, particularly in sectors with long production chains and complex ancillary infrastructures, like the transport sector. The new EU Climate Policy Framework under the EU Green Deal has created the momentum for more ambitious climate goals at the European level. The establishment of the new EU Climate Policy Framework does not only build on the ambition of its climate goals, but also on the sectors that are now targeted. While the ETS proved to be an efficient tool to initiate the decarbonisation of the energy and manufacturing industries, the new ESR, LULUCF, aviation, and maritime regulations under the 'Fit for 55' package focus on sectors that have made limited progress so far, including all forms of transport.

This new generation of EU policies may reinforce the traditional Nordic leadership in green policy-making, which is now entering a new stage. With 'Our Vision 2030', the Nordic Region has ambitions 'to become the most sustainable and integrated region in the world' and actively advocates carbon neutrality. In line with this shared strategy, each of the Nordic countries has adopted climate goals that, in most cases, go beyond the EU ambition to become carbon-neutral by 2050.

If successfully implemented, the new generation of climate policies in the Nordic countries will contribute to inducing a system change with far-reaching economic and social implications. As technologies evolve and new competitiveness landscapes emerge, some industries and subnational regions will gain momentum and others will lose pace. Such processes will impact workers and households differently, depending on the sector of employment, the region where they live, their income levels, and expenditure distribution. It is therefore important to understand how climate policies affect specific industries, social groups, and territories by looking into their financial, distributive, and territorial impacts.

In this study, we have qualified and quantified the effects on the Nordic economies in 2030 of achieving goals for the bio-content of motor fuels and the electrification of car fleets. We have also included the effects of completing the phase-out of coal as a fuel for electricity. As shown in Table 7, these policies alone will not be sufficient to achieve the Nordic greenhouse targets for 2030, except in Sweden. Nevertheless, our results support an optimistic conclusion for two reasons.

First, the policies we have looked at will cause significant reductions in greenhouse emissions at moderate macroeconomic cost. That is indicated in the first three rows of Table 19. The percentage emission reductions are between six times and 30 times greater than the percentage GDP losses. Norway and Iceland have the worst ratios. Greenhouse policies have a relatively large negative effect on Norway's GDP (see Table 8) and a relatively small effect on its gross emissions (Table 5). The GDP effect for Norway is exacerbated by reduction in the use of oil resources (Table 9). The muted emissions effect is explained by the relative lack of opportunity to reduce emissions from combustion of coal (no coal-electricity industry) and the relatively small-targeted increase in the biofuel share of motor fuels (Table 3). In Iceland's case, the policies have little effect on greenhouse emissions while causing a GDP-reducing substitution of lightly-taxed electricity for more heavily-taxed motor fuels.

Table 19. Policy-induced percentage deviations in 2030 for selected variables

		Denmark	Finland	Iceland	Norway	Sweden
Table 6	Total (gross) emissions	-6.72	-27.36	-1.12	-7.23	-39.12
Table 8	Real GDP	-0.73	-1.16	-0.18	-1.22	-1.31
	Ratio: % emission reduction to % GDP loss	*9*	*24*	*6*	*6*	*30*
	Worst results for:					
Table 12*	Employment by **occupation**	-1.13	-1.93	-1.31	-0.69	-2.59
Table 13	Employment by **wage band**	-0.28	-0.48	-0.10	-0.24	-0.36
Table 14	Employment by **age group**	-0.10	-0.05	-0.09	-0.01	-0.11
Table 15	Employment by **educational requirement**	-0.25	-0.22	-0.14	-0.25	-0.71
Table 16	Employment by **NUTS2 region**	-0.17	-0.25	0.00	-0.49	-0.37
Table 17	Cost-of-living increase:	0.28	0.18			1.09

* These are the worst employment results over all 39 occupations in our model, not just the selected occupations shown in Table 12.

The second reason for an optimistic interpretation of the results is illustrated by the lower panel of Table 19. It implies that significant reductions in emissions can be achieved with very little structural disruption.

In Denmark, the percentage deviation in employment in 2030, in the worst-affected occupation out of the 39 in our model is -1.13 per cent. That is the result for *Personal care* workers in the bottom panel of Table 12. An adjustment of that size would not necessitate employed workers losing their jobs. It does not mean that 1.13 per cent of Denmark's personal care workers will be put out of work in 2030. From the top two panels of Table 12, we can see that it means employment of *Personal care* workers will grow between 2019 and 2030 by 3.8 per cent according to the policy-based scenario as opposed to 4.9 per cent according to the baseline scenario.

In Norway, the worst affected occupation is *Health professional*, with negative deviations of 0.69 per cent. This occupation has strong baseline growth in Norway. Adoption of greenhouse policies means that their employment growth will be slightly lower than it otherwise would have been.

In Finland and Sweden, the worst-affected occupation is *Handicraft and Printing*, with negative deviations of 1.93 and 2.59 per cent, respectively. In both countries, employment in this occupation falls according to the baseline (top panel of Table 12). Greenhouse policies could therefore exacerbate a potential adjustment problem, particularly in Finland. However, even with the negative greenhouse contribution, it seems likely that the decline in employment opportunities for *Printing* workers over 11 years would be managed by natural attrition.

For Iceland, the narrative is similar to that in Finland and Sweden. The occupation worst affected by greenhouse policies is *Agriculture, forestry and fishing*, with a deviation of -1.31 per cent. This occupation has declining employment under the baseline scenario. Again, it seems likely that even with the negative greenhouse contribution the decline in employment opportunities for Iceland's *Agriculture, forestry, and fishing* labourers would be managed by natural attrition.

Our estimates show that some of the contractions observed in specific sectors seem to affect industrial output (Table 10) more intensively than employment (Table 11). That is illustrated by the results for fuel-based electricity production (industry 31) in Finland and Sweden. These results suggest that, in many energy-intensive sectors, substantial reductions in greenhouse gas emissions can be achieved with minimal impacts on output and an overall increase in employment.

In any case, when analysing these results, it should be considered that the sectoral contractions observed in some industries have been calculated without taking processes of innovation and technological change into consideration. For instance, the modest contraction of the wood products industry expected in Finland, Sweden, and Norway is driven by the diversion of feedstock into motor fuels, which might undermine the competitiveness of these industries. However, this outcome is far from being inevitable if product innovation and diversification strategies are adopted in the affected sectors. In the wood industry this can be achieved, for example, by cascading the use of biomass (European Commission 2018a, b). Looking at the other dimensions of employment (wage band, age, education, and region), we can see in Table 19 that the policy-induced deviations for the worst-affected groups are negligible, amounting to less than one per cent in absolute terms.

Large policy-induced negative employment deviations can be found among our industry results (Table 11). However, in terms of adjustment, we consider the occupational and subnational regional results to be of prime relevance. It is reassuring that the greenhouse policies do not generate any large negative employment deviations in these two respects. It means these policies are unlikely to cause skill-based or regional mismatches in Nordic labour markets.

The final row of results in Table 19 shows the policy-induced cost-of-living increases relative to the national average for the worst affected group of households in Denmark, Finland, and Sweden. In all cases, the worst affected households are rural households in upper income deciles. These households devote relatively high shares of their consumer spending to motor fuels. Nevertheless, even for these households, the relative cost-of-living effect of greenhouse policies is small.

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About this publication

What impact do climate change policies have on Nordic economies, industries, and households?

This report is the first out of four reports of the project "Ensuring inclusive economic growth in the transition to a green economy (EnIGG)". The EnIGG project is a cross-sectoral project initiated and financed by the Nordic Council of Ministers and coordinated by Nordregio. It aims to increase knowledge on how to strengthen the Nordic economies in a challenging context and accelerate the green transition towards a climate-neutral economy while ensuring that these processes are inclusive.

The research for this report was conducted by researchers from Victoria University (Australia), Merit Economics (Finland) and Nordregio, with contributions from the Centre for Regional & Tourism Research (Denmark) and Reykjavik University (Iceland). The report analyses the impact of selected climate policy measures on Nordic economies, industries, and households.

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