INDUSTRY, EMPLOYMENT, DISTRIBUTIONAL AND MACRO-ECONOMIC EFFECTS IN THE NORDIC COUNTRIES OF THEIR GREENHOUSE POLICIES

by

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Summary

(1) This report contains a quantitative analysis of the possible effects on the Nordic economies of a selection of greenhouse policies for 2019 to 2030. The policies we consider are:
   (a) achievement of targets for increased shares of biofuels in motor fuels (see Table 3.1);
   (b) achievement of targets for increased shares of electric vehicles in passenger-car fleets (see Table 3.3); and
   (c) phasing-out of remaining coal-fired electricity.

(2) The analytical tool that we use in the analysis is Nordic-TERM. This is a multi-regional computable general equilibrium (CGE) model. It 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 households classified by income decile and urban/intermediate/rural. With this level of detail, Nordic-TERM is an ideal tool for looking at distributional and structural effects of policies.

(3) 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 assume 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 adds shocks to the baseline to represent (a) to (c) in point (1).

(4) The shocks in the policy run take account of:
   - increases in the cost of motor fuels to industries (mainly the Road transport industry) associated with the achievement of bio-fuel targets in diesel;
   - increases in the cost of motor fuels to households associated with the achievement of bio-fuel targets;
   - changes in the composition of inputs in the production of Motor fuels (substitution of bio materials for oil);
   - increases in the use of electricity by households associated with the achievement of targets for the electric-vehicle share of the passenger car fleet;
   - reductions in the use of motor fuels by households associated with the reduction in share of passenger cars accounted for by internal combustion vehicles;
   - increased expenditure by households on charging station for electric vehicles; and
   - loss of physical capital through scrapping of remaining coal-fired electricity generation and its replacement by other forms of generation.

(5) The simulation results indicate that meeting targets for biofuels and electrification of car fleets together with phasing-out of remaining coal-fired electricity generation will be sufficient to meet the 2030 emission reduction target for Sweden but not for the other Nordic countries (Table 4.13).

(6) Implementing 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 in 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, see Table 4.1.

(7) The employment deviations in 2030 for the 25 NUTS2 Nordic regions caused by the greenhouse policies are all less than 1 per cent in absolute terms (Table 4.9). The largest positive deviation is for SE31 (Norra Mellansverige), 0.37 per cent, and the largest negative deviation is for FI20 (Åland), -0.94 per cent. With regard to greenhouse policies, SE31 has a favourable mix of industries (notably a dependence on forestry activity) compared with other SE regions. FI20 has an unfavourable mix of industries (notably the remnants of coal-fired electricity) compared with other FI regions.

(8) In all the Nordic countries, greenhouse policies have negative employment effects on consumption-oriented occupations such as Health professional and Personal care worker (see Table 4.5). The effects for employment in Scientific & 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 per cent (Printing in Sweden).

(9) As could be anticipated, greenhouse policies increase living costs for rural households relative to urban and intermediate households. There is no systematic pattern across deciles: high-income families are just as likely to suffer relative cost-of-living increases as low-income families. However, the relative effects for all family types are small (Table 4.10).

(10) The results in this report support an optimistic conclusion. They imply that significant reductions in greenhouse emissions can be obtained at moderate macroeconomic cost with almost no structural disruption (Table 5.1). From an adjustment point of view, we think that the occupational and sub-national regional results are of prime relevance. That the greenhouse policies do not generate any large negative employment deviations in these two dimensions is reassuring. It means these policies are unlikely to cause skill or locational mis-matches in Nordic labour markets.

1. INTRODUCTION

1.1. Objectives and background

This project aims to analyze some of the key policies that are relevant to achieving the climate targets of the Nordic countries.

Although not all of the Nordic countries are members of the European Union, all of them have committed to EU climate policies.

European climate policies in all EU countries plus some other European countries, including the Nordic countries, are implemented in two parts. These parts divide the policies into those for the emissions trading sector and those for the effort sharing regulation sector. Whereas the emissions trading sector adopts a common European target, the effort sharing sector relies on domestic targets.

The EU target for the emissions trading sector (ETS) is a 43% reduction in greenhouse gas emissions by 2030 from their 2005 level. The ETS sector comprises:

- electricity and heat generation,
- energy-intensive industry sectors including oil refineries, steel works, and production of iron, aluminium, metals, cement, lime, glass, ceramics, pulp, paper, cardboard, acids and bulk organic chemicals,
- commercial aviation within the European Economic Area.

Targets vary across countries for the effort sharing regulation (ESR) sector. Current ESR targets for 2030 in the Nordic countries expressed as percentage reductions from 2005 levels are as follows:

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

The ESR sector comprises: transport (less aviation), construction, heating, housing and agriculture.

The split between the ETS and ESR sectors affects the cost effectiveness of climate policies. It has been widely recognized that the marginal costs of emission reductions are unlikely to be equalized between the two sectors because the ETS/ESR split is arbitrary. Within the ETS sector, equalization of the marginal cost of emission reductions is facilitated. This is because businesses within this sector have to either acquire emission permits or to reduce emissions to the point where the marginal cost of abatement matches the permit price. The ESR sector, on the other hand, is subject to a variety of activity-specific domestic regulations. There can be no expectation that these regulations will deliver equalization 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.

This study is intended primarily to inform policy formulation in the Nordic countries. Consequently, we focus on the Nordic ESR sectors where domestic policies have an impact. Focusing on ESR policies may pinpoint possible improvements from the point of view of marginal cost equalization. Finally, many of the measures in the ESR sector directly affect households, generating much of the Nordic policy debate on the effects of climate policies.

We hope to contribute clarifying analysis to this debate by estimating the effects in the Nordic countries of ESR policies on living costs of households in different socio-economic groups and on employment opportunities in different occupations and sub-national regions.

Within the ESR sector, the main policy initiatives in the Nordic countries for the next decade, and the ones chosen for our study, are de-carbonizing the transport sector. These polices centre on electrification of car fleets and increasing use of bio-fuels in the remaining internal-combustion-engine vehicles. We also include in our study the effects further de-carbonizing of the power sector through the phasing-out of remaining coal generation.

1.2. Analytical method: the Nordic-TERM model

Our main analytical tool for this project is Nordic-TERM: Nordic because the model focuses on the Nordic countries and TERM because the model is in the tradition of **T**he **E**normous **R**egional **M**odels initially developed by Mark Horridge and colleagues at the Centre of Policy Studies. Information on TERM models in general and the technical details of Nordic-TERM in particular are given by Glyn Wittwer in research memorandum (RM4, available at ###Carlos to post on line somewhere #). Here we provide a brief overview.

Nordic-TERM, as with all TERM models, is a multi-regional computable general equilibrium (CGE) model. Created for this project, Nordic-TERM identifies the five Nordic countries, Denmark (DK), Finland (FI), Sweden (SE), Norway (NO) and Iceland (IS), and the Rest of Europe (RoE). Each Nordic country is split into its NUTS2 regions: 5 regions in DK; 5 in FI; 8 in SE; 7 in NO; and 1 in IS. With 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 have chosen the CGE approach for this study for four reasons.

First, CGE models are a practical framework for representing micro-economic policies. This is because CGE models incorporate descriptions of inputs to industries and sales to users. As explained in section 3, for this project we need to shock our model with changes in the composition of inputs to the creation of motor fuels and changes in the composition of expenditures by households including a switch away from motor fuels to increased use of electricity (associated with the adoption of electric vehicles). The quantitative details of the shocks (how much less motor fuels, how much extra electricity, etc) are always subject to debate. With 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 size of the shocks within plausible ranges.

Second, CGE models specify explicit price-sensitive behaviour for multiple agents. With a CGE model we can trace out how the demands for different products by households, firms, exporters and importers are affected by changes in prices. This is important for the present study which involves policy-induced changes in commodity prices, particularly energy products.

Third, CGE models incorporate the links between different economic agents. The most obvious are input-output links in which one agent (e.g. the motor vehicle industry) is a customer for the product of another agent (e.g. the fabricated metals industry). But 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 these directly affected activities.

Fourth, a CGE model allows 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 by down-stream add-on programs. For this project, we have created add-on facilities which take core Nordic-TERM results and compute implications for: greenhouse gas emissions; employment by occupation and wage-band; and living costs for households classified by income decile and location (urban, medium and rural).

1.3. Roadmap for the report

We conduct two types of simulation with Nordic-TERM. The first is a *baseline* run showing the evolution of the Nordic economies from 2019 to 2030 in the absence of greenhouse policies beyond those already implemented by 2019. This not only excludes policies that are yet to be agreed, but also policies that are agreed but yet to be implemented. The second is a *policy* run showing the evolution of the Nordic economies with de-carbonization policies for the transport sector and with phase out of coal in the power sector. Comparison of the policy and baseline results shows the effects of anticipated policies by the Nordic countries.

Section 2 describes the baseline run. Section 3 describes the representation of greenhouse policies in Nordic-TERM. In section 4, we describe the policy run and set out the effects of the greenhouse policies as deviations from the baseline. Section 5 is a summary of conclusions.

Technical details on the formulation of the policy shocks and the calculation of welfare effects are given in appendices to section 3 and 4. The report is supported by 4 research memoranda. Research memorandum 1 (RM1) sets out the data used to determine greenhouse gas emissions per unit of activity in each industry. RM2 contains the add-on equations and data for determining employment by industry, occupation, wage-band and NUTS2 region. RM3 gives the equations and data used for calculating cost-of-living results for different types of household. As already mentioned, RM4 documents the Nordic-TERM model.

2. BASELINE SIMULATION: 2019 TO 2030

This section describes the baseline simulation for 2019 to 2030, focusing on macro variables, output projections for industries by nation, employment projections for industries and sub-national regions, and emissions projections by nation. The baseline also contains projections for employment by occupation, wage band, education requirement and age. We introduce these detailed labour market dimensions in the discussion of the policy results in section 4.

CGE models can be run with different choices for the length of a period. One possibility is year-on-year simulations where the length of each period is one year. However for this project, we are concerned with long-run effects. Consequently, we are able to simplify the simulations by having just one period of 11 years: 2019 to 2030. Each computation starts with a database for 2019. Then we apply shocks for the exogenous variables that represent their movement from 2019 to 2030. The model generates results for endogenous variables that show their implied movements from 2019 to 2030. Another way to put this is that the model starts from a picture of 2019 and generates a picture of 2030.

2.1. Baseline GDP and employment forecasts for 2019-30

Table 2.1 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 a baseline simulation.

In the baseline simulation, GDP and employment growth were set exogenously for each of the Nordic countries and Rest of Europe (RoE). In determining these variables, we started with historical GDP data from the OECD available at https://data.oecd.org/gdp/real-gdp-forecast.htm#indicator-chart . From these data, we derived GDP growth for the decades 2001-11 and 2011-21. Next, we accessed the World Bank historical data and projections for growth in population aged between 15 and 64 (working age). These are available at https://databank.worldbank.org/source/population-estimates-and-projections/preview/on# . Combining the historical data for GDP and working-age population, we derived growth in productivity for the decades 2001-11 and 2011-21 where productivity is defined as GDP divided by working-age population. 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 working-age population. With employment growth projected in this way and our productivity assumption in place, we derived GDP growth. Our calculations are shown in Table 2.2.

In using the GDP and working-age population forecasts from Table 2.2 in our baseline simulation from 2019 to 2030, we assume that the annual growth rates implied by Table 2.2 for the 10-year period 2021 to 2031 apply to the 11-year period 2019 to 2030. For example, in row (9) of Table 2.2, the growth in GDP over 10 years for DK is given as 10.1 per cent. In Table 2.1, this is translated in row 6 to 11.2 per cent [= $100*(1.101^{11/10} – 1)$].

2.2. Other baseline assumptions for 2019-2030

(1) At the sub-national regional level, real household consumption and real government consumption move by the same percentage. RoE and Iceland are single regions. Consequently, our assumption of equal growth in private and public consumption is reflected exactly at the national level for RoE and Iceland (see Table 2.1). For the other four Nordic countries, Table 2.1 can show small differences in C and G at the national level.

(2) Household consumption in nominal terms in each subnational region grows at the same rate as the region's nominal GDP.

(3) Rates of return on investment in all industries and all regions in 2030 are the same as in 2019.

(4) The investment to capital ratio in 2030 in all industries and all regions *in* 2030 is the same as in 2019.

Table 2.1. Baseline national forecasts: 2019-2030 (percent growth for 11 years)

(Sim C22)

		DK	FI	SE	NO	IS	RoE
1	Real h'hold cons (C)	13.6	16.0	24.6	14.4	19.1	5.9
2	Real investment (I)	8.3	8.8	15.1	10.3	12.9	2.1
3	Real gov cons (G)	13.6	16.0	24.2	14.3	19.1	5.9
4	Export volumes (X)	11.8	13.8	19.0	11.2	14.7	13.0
5	Import volumes (M)	10.8	13.1	21.4	15.2	15.1	14.8
6	Real GDP	11.2	13.5	21.5	12.7	16.4	3.8
7	Aggregate employment	-1.5	-2.0	2.7	5.5	2.2	-6.5
8	Ave real wage	20.1	25.0	29.5	12.9	24.2	18.8
9	Aggregate cap stock	8.2	8.8	15.0	10.3	12.9	2.1
10	GDP price index	6.3	6.4	6.2	5.3	7.2	7.2
11	CPI	4.1	4.1	3.7	3.9	4.8	5.1
12	Export price index	3.3	3.4	3.4	1.4	3.5	4.1
13	Import price index	3.2	2.6	1.4	1.5	3.7	0.9
14	Population	3.5	0.1	5.0	8.9	5.2	-0.8

Table 2.2. Derivation of GDP and employment forecasts for 2021-31(%)

		DK	FI	SE	NO	IS	RoE
(1)	GDP: 2001-11	8.5	19.1	26.2	15.7	26.5	11.6
(2)	GDP: 2011-21	19.3	7.5	20.6	17.2	29.5	9.1
(3)	Working-age pop: 2001-11	1.8	2.1	6.8	12.0	14.6	2.1
(4)	Working-age pop: 2011-21	2.3	-4.0	5.0	7.3	12.9	-1.4
(5)	Working-age pop: 2021-31	-1.3	-1.8	2.5	4.9	2.0	-5.9
(6)	Productivity growth:2001-11	6.6	16.6	18.1	3.3	10.4	9.3
(7)	Productivity growth:2011-21	16.6	12.0	15.0	9.2	14.7	10.6
(8)	Productivity growth:2021-31	11.6	14.3	16.5	6.3	12.6	10.0
(9)	GDP:2021-31	10.1	12.2	19.4	11.5	14.8	3.5
(10)	Total population: 2021-31	3.2	0.1	4.5	8.0	4.8	-0.7

Notes. For RoE we used data for the Euro area even though this includes some of the Nordic countries. Rows (1) and (2) are OECD data. Rows (3) and (4) are World Bank data and row (5) is a World Bank projection. Row (6) is derived from rows (1) and (3), and row (7) is derived from rows (2) and (4). Row (8) is the average of rows (6) and (7). Row (9) is derived from rows (5) and (8). For 2021-31 we assume that employment growth is the same as growth in working-age population. Row (10) shows World Bank total populations projections and is included in this table for convenience. These projections have no role in the derivation of the GDP and employment forecasts, but they do play a minor role in the baseline simulations.

(5) Total population in each nation moves in accordance with World Bank projections given in row (10) of Table 2.2 translated from 10 years to 11 years. We assume the same movement in the population-to-employment ratio for all regions in a nation.

(6) Prices of imports of goods and services to the Nordic plus RoE area (that is prices of imports from China, U.S. etc) move in the same way as the average prices of goods and services produced in Nordic plus RoE nations.

(7) Total factor productivity movements for 2019-2030 are determined in the baseline simulation by our assumptions for GDP, employment and rates of return on capital (which ties down the growth of capital stock). Around the national total-factor-productivity movements, we introduce broad sectoral detail. We assume that

productivity growth in agriculture is high relative to manufacturing, which is high relative to utilities and mining, which is high relative to services.

(8) The world demand curves for European products move out at the rate of 3.5 per cent a year, reflecting world economic growth.

2.3. Main features of the macro forecasts

While the forecasts for GDP, employment, household consumption and public consumption are set exogenously or follow in a simple way from the assumptions listed in section 2.2, the forecasts for the other variables in Table 2.1 are determined endogenously in the Nordic-TERM model.

Under our assumption of fixed rates of return on capital and strong productivity growth consistent with that of the last 20 years (row 8 in Table 2.2), Nordic-TERM implies rapid growth in real wage rates (row 8, Table 2.1). With real wages growing and rates of return fixed, capital/labour ratios in all countries increase (compare rows 7 and 9, Table 2.1). This contributes to both wage and productivity growth.

Real household and government consumption (rows 1 & 3, Table 2.1) grow a little quicker than real GDP. However, despite the increase in capital/labour ratios, the percentage increase in investment in all countries is less than the percentage increase in GDP (compare rows 2 & 6). With consumption growing a little quicker than GDP and investment growing slower, growth in imports approximately matches growth in exports in all countries (rows 4 & 5).

2.4. Baseline forecasts for industry outputs

Table 2.3 presents baseline forecasts for percentage growth in output by industry and nation. Table 2.3a presents the same information but as deviations from aggregate national output, measured by growth in GDP. For example in Table 2.3, growth in the output of Crops in DK is -4.3 per cent. In Table 2.3a we deduct GDP growth for DK (11.2 per cent, Table 2.1) so that the DK Crop entry becomes -15.5 (= -4.3 – 11.2).

Referring to Table 2.3a, we see for all countries that Services of dwellings (industry 53), Health and social services (52), Public administration and defence (50), Accommodation and food (39) and Fishing & aqua (4) have above average output growth. Products 53, 52, 50 and 39 are non-traded and consumption-oriented (either private or public), and have high expenditure elasticities. Their elevated output growth reflects our macro forecast that growth in C & G will exceed growth in GDP, see Table 2.1. In our baseline, the consumer price of Fishing & aqua (product 4) falls relative to the CPI in all regions, inducing substitution towards this product. The fall in the relative price of the product is explained by two factors. First, the Fishing & aqua industry is among those we have assumed to have high total-factor productivity growth. Second, the Fishing & aqua industry is highly capital intensive. As mentioned in the discussion of Table 2.1, the cost of using capital falls relative to the cost of labour. This reduces the relative price of capital-intensive products.

All countries show below average output growth for Construction (37), Fabricated metals (22), Other business services (48), Communication (44), Education (51), Insurance and pensions (46), Electric-coal (29) and Coal (5).

Table 2.3. Baseline forecasts for output by industry and nation (% growth, 2019-30)

	DK	FI	SE	NO	IS	RoE
1 Crops	-4.3	2.5	0.7	13.7	2.8	2.1
2 Livestock	15.5	17.1	18.8	17.1	22.3	5
3 ForestryLogs	1.7	21.3	28.5	15.7	17.2	3.1
4 FishingAqua	16.5	26.8	23.2	17.2	22.6	9.8
5 Coal	*NA*	4.5	9.3	5.4	*NA*	1.7
6 Oil	16.5	10.9	12.1	9.5	*NA*	7.4
7 Gas	15.7	4.6	*NA*	9.5	*NA*	3.3
8 OthMining	5.2	8	23	4	3.6	-0.6
9 FoodBevTob	14	9.1	17.6	18	35.2	5.2
10 Textiles	2	1.8	14.6	9.3	22.6	-3.5
11 Apparel	10.2	-2.9	18.7	9.2	19	-4
12 LeatherPrd	5.8	9.4	9	13.8	-1.6	-2.1
13 WoodProds	-3	20.8	27.1	10.6	8	0.9
14 PaperProds	5	22.2	27.6	11.8	23.3	0.8
15 PetrolCoalP	13.1	13.4	19.9	16.7	13.1	9
16 ChemicalPrd	18.7	16.4	37.2	11.4	16.5	3.7
17 Pharmaceutic	26.7	14.8	40.1	10.6	26	5.8
18 RubberPlas	12.9	12	27.6	11.5	16.4	-0.4
19 NonMetMinPrd	4.1	9.5	18.6	12.8	10.2	1.4
20 FeMetals	-1.9	7.8	17.2	15.6	14	-0.1
21 NonFeMetals	-4.6	12.8	13.4	16	5	1.8
22 FabriMetals	3.1	7.3	16.9	6.7	6	-0.8
23 Computer &optics	6	6.9	27.3	13	3.9	-3.2
24 ElectricEqp	5.5	8.8	19.9	13.2	11.1	-2.2
25 MachineNEC	7.8	9.8	19.4	12.7	13.2	-1.4
26 MotorVehicle	1.4	6.6	22.5	14.7	11.5	3.5
27 OthTransEqp	-6.5	1.8	29.9	8.2	-10.7	0.9
28 FurnitRepair	6.5	10.1	18.8	12.7	15.8	-0.9
29 ElecCoal	6.3	6.3	*NA*	*NA*	*NA*	1.7
30 ElecGas	18.3	10	10.8	22.3	*NA*	7.3
31 ElecOther	20.5	5	20.9	25.4	*NA*	8.1
32 ElecHydro	*NA*	0.7	11.9	13.6	12.2	-10.4
33 ElecNuc	*NA*	19.5	36.4	*NA*	*NA*	3
34 ElecDist	11.8	12.3	23.1	14	12.2	3.5
35 GasSupDist	15.5	*NA*	18.7	14.1	*NA*	2.9
36 Water	11	14.3	21.7	13	15.3	3.9
37 Construction	7.9	10.6	17.6	11.1	12.5	2.5
38 Wholesale & retail	10.1	12	20.2	13.2	16.3	4.3
39 AccomFood	15.2	17.5	26.8	14.4	20.8	6.9
40 LandTransprt	9.3	12.1	20.4	13.1	12.6	3.7
41 WaterTrnsprt	12.8	10.4	20.3	13.8	11.4	5.3
42 AirTransport	14.2	13.8	18.9	13.9	17.1	8.6
43 Warehousing	10.2	12.2	20.6	14.3	11.6	3.6
44 Communication	9.5	10.6	17.8	11.4	15.5	2.7
45 Finance	10.7	12.3	20.4	14.4	14.9	2.4
46 InsurPension	2.3	11.5	19.6	12.5	14.8	2.8
47 RentLease	11.6	13.1	21	12.8	16.5	4.1
48 OthBusSrv	8.6	9.6	16	10.7	15	1.6
49 Recreation &per serv	11.7	11.3	18.7	12.3	10.7	2.4
50 PubAdm & defence	12.9	15.4	23.6	13.9	17.5	5.5
51 Education	8.6	12.8	20.8	12.3	11.6	2.9
52 Health &social serv	13.3	15.7	23.6	13.7	17	5.2
53 Services of dwellings	23.6	28.3	39	18.6	30.9	11.1

NA: Output is negligible industries in these cells

Table 2.3a. Baseline: output by industry relative to GDP (% growth, 2019-2030)

	DK	FI	SE	NO	IS	RoE
1 Crops	-15.5	-11.0	-20.8	1.0	-13.6	-1.7
2 Livestock	4.3	3.6	-2.7	4.4	5.9	1.2
3 ForestryLogs	-9.5	7.8	7.0	3.0	0.8	-0.7
4 FishingAqua	5.3	13.3	1.7	4.5	6.2	6.0
5 Coal	*NA*	-9.0	-12.2	-7.3	*NA*	-2.1
6 Oil	5.3	-2.6	-9.4	-3.2	*NA*	3.6
7 Gas	4.5	-8.9	*NA*	-3.2	*NA*	-0.5
8 OthMining	-6.0	-5.5	1.5	-8.7	-12.8	-4.4
9 FoodBevTob	2.8	-4.4	-3.9	5.3	18.8	1.4
10 Textiles	-9.2	-11.7	-6.9	-3.4	6.2	-7.3
11 Apparel	-1.0	-16.4	-2.8	-3.5	2.6	-7.8
12 LeatherPrd	-5.4	-4.1	-12.5	1.1	-18.0	-5.9
13 WoodProds	-14.2	7.3	5.6	-2.1	-8.4	-2.9
14 PaperProds	-6.2	8.7	6.1	-0.9	6.9	-3.0
15 PetrolCoalP	1.9	-0.1	-1.6	4.0	-3.3	5.2
16 ChemicalPrd	7.5	2.9	15.7	-1.3	0.1	-0.1
17 Pharmaceutic	15.5	1.3	18.6	-2.1	9.6	2.0
18 RubberPlas	1.7	-1.5	6.1	-1.2	0.0	-4.2
19 NonMetMinPrd	-7.1	-4.0	-2.9	0.1	-6.2	-2.4
20 FeMetals	-13.1	-5.7	-4.3	2.9	-2.4	-3.9
21 NonFeMetals	-15.8	-0.7	-8.1	3.3	-11.4	-2.0
22 FabriMetals	-8.1	-6.2	-4.6	-6.0	-10.4	-4.6
23 Computer &optics	-5.2	-6.6	5.8	0.3	-12.5	-7.0
24 ElectricEqp	-5.7	-4.7	-1.6	0.5	-5.3	-6.0
25 MachineNEC	-3.4	-3.7	-2.1	0.0	-3.2	-5.2
26 MotorVehicle	-9.8	-6.9	1.0	2.0	-4.9	-0.3
27 OthTransEqp	-17.7	-11.7	8.4	-4.5	-27.1	-2.9
28 FurnitRepair	-4.7	-3.4	-2.7	0.0	-0.6	-4.7
29 ElecCoal	-4.9	-7.2	*NA*	*NA*	*NA*	-2.1
30 ElecGas	7.1	-3.5	-10.7	9.6	*NA*	3.5
31 ElecOther	9.3	-8.5	-0.6	12.7	*NA*	4.3
32 ElecHydro	*NA*	-12.8	-9.6	0.9	-4.2	-14.2
33 ElecNuc	*NA*	6.0	14.9	*NA*	*NA*	-0.8
34 ElecDist	0.6	-1.2	1.6	1.3	-4.2	-0.3
35 GasSupDist	4.3	*NA*	-2.8	1.4	*NA*	-0.9
36 Water	-0.2	0.8	0.2	0.3	-1.1	0.1
37 Construction	-3.3	-2.9	-3.9	-1.6	-3.9	-1.3
38 Wholesale & retail	-1.1	-1.5	-1.3	0.5	-0.1	0.5
39 AccomFood	4.0	4.0	5.3	1.7	4.4	3.1
40 LandTransprt	-1.9	-1.4	-1.1	0.4	-3.8	-0.1
41 WaterTrnsprt	1.6	-3.1	-1.2	1.1	-5.0	1.5
42 AirTransport	3.0	0.3	-2.6	1.2	0.7	4.8
43 Warehousing	-1.0	-1.3	-0.9	1.6	-4.8	-0.2
44 Communication	-1.7	-2.9	-3.7	-1.3	-0.9	-1.1
45 Finance	-0.5	-1.2	-1.1	1.7	-1.5	-1.4
46 InsurPension	-8.9	-2.0	-1.9	-0.2	-1.6	-1.0
47 RentLease	0.4	-0.4	-0.5	0.1	0.1	0.3
48 OthBusSrv	-2.6	-3.9	-5.5	-2.0	-1.4	-2.2
49 Recreation &per serv	0.5	-2.2	-2.8	-0.4	-5.7	-1.4
50 PubAdm & defence	1.7	1.9	2.1	1.2	1.1	1.7
51 Education	-2.6	-0.7	-0.7	-0.4	-4.8	-0.9
52 Health &social serv	2.1	2.2	2.1	1.0	0.6	1.4
53 Services of dwellings	12.4	14.8	17.5	5.9	14.5	7.3

NA: Output is negligible industries in these cells

Construction (37), Fabricated metals (22), Other business services (48) and Communication (44) rely on investment for considerable fractions of their sales. Growth in these industries is damped because investment grows slower than GDP in all countries. In addition, the prices of Other business services and Communication rise relative to the general price level. This is mainly because these industries are among those for which we assumed low total-factor productivity growth.

Education (51) and Insurance and pensions (46) have low total-factor productivity growth. This makes them relatively expensive to consumers, inducing negative substitution effects.

Recall that the baseline includes no greenhouse policies. Consequently, the inclusion of Electric-coal (29) and Coal (5) in the list of industries with below average growth prospects in all Nordic countries is noteworthy. It implies that even without greenhouse policies, generation of electricity by coal combustion would be replaced by generation industries based on other methods. Coal electricity is labour intensive relative to other method of generating electricity. Thus, in our baseline, the cost of coal electricity rises relative to that of electricity generated by other methods.

For most products, growth prospects are above average (positive entry in Table 2.3a) in some countries but below average (negative entry) in others. For example, Pharmaceuticals (17) has above average prospects in all Nordic countries except Norway. Ferrous metals (20) and Non-ferrous metals (21) on the other hand have above average prospects in Norway but below average prospects in all other countries. As can be seen from row 8 in Table 2.2, Norway has lower projected productivity growth than the other countries, leading to lower wage growth, row 8 Table 2.1. This means that the cost advantage enjoyed by capital-intensive industries such as Pharmaceuticals is muted in Norway compared with the other Nordic countries. Similarly, relatively labour-intensive traded-goods industries such as Ferrous metals and Non-ferrous metals gain an advantage in Norway relative to these industries in other Nordic countries.

Apart from labour and capital costs, differences in trade orientation can explain differences across the Nordic countries in baseline prospects for a given industry. Consider for example Wood products (13). This industry has above average prospects in Finland and Sweden. Both these countries have significant exports of Wood products to fast growing economies outside Europe. This is not the case for the Wood products industries in other Nordic countries.

Other transport equipment (27) is an industry in which both differences in primary-factor inputs and trade orientation are important in explaining differences in prospects across the Nordic countries. In Sweden, the industry has above average prospects, whereas it has below average prospects in the other countries. For Sweden, nearly half the industry's output is exported to countries outside Europe. The corresponding exports shares for the other Nordic countries are much lower. At the same time, the Swedish industry is capital intensive relative to its counterparts in the other Nordic countries.

2.5. Baseline forecasts for industry employment

Table 2.4 shows baseline employment growth from 2019 to 2030 by industry and nation. These employment projections follow in a mechanical way from the output projections in

Table 2.3 and from our baseline sectoral productivity assumptions. For each of the 5 Nordic countries, very good fits are obtained in regression equations of the form

$$\text{emp(i,n)} = \alpha_o + \alpha_1 * \text{output(i,n)} - \alpha_2 * \text{productivity(i)}\ ,\ \text{i} \in \text{IND(n)} \qquad (2.1)$$

where

emp(i,n) is the baseline employment growth projection from Table 2.4 for industry i in nation n;

output(i,n) is the baseline output growth projection from Table 2.3 for industry i in nation n;

productivity(i) is productivity growth relative to aggregate productivity growth assumed for industry i, see point (7) in section 2.2;

IND(n) is the set of industries in nation n that have non-negligible output (we exclude the industries marked *NA* in Tables 2.3 and 2.4; and

α_0, α_1 and α_2 are regression coefficients.

For the 5 Nordic countries, regression equation (2.1) gives R^2 values of between 0.89 and 0.96.

2.6. Baseline forecasts for employment by nation and region

The first row in each panel of Table 2.5 shows baseline employment forecasts. The national forecasts are taken from Table 2.1. In Table 2.5, national employment forecasts are disaggregated to NUTS2 regions. These regions are defined under the table and can be identified in the map. No disaggregation is given for Iceland. In Iceland there is only one NUTS2 region.

The employment growth forecast for a region within a nation can differ from the national employment growth forecast for two reasons:

(1) the industrial composition of employment in the region differs from that in the nation; and
(2) growth rates for industries in the region differ from those for the corresponding industries at the national level.

We refer to (1) as the industry-mix effect. In calculating this effect, we assume that the growth rate for each industry at the regional level is the same as the industry's growth at the national level. Thus, a region has a positive industry-mix effect if it has relatively large shares of its employment in industries with strong employment growth at the national level and relatively low shares of its employment in industries with weak employment growth at the national level. By relative shares, we mean regional shares relative to national shares.

We refer to (2) as the industry-growth effect. In calculating this effect, we compare the employment growth forecast for a region with what it would have been if regional employment growth in each industry had been the same as the industry's national employment growth.

Mathematically, we can write the two effects for region r as:

$$\text{Ind-mix effect(r)} = \sum_{j \in \text{Ind}} \left[\text{SR}(j,r) - \text{SN}(j,n(r)) \right] * \text{en}(j,n(r)) \qquad (2.2)$$

Table 2.4. Baseline forecasts for employment by industry* and nation (% growth, 2019-30)

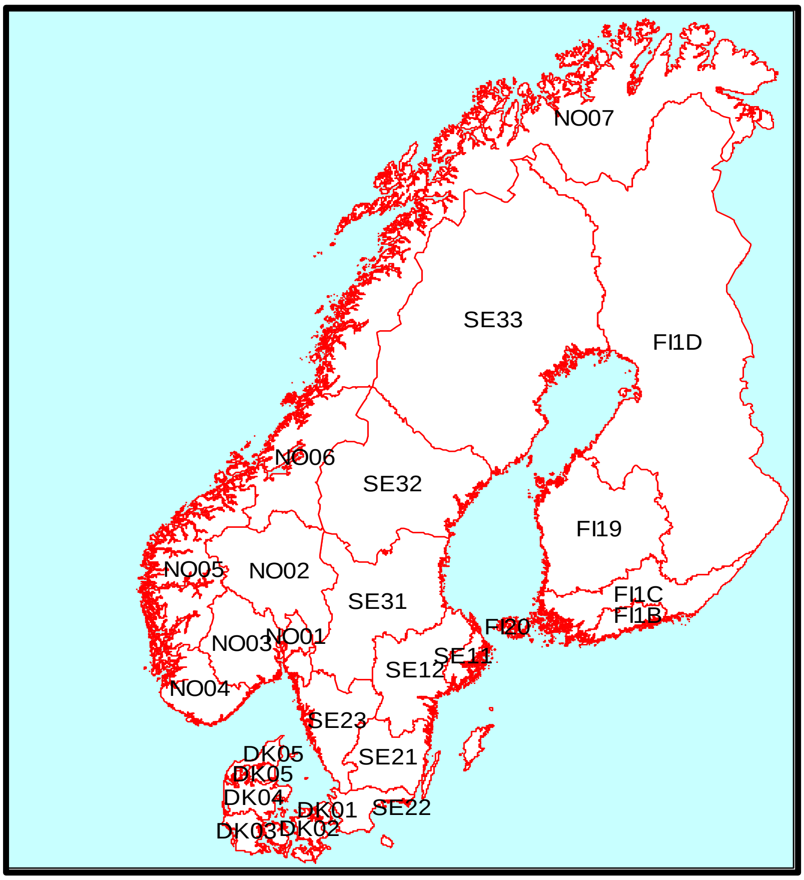
	DK	FI	SE	NO	IS	RoE
1 Crops	-29.2	-25.6	-28.9	-9.2	-24.2	-21.1
2 Livestock	-12.0	-13.1	-13.9	-6.0	-6.9	-19.0
3 ForestryLogs	-24.1	-12.7	-9.9	-9.1	-11.3	-21.3
4 FishingAqua	-16.6	-8.9	-15.4	-10.1	-13.5	-20.8
5 Coal	*NA*	-21.0	-17.0	-8.7	*NA*	-13.5
6 Oil	*-2.3*	-11.7	*NA*	-3.2	*NA*	-9.5
7 Gas	-3.1	-21.3	*NA*	-3.2	*NA*	-13.7
8 OthMining	-10.7	-12.4	-3.1	-6.8	-12.8	-14.8
9 FoodBevTob	-6.4	-13.4	-9.2	0.7	5.6	-12.9
10 Textiles	-15.8	-18.5	-10.6	-6.5	-2.9	-19.4
11 Apparel	-9.8	-22.7	-8.5	-7.5	-8.2	-19.7
12 LeatherPrd	-12.5	-13.3	-11.5	-3.5	-22.0	-18.3
13 WoodProds	-19.6	-2.7	-1.0	-4.6	-12.5	-15.5
14 PaperProds	-13.5	-3.5	-2.0	-3.9	-4.5	-15.9
15 PetrolCoalP	-10.2	-12.4	-11.2	-1.9	*NA*	-11.2
16 ChemicalPrd	-5.5	-9.7	2.2	-6.0	-8.8	-14.5
17 Pharmaceutic	-0.2	-12.0	3.1	-7.4	-2.9	-13.4
18 RubberPlas	-8.0	-10.8	-2.1	-4.5	-7.3	-16.2
19 NonMetMinPrd	-13.7	-12.3	-7.8	-3.6	-9.9	-15.3
20 FeMetals	-18.3	-13.4	-9.2	-1.6	-9.1	-16.7
21 NonFeMetals	-20.3	-11.9	-12.1	-1.4	-16.8	-15.4
22 FabriMetals	-14.4	-13.8	-9.1	-8.1	-12.9	-16.5
23 Computer &optics	-13.5	-16.0	-3.4	-3.7	-15.9	-19.0
24 ElectricEqp	-13.4	-13.9	-8.1	-3.2	-11.1	-18.0
25 MachineNEC	-11.3	-12.9	-8.2	-3.5	-9.4	-17.1
26 MotorVehicle	-16.6	-14.4	-6.3	-1.5	-11.0	-13.6
27 OthTransEqp	-23.1	-17.7	-1.1	-6.3	-25.9	-15.2
28 FurnitRepair	-11.9	-12.9	-8.6	-3.0	-7.6	-16.9
29 ElecCoal	-10.2	-12.6	*NA*	*NA*	*NA*	-11.3
30 ElecGas	-1.6	-11.2	-13.6	7.4	*NA*	-7.6
31 ElecOther	0.3	-14.6	2.2	9.9	*NA*	-6.9
32 ElecHydro	*NA*	-17.8	-12.0	0.2	-6.4	-21.5
33 ElecNuc	*NA*	-4.2	5.3	0.0	*NA*	-11.5
34 ElecDist	-6.5	-8.8	-3.6	0.3	-7.1	-10.2
35 GasSupDist	-4.2	*NA*	-5.9	0.8	*NA*	-11.3
36 Water	-3.1	-2.8	1.5	2.3	-0.6	-7.9
37 Construction	-5.5	-6.2	-3.0	0.4	-2.3	-9.7
38 Wholesale & retail	1.0	-0.4	4.1	8.5	4.0	-3.5
39 AccomFood	6.6	5.7	11.4	10.2	9.4	-0.1
40 LandTransprt	0.6	0.3	3.8	7.4	2.9	-3.5
41 WaterTrnsprt	-0.1	-1.3	5.0	7.2	3.7	-3.7
42 AirTransport	4.6	-0.1	3.2	9.7	2.7	0.8
43 Warehousing	-0.1	-1.5	1.6	7.5	0.1	-4.6
44 Communication	-1.0	-2.9	0.4	5.5	0.8	-5.3
45 Finance	-0.3	0.5	3.4	6.9	1.2	-4.8
46 InsurPension	-4.8	-2.2	1.1	6.2	0.6	-5.1
47 RentLease	-1.2	-3.1	0.3	5.4	-0.1	-5.9
48 OthBusSrv	-0.5	-2.4	0.6	5.7	1.6	-5.2
49 Recreation &per serv	1.4	-1.2	2.3	6.9	-0.5	-4.5
50 PubAdm & defence	4.4	4.0	9.4	9.2	7.5	-0.7
51 Education	1.7	3.3	8.8	8.7	3.8	-1.7
52 Health &social serv	6.1	5.9	11.3	10.1	8.7	0.4
53 Services of dwellings	6.6	7.1	11.8	9.1	11.1	-1.1

NA: Output is negligible industries in these cells.

* 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 made a few aggregations. For example our industry 1, Crops, is an aggregation of the first 8 GTAP industries. We have also disaggregated the GTAP electricity generation industry into 5 generating industries (our industries 29-34).

Table 2.5. Baseline forecasts for employment, nations & regions: 2019-2030 (per cent growth)

	Denmark	DK01	DK02	DK03	DK04	DK05			
Employment	**-1.5**	-0.8	-1.6	-1.9	-1.9	-2.0			
Dev from nation		0.7	-0.1	-0.4	-0.4	-0.5			
Ind. mix		1.1	0.0	-0.7	-0.7	-0.8			
Ind. growth		-0.4	-0.1	0.3	0.3	0.2			
	Finland	FI19	FI1B	FI1C	FI1D	FI20			
Employment	**-2.0**	-2.3	-1.5	-2.1	-2.3	-3.4			
Dev from nation		-0.3	0.5	-0.1	-0.3	-1.4			
Ind. mix		-0.6	0.6	-0.2	0.1	-0.6			
Ind. growth		0.3	-0.1	0.1	-0.4	-0.8			
	Sweden	SE11	SE12	SE21	SE22	SE23	SE31	SE32	SE33
Employment	**2.7**	2.8	2.5	2.0	2.3	4.0	2.2	1.6	1.8
Dev from nation		0.1	-0.2	-0.8	-0.4	1.3	-0.6	-1.1	-0.9
Ind. mix		0.4	0.2	-0.9	0.0	-0.1	-0.3	-0.4	-0.1
Ind. growth		-0.4	-0.5	0.2	-0.3	1.4	-0.2	-0.7	-0.8
	Norway	NO01	NO02	NO03	NO04	NO05	NO06	NO07	
Employment	**5.5**	6.0	5.1	5.2	4.4	6.1	5.2	5.3	
Dev from nation		0.6	-0.4	-0.2	-1.1	0.6	-0.2	-0.1	
Ind. mix		1.0	-0.3	-0.3	-1.1	-0.4	-0.1	0.6	
Ind. growth		-0.4	-0.1	0.1	0.1	1.0	-0.2	-0.8	



DK01	Hovedstaden
DK02	Sjælland
DK03	Syddanmark
DK04	Midtjylland
DK05	Nordjylland
FI19	West Finland
FI1B	Helsinki-Uusimaa
FI1C	South Finland
FI1D	North and East Finland
FI20	Åland
NO01	Oslo og Akershus
NO02	Hedmark og Oppland
NO03	Sør-Østlandet
NO04	Agder og RogÅland
NO05	Vestlandet
NO06	Trøndelag
NO07	Nord-Norge
SE11	Stockholm
SE12	Östra Mellansverige
SE21	Småland med öarna
SE22	Sydsverige
SE23	Västsverige
SE31	Norra Mellansverige
SE32	Mellersta Norrland
SE33	Övre Norrlan

and

$$\text{Ind-growth effect(r)} = \sum_{j \in Ind} SR(j,r) * \left[er(j,r) - en(j,n(r)) \right] \qquad (2.3)$$

where

SR(j,r) is the share of region r's employment accounted for by industry j;

SN(j,n(r)) is the share of employment in the nation to which r belongs accounted for by industry j;

er(j,r) is the percentage growth in employment in industry j in region r; and

en(j,n(r)) is the percentage employment growth in industry j in the nation to which r belongs.

The two effects are a complete decomposition of the deviation between the growth rate of employment in region r and the growth rate in employment in the nation to which r belongs:

$$\begin{aligned} &\text{Ind-growth effect(r)} + \text{Ind-mix effect(r)} \\ &\quad = \sum_{j \in Ind} SR(j,r) * \left[er(j,r) - en(j,n(r)) \right] + \sum_{j \in Ind} \left[SR(j,r) - SN(j,n(r)) \right] * en(j,n(r)) \\ &\quad = \sum_{j \in Ind} SR(j,r) * er(j,r) - \sum_{j \in Ind} SN(j,n(r) * en(j,n(r)) \\ &\quad = ertot(r) - entot(n(r)) \end{aligned} \qquad (2.4)$$

where

ertot(r) is total employment growth for region r; and

entot(n(r)) is total employment growth in the nation to which r belongs.

The second row of results for each country in Table 2.5 shows the deviations between the regional and national growth rates in employment, and the third and fourth rows show the decompositions of these deviations into the industry-mix effects and industry-growth effects. For example, DK01 (Hovedstaden) has employment forecast growth that is 0.7 percentage points above that for Denmark as a whole [=(-0.8) – (-1.5)]. The deviation in DK01's forecast from the national forecast is decomposed into an industry-mix effect of 1.1 percentage points and an industry-growth effect of -0.4 percentage points. [1]

What this means is that from the point of view of employment, DK01 has a favourable mix of industries, but that DK01's industries have on average slightly lower employment growth rates than the corresponding industries at the national level.

From the Nordic-TERM database, we find that DK01 has a relatively high share of its employment in public administration and relatively low shares in manufacturing and agriculture. This produces a positive industry-mix effect (1.1 percentage points) because baseline employment growth in public administration is high for Denmark whereas baseline employment in manufacturing and agriculture is low. In the case of public administration, output grows broadly in line with Denmark's GDP, but measured productivity growth is low, giving the industry high employment growth. In the cases of manufacturing and agriculture,

[1] In some cases, rounding errors prevent the two effects from adding precisely to the gap between the forecast for the region and the forecast for the nation.

baseline output growth in Denmark is below that of GDP and productivity growth is relatively high, giving these two sectors low employment growth.

We traced the negative industry-growth effect for DK01 (-0.4 percentage points) to wage rates. Baseline wage rates in DK01 rise slightly faster than in the other regions of Denmark. This reflects DK01's relatively favourable employment situation (-0.8 per cent compared with growth between -1.6 and -2.0 per cent in the rest of Denmark). Higher wage growth in DK01 reduces the competitiveness of DK01's industries, giving them on average lower growth rates than the corresponding industries in other Danish regions.

While for DK01, the industry-mix effect is the dominant contributor to the gap between the region's employment growth and that of the nation (1.1 compared with -0.4), for other regions the industry growth effect is dominant. For example, in SE23 (Vastsverige) the industry-growth effect is large (1.4 percentage points) whereas the industry-mix effect is small (-0.1 percentage points). We found that exports of commodities to the rest of the world leaving Sweden from ports in SE23 are nearly half the size of SE23's economy. This is a much larger fraction than for any other Nordic region. In our baseline, non-European trade partners have high rates of growth relative to Europe. This gives enhanced growth prospects to industries in regions such as SE23 that rely directly or indirectly on trade with non-European partners.

Among all the Nordic regions, FI20 (Aland) has the lowest baseline employment growth (-3.4 per cent) and the largest absolute gap between its employment growth and that of its nation (1.4 percentage points). Both the industry-mix effect and the industry-growth effect are negative for FI20 (-0.6 and -0.8).

FI20 scores a negative industry-mix effect because it has low employment shares for Public administration & defence (ind 50) and Health &social services (ind 52), both of which have strong employment growth at the national level. At the same time FI20 has high employment shares for Construction (ind 37) and various manufacturing industries such as Food & beverages (ind 9) and Other transport equipment (ind 27), all of which have strongly negative employment growth at the national level.

Most industries in FI20 exhibit less growth than the corresponding industries in the rest of Finland, giving FI20 a negative industry-growth effect. Industry growth in FI20 is negatively affected by weak private and public consumption associated with the region's unfavourable industry-mix. As we have seen in the discussion of SE23, an unfavourable industry-mix effect does not guarantee a negative industry-growth effect. However, unlike the situation for SE20, in the case of FI20 trade links are not sufficient to overcome the negative effects of damped local consumption demand.

2.7. Baseline forecasts for CO2 emissions

Table 2.6a gives data on CO2eq emissions in Nordic countries in 2019. In all these countries, combustion of Petroleum & coal products, mainly in truck and car transport, accounts for an important part of total emissions. This justifies the focus of the Nordic countries on de-carbonizing the road transport sector.

In 2019, burning coal was still a significant source of emissions for Nordic countries. In FI and DK, coal was burnt primarily in the generation of electricity (ind 29, ElecCoal). In the other countries coal was used in various industrial processes such as metals production.

Burning gas is important in electricity generation for FI and IS. In NO and SE, gas is an input to industries such as chemicals, metals production and production of petroleum and coal products. In DK, gas is burnt by households and in industrial processes.

FI, SE and NO use forests for carbon sequestration, giving them negative entries in Table 2.6a in the forestry & land row. For DK and IS the entries in this row are positive indicating carbon-releasing changes in forestry activities and land use. The “other” row in Table 2.6a refers to emissions from non-combustion activities such as: emissions produced in agriculture by livestock and soil disturbance; fugitive emissions, such as methane emissions from open-cut coal mines; emissions produced from manufacturing processes, e.g. manufacture of cement; and waste emissions, including methane from the breakdown of solid wastes.

In our modelling, we calculate input emission coefficients (emissions per unit of use of coal, gas, petroleum & coal products) and output emission coefficients (emissions from output activities by industries). This gives us a basis for projecting effects on emissions of growth in output by industries and consumption by households. We also use emission coefficients for estimating the effects on emissions of policies that change the composition of inputs to industries and the commodity composition of consumption e.g. substitution of bio-materials for fossil materials in production of motor fuels, and the substitution of electricity for motor fuels by households.

The source for our emissions data and the technicalities of our emission modelling are set out in RM1, available at ###Carlos to post on line somewhere #.

Table 2.6b projects Table 2.6a forward to 2030 under baseline assumptions. These include the assumption that there are no greenhouse policies beyond those already in place in 2019. As can be seen from Tables 2.6a and 2.6b, we assume no change in emissions from forestry and land use. However, emissions from other sources increase with output and consumption activities. Baseline percentage increases in emissions between 2019 and 2030 deduced from the “Total” rows of Table 2.6a&b are shown in Table 2.6c.

The “Total” rows in Tables 2.6a&b and the percentage changes in Table 2.6c refer to emissions *including* those from forestry and land use, somewhat confusingly called *net* emissions. When emissions from forestry and land use are excluded, the resulting measure is referred to as *gross* emissions. Table 2.7 shows baseline percentage growth in both net and gross emissions and compares these projections with baseline GDP growth.

With no new greenhouse policies included in the baseline, growth in gross emissions is broadly in line with GDP growth in all Nordic countries. However, when emissions from forestry and land use are included (net emissions), we see that baseline CO2eq net emission growth for SE far exceeds baseline GDP growth. For IS the reverse is true.

SE has large negative CO2eq emissions from its Forestry activities (see Table 2.6a). We assume no change in these emissions. SE’s emissions from other sources grow approximately at the rate of GDP. With no change in the large negative contributor to SE’s total emissions and positive growth in the other contributors, SE’s net CO2 emissions show a very large positive percentage increase.

In the case of IS, most of the emissions are from land use. We assume in the baseline that this is constant. Emissions from other sources grow approximately in line with GDP, leaving net emissions for IS with low growth relative to GDP.

Table 2.6a. CO2eq. emissions (Kt) for 2019

	DK	FI	SE	NO	IS
Combustion of					
Coal	3588	15250	8098	4085	685
Gas	6012	4314	1775	13707	0
PetrolCoalPrds	20146	19267	24545	15953	996
Activity in					
Forestry & land	2893	-13590	-36736	-16436	9020
Other	14491	13905	16393	17330	3031
Total (net)	47130	39146	14075	34639	13732

Table 2.6b. CO2eq. emissions (Kt) for 2030 without new policies: baseline

	DK	FI	SE	NO	IS
Combustion of					
Coal	3819	16660	9751	4649	781
Gas	6964	4830	2239	15664	0
PetrolCoalPrds	22685	21796	29872	18206	1145
Activity in					
Forestry & land	2893	-13589	-36737	-16438	9020
Other	15729	15534	19437	19748	3364
Total (net)	52090	45231	24562	41829	14310

Table 2.6c. Percentage change in net CO2eq. emissions between 2019 and 2030: baseline

	DK	FI	SE	NO	IS
%change 2019-30	10.5	15.5	74.5	20.8	4.2

Table 2.7. Baseline forecasts for CO2eq. emissions and Real GDP (%, 2019-2030)

	Net co2 eq.*	Gross co2 eq**	Real GDP
DK	10.5	11.2	11.2
FI	15.5	11.5	13.5
SE	74.5	20.6	21.5
NO	20.8	14.1	12.7
IS	4.2	12.3	16.4

* Includes forestry and land use

** Excludes forestry and land use

3. REPRESENTING NORDIC GREENHOUSE POLICIES: SETTING THE POLICY SHOCKS

3.1. Introduction

As explained in section 1, we simulate Nordic policies for reducing emissions focusing mainly on the effort-sharing regulation (ESR) sector. Central to this sector are policies concerned with road transport. We also assume that the Nordic countries will move close to eliminating the use of coal in electric-power generation. To conduct our simulations, we must formulate shocks to be applied in the Nordic-TERM model to represent:

- ➢ increases in the cost of motor fuels to industries (mainly the Road transport industry) associated with the achievement of bio-fuel targets in diesel;
- ➢ increases in the cost of motor fuels to households associated with the achievement of bio-fuel targets;

- changes in the composition of inputs in the production of Motor fuels (substitution of bio materials for oil);
- increases in the use of electricity by households associated with the achievement 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 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 remaining coal-fired electricity generation and its replacement by other forms of generation.

This section describes how we formulated the shocks, making clear the assumptions we have made and identifying the data sources on which we have relied.

The main information sources for modelling climate policies in the Nordic countries are national reports (referenced at the foot of Table 3.1). Policy targets and some of the measures Nordic countries are adopting are reported in a broadly comparable fashion by their governments' progress reports and action plans to the EU. These reports are updated every three years. We used data from the reports for 2019. These were the most recent reports when we started this project. 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 referring to research reports. What is common to the reports is that the detail on policy targets is richer than the detail on policy measures.

3.2. Biofuels

Biofuel targets in diesel blends

All of the Nordic countries have targets to increase the renewable proportion of motor fuels (gasoline plus diesel).

The first two columns in Table 3.1 show the actual share of biofuels in motor fuels in 2020 (column 1), and the target for 2030 (column 2), as it was in 2020. The formulation of the blending target varies between the Nordic countries. For most of them, the biofuel blending target was expressed in terms of biofuel share in motor fuels. One exception was Sweden, where the target was expressed separately for petrol and diesel in the 2018 law.

The Danish Integrated National and Climate Plan of 2019 sets a renewable energy target for the transport sector which aims at increasing the renewable share from some 9 per cent in 2020 to 19 per cent in 2030, mostly by increased use of electricity. The biofuel target for liquid fuels in 2020 was 5.75 per cent but the actual share was about 6 per cent in 2020. For 2030, the biofuel target for liquid fuels in the transport sector was about 7 per cent.

For 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 11.7 per cent. The Norwegian blending requirement for 2020 was 20 per cent, and it was planned to be raised by 10 percentage points (which with double-counting of emission reductions for latest generation biofuels would be credited for 40 per cent).

The Swedish blending target is expressed in terms of an emission reduction obligation, which is defined as emission reduction compared to emissions from producing the same amount of energy with fossil fuels. This amounts to blending requirements that are given separately for petrol and diesel in the 2018 law. In Sweden, the share of biofuels in motor fuels in 2020 was about 23 per cent. The biofuel target for 2030 was 28 per cent for petrol and 66 per cent for diesel. Assuming the petrol and diesel shares of 2020 applied also in 2030, the emission target would require an overall blending share for low-emission fuels in 2030 of about 63 per cent.

In 2020, the share of renewables in Iceland's transport sector was 11.4 per cent including electricity, and it was expected to grow as EVs become more common. Electricity is to account for most of the increase of renewables in Iceland's transport sector. The share of biofuels in motor fuels was about 7.6 per cent in 2020 and was expected to increase only slightly, to about 8 per cent by 2030.

Diesel fuels account for different fractions of motor fuel use by passenger-car fleets in the five countries [see column 8 in Table 3.1] and for approximately 100 per cent in their road-transport sectors. For all the countries except Sweden, we 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. For these countries, we assume that the bio-shares in gasoline will remain at about 12 per cent in 2030 which is about the maximum compatible with the gasoline-using motors in the current generations of passenger cars and biofuels. For Sweden, achieving the 28 per cent bio-fuel target for petrol will require either new types of fuel or cars with modified engines. We don't take into account the development costs of new fuels or engine modifications. However, we think that these costs are likely to be quite small because motor fuel use in Sweden is predominantly diesel.

As explained in Appendix A3.1, we calculated implied biofuel targets for diesel fuels, assuming no increase in bio-shares in gasoline for all countries except Sweden, for which we increased the gasoline bio share from 12 per cent to 28 per cent. The results of these calculations are in columns (3) and (4) of Table 3.1. The 2020 shares and the targets for 2030 expressed in terms of bio shares for diesel are not much different from the bio shares expressed in terms of motor fuels, that is columns (3) and (4) are similar to columns (1) and (2).

Effect of biofuel targets on costs of motor fuels

Biofuels cost more than energy-equivalent quantities of fossil fuels. We assume that the cost in 2030 of bio-diesel per litre is 1.81 euro and the cost of an equivalent amount of fossil diesel is 0.61 euro.[2] Thus, the adoption of higher bio shares in diesel fuels will increase their costs in 2030 relative what these costs would have been if the bio shares remained at their 2020 levels. We calculate the percentage cost increase in 2030 resulting from the bio targets according to:

$$\text{\% increase in cost of blended diesel in 2030} = 100 * \left[\frac{(1-s_{2r})*0.61 + s_{2r}*1.81}{(1-s_{1r})*0.61 + s_{1r}*1.81} - 1 \right] \quad (3.1)$$

[2] Costs of biofuels are estimated on the basis of a recent study by AFRY: Esa Sipilä , Henna Poikolainen, Anna Lilja, Taneli Rautio and Nils-Olof Nylund (2021): Increasing the level of distribution obligation in road transport. Prime Minister's Office, VN/13807/2021. (in Finnish, but including a summary in English) Liikenteen_jakeluvelvoitetason_nosto (valtioneuvosto.fi)

Table 3.1. Calculation of % increases in Motor fuel costs in 2030

	Bio fuels % in motor fuels		Bio fuels % in diesel		Cost of diesel blend in 2030		Diesel blend	Diesel share in passenger-car motor fuel use	Car fuels used by H'hlds	Average over all motor fuels
	2020	Target 2030	2020	Target 2030	with baseline shares	with target shares	% price rise, 2030		% price rise, 2030	% price rise, 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
Sweden	23	63	23.88	66.00	0.897	1.402	56.404	0.38	36.53	54.02
Norway	20	30	20.30	30.69	0.854	0.978	14.592	0.56	8.29	14.07
Iceland	7.6	8	7.02	7.47	0.694	0.700	0.783	0.33	0.23	0.69

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) Also refer to Appendix A1.2.

Table 3.2. Calculating the % change in oil per unit of output of motor fuels

	Bio fuels % in motor fuels (see col 1&2, Table 3.1) 2020	Target 2030	% change in oil content
DK	6	7	-1.1
FI	11.7	30	-20.7
SE	23	63	-51.9
NO	20	30	-12.5
IS	7.6	8	-0.4

Table 3.3. Targets for sales of electric vehicles and effect on household motor fuel consumption in 2030

	EV share 2020-2030 (%)	Policy	Policy induced % change in 2030 in H'hld consumption of motor fuels
Denmark	1.9 ->25.0	775000 EV target	-23.5
Finland	2.0 ->26.0	750000 EV target	-24.8
Sweden	6.2->48.1	60% EV sales share	-44.6
Norway	22.1 -> 62.2	70% EV sales share	-51.5
Iceland	4.6-> 47.4	60% EV sales share	-44.9

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. License: 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 reduced by 21 % from 2010 in the year 2020, target a reduction of 66% by 2030; thus, reduction of 43% from 2020. From this and the share of diesels in 2020 it is possible to derive the biofuel blending target. Sweden's long-term strategy for reducing greenhouse gas emissions (unfccc.int)

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

where

s_{1r} is the *baseline* biofuel share in diesel in country r [0.0539 in Denmark, for example, see col (3), Table3.1];

s_{2r} is the *target* or policy biofuel share in diesel in country r [0.0649 in Denmark, see col (4), Table3.1]; and

1.81 and 0.61 are the assumed costs of bio-diesel per litre and an equivalent amount of fossil diesel.

Effect of biofuel targets on costs of motor fuels

Biofuels cost more than energy-equivalent quantities of fossil fuels. We assume that the cost in 2030 of bio-diesel per litre is 1.81 euro and the cost of an equivalent amount of fossil diesel is 0.61 euro.[3] Thus, the adoption of higher bio shares in diesel fuels will increase their costs in 2030 relative what these costs would have been if the bio shares remained at their 2020 levels. We calculate the percentage cost increase in 2030 resulting from the bio targets according to:

$$\text{\% increase in cost of blended diesel in 2030} = 100*\left[\frac{(1-s_{2r})*0.61+s_{2r}*1.81}{(1-s_{1r})*0.61+s_{1r}*1.81}-1\right] \quad (3.1)$$

where

s_{1r} is the *baseline* biofuel share in diesel in country r [0.0539 in Denmark, for example, see col (3), Table3.1];

s_{2r} is the *target* or policy biofuel share in diesel in country r [0.0649 in Denmark, see col (4), Table3.1]; and

1.81 and 0.61 are the assumed costs of bio-diesel per litre and an equivalent amount of fossil diesel.

The calculation of the prices of blended diesel with the baseline and target shares are shown in columns (5) and (6) of Table 3.1. The percentage price increases for blended diesel in 2030 calculated according to (3.1) are shown in column (7) of Table 3.1. These price increases apply to all diesel fuel used by the transport sector in each country.

Increases in the cost of *blended diesel fuels* will also affect the average cost of motor fuels to households in each of the Nordic countries. In calculating the percentage effect on fuel prices for the passenger-car fleet, we assume that the cost of *petroleum blends* in 2030 will be 0.82 euro per litre, the same as its cost in 2020. We calculate the percentage increase in fuel cost for passenger cars as:

% increase in ave cost of motor fuel to households in country r

$$=100*\left[\frac{(1-h_r)*0.82+h_r*\text{pdiesel}(2030)}{(1-h_r)*0.82+h_r*\text{pdiesel}(2020)}-1\right] \quad \text{for } r \neq SE \qquad (3.2a)$$

and

% increase in ave cost of motor fuel to households in Sweden

$$=100*\left[\frac{(1-h_{SE})*1.01+h_{SE}*\text{pdiesel}(2030)}{(1-h_{SE})*0.82+h_{SE}*\text{pdiesel}(2020)}-1\right] \qquad (3.2b)$$

where

[3] Costs of biofuels are estimated on the basis of a recent study by AFRY: Esa Sipilä , Henna Poikolainen, Anna Lilja, Taneli Rautio and Nils-Olof Nylund (2021): Increasing the level of distribution obligation in road transport. Prime Minister's Office, VN/13807/2021. (in Finnish, but including a summary in English) Liikenteen_jakeluvelvoitetason_nosto (valtioneuvosto.fi)

h_r is the share of country r's internal-combustion passenger-car fleet accounted for by diesel cars, assumed to be the same in 2020 and 2030, see column (8) of Table 3.1;
0.82 is the cost of blended petroleum used in passenger vehicles for all countries in 2020 and in all countries except Sweden in 2030;
1.01 is the cost of blended petroleum used in passenger vehicles in Sweden in 2030, taking account of Sweden's increased bio-blending target for 2030[4];
pdiesel(2020) is the price of blended diesel in 2020 (same as the baseline price in 2030); and
pdiesel(2030) the price of blended diesel in 2030 with increased bio shares.
The two diesel prices are calculated in columns (5) and (6) of Table 3.1.

Column (9) of Table 3.1 shows the percentage increases in the average cost of motor fuels to households in each country calculated according to (3.2a&b). We assume that the national percentage cost increase applies to the regions within a country.

Column (10) of Table 3.1 shows the cost increase for motor fuels in 2030, averaged across industries and households, caused by the adoption of the bio fuel targets. In calculating these averages, we applied shares from the Nordic-TERM database to the price increases in columns (7) and (9) in Table 3.1.

We assume that all motor fuels (fossil-based and renewable) are produced in a single Nordic-TERM industry, Petroleum and coal products. The coal component of this industry is negligible – we will refer to the industry simply as Motor fuels. We impose the price increases for Motor fuels from column (10) of Table 3.1 on the Motor fuels industry through a "technological deterioration" that causes an increase in inputs per unit of output. Then we introduce the different price increases for industries and households [columns (7) and (9)] through phantom taxes/subsidies.

Inputs to the Motor fuels industry

Here we describe the shocks that we applied in Nordic-TERM to simulate the switch from Oil to renewable materials in the Motor fuels industry.

With a switch towards bio fuels, the Oil input to Motor fuels per unit of output will fall and the input of materials from agriculture and forestry will rise. We assume that with the achievement of the biofuel targets in columns (1) and (2) of Table 3.1, the percentage reductions in oil input per unit of output in motor fuels will be in line with the percentage reduction in the non-bio shares of motor fuels. Our calculations are shown in Table 3.2. For DK, for example, the reduction is 1.1 per cent [= 100*((1-7/100)/(1-6/100)-1)].

For Denmark, we assume that Oil displaced by biofuels in 2030 is replaced by products from the Crops industry. For the other Nordic countries, we assume that the replacement materials are supplied from the Forestry industry. Initially, we assumed that the replacement of Oil per unit of output of motor fuels was with bio materials of equal value. But this caused difficulties in simulating the cost increases for Motor fuel implied by Table.3.1: too much cost increase concentrated on too small a share (the non-oil, non-bio share) of Motor fuel inputs. This led us to assume that replacement of Oil was with bio materials worth 1.5 times the value of the replaced Oil. With substantial increases in demands for the products of the Crops and Forestry industries, Nordic-TERM generates increases in the prices of these

[4] We calculated the cost of blended petrol for Sweden in 2020 as $1.01 = 0.82 + (0.28 - 0.12) * (1.81 - 0.61)$.

products. The model then indicates that part of the demand increases will be satisfied by increased imports and diversion of exports back onto the domestic market.

3.3. Electric vehicles (EV)

EV targets

The approximate targets for increasing the share of electric vehicles (EVs) in passenger car fleets are given in Table 3.3. 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[5], whereas Finland is targeting 750,000. These targets imply an increase of 23.1 percentage points in the share of EVs in Denmark and 24.0 percentage points for Finland.

For the other Nordic countries, we assume that EV shares in total sales of passenger cars in each year from 2020 to 2030 will be in line with current expectations: 70 per cent in Norway and 60 per cent in Sweden and Iceland. As explained in Appendix A3.2, these sale-share assumptions combined with assumptions concerning scrapping rates for 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 shares grow from 6.2 per cent to 48.1 per cent and from 4.6 per cent to 47.4 per cent.

Household consumption of motor fuels

As shown in the last column of Table 3.3, we assume that household consumption of motor fuels declines in line with in the increase in the EV share of the passenger car fleet. Thus, for example, we assume that EV policies in Denmark mean that household consumption of motor fuels in 2030 will be 23.5 per cent lower because of the EV policy than it would be without the policy [-23.5 = 100*((1-25.0/100)/(1-1.9/100)-1)]. We assume that this 23.5 per cent reduction applies to all NUTS2 regions in DK. Similarly, for the other Nordic countries, we assume that the national reductions in household consumption of Motor fuels in 2030 apply in all regions.

Household demand for electricity

Increases in the numbers of electric vehicles imply increases in the demand for electricity by households. In terms of pure energy, electricity demand does not have to increase in the same proportion as the reduction in demand for Motor fuels. As noted in guidelines published by the Finnish Transport authority (TrafiCom), the cost of driving a car in the compact class one hundred kilometers is about 12.5 euros with fossil fuels but only about 4.5 euros with electricity. This is because electric motors are much more energy efficient than combustion engines. A combustion engine is able to turn roughly a third of the energy content of motor fuels into motion, whereas an electric motor scarcely wastes any energy stored in the battery. Moreover, EVs are able to capture some of the energy lost in braking. Consequently, the increase in the demand for electricity in energy terms is only about a third of that in the replaced motor fuels. Taking the one-third principle into account, together with the baseline (no policy) levels of household electricity consumption, we calculated that EV policies would increase electricity consumption in 2030 at national levels by the percentages

[5] The Danish parliament declared a more ambitious target of a million EVs in 2020 but thus far there are policies in place for supporting the earlier government target of 775000 EVs by 2030.

shown in Table 3.4. The percentage shocks applied at the regional level to capture the increases in household electricity consumption varied from the national percentages shown in Table 3.4. This reflects differences across regions within a country in the shares of total consumption accounted for by Electricity and Motor fuels: regions with a relatively high electricity share and a low motor-fuel share in the baseline solution for 2030 needed a relatively low percentage shock to their electricity consumption to account for replacement of motor fuels by extra electricity.

Cost of home charging stations

As households acquire EVs, they will also need to install home charging stations. The current price of a standard 21 KW station is around 1000 euros. To have it installed costs an additional 1100 euros (estimate from Finland applied to the other Nordic countries). We assume one home charging station per EV. Using 2100 euro and the increase in the number of the EVs, gives a rough estimate of the extra cost to households over the period 2020 to 2030 of installing charging stations to accommodate extra EVs. These estimates are given in Table 3.5, calculated as the increase in EVs times 2100.

Our simulations are concerned with how greenhouse policies affect the Nordic economies of 2030. Consequently, we require an estimate of the cost to households in 2030 of charging stations, not the total cost between 2020 and 2030. To obtain the cost in 2030, we divide the total cost by 10. We assume that the resulting number (e.g. 153m euro for Denmark) is extra expenditure that households are required to make in 2030 on electrical equipment. In allocating the national cost of charging stations to regions within a country, we used regional shares in baseline 2030 household consumption of motor fuels. These shares are a proxy for regional shares in the passenger car fleet, and therefore a proxy for regional shares in the national purchase of EVs.

Prices of EVs

We considered the prices of EVs. Initially these were considerably higher than those of equivalent combustion-engine cars. However, the price of EVs is fast approaching the price of combustion-engine cars. Most industry commentators predict that price equality between EVs and internal combustion vehicles will be achieved around 2025. This seems to be the view of many car manufacturers as well; for example, the CEOs of both VW Group and Volvo have recently shared the above prediction[6]. Some of the Nordic countries are already reducing the subsidization of EVs. In our simulations, we assume that the prices of EVs in 2030 are similar to those of the cars that they replace.

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[6] Volkswagen foresees EV price parity with ICE by 2025, 50% EV sales by 2030 - CNET
Volvo CEO's bold prediction: EV-ICE price parity by 2025 | Automotive News (autonews.com)

Table 3.4. EV-related % increase in household electricity consumption in 2030

Denmark	3.32
Finland	2.60
Sweden	2.98
Norway	7.87
Iceland	1.66

Table 3.5. Calculating extra household expenditures on charging stations

	EVs 2020	EVs 2030	Total cost 2020-30 M€	Cost in 2030, M€
Denmark	48617	775,000	1,525	153
Finland	55,275	750,000	1,459	146
Sweden	308485	2,915,013	5,474	547
Norway	612136	2,067,528	3,056	306
Iceland	11,988	149,286	288	29

3.4. Electricity generation sector

We assume that by 2030 the use of coal in power generation will have almost entirely disappeared. We simulate this by scrapping 90% of the capital (and also investment) in Nordic-TERM's ElecCoal industry. We make a corresponding reduction in the aggregate capital stock of the nation. In our simulations, Coal electricity is replaced endogenously by low or zero-carbon alternatives.

Appendix A3. Detailed modelling to facilitate the setting of policy shocks

A3.1. Translating bio shares for motor fuels into bio shares for diesel

The motor-fuel bio share (MFBioSh) for each country is given by

$$\begin{aligned} \mathrm{MFBioSh} = {} & \mathrm{SS_I} * \mathrm{DieselBioSh} \\ & + \mathrm{SS_H} * \mathrm{DieselCarSh} * \mathrm{DieselBioSh} \\ & + \mathrm{SS_H} * (1 - \mathrm{DieselCarSh}) * \mathrm{GasolineBioSh} \end{aligned} \qquad \text{(A3.1.1)}$$

where

SS_I and SS_H are the shares of the sales of Motor fuels that go to industries (mainly the transport industries) and households;
DieselBioSh is the renewable share in diesel fuels;
DieselCarSh is the share of the combustion-engine passenger fleet that uses diesel fuel; and
GasolineBioSh is the renewable share in gasoline fuels.

In (A3.1.1), we assume that motor fuels supplied to industries are entirely diesel, whereas households use both diesel and gasoline in the passenger-car fleet.

Rearranging (A3.1.1) we obtain

$$\text{DieselBioSh} = \frac{\text{MFBioSh} - SS_H * (1 - \text{DieselCarSh}) * \text{GasolineBioSh}}{SS_I + SS_H * \text{DieselCarSh}} \quad \text{(A3.1.2)}$$

Values for SS_I and SS_H can be deduced from the Nordic-TERM database. For DieselCarSh, we use the values shown in column (8) of Table 3.1 for both 2020 and 2030. For GasolineBioSh, we use 0.12 for all countries in 2020 and 2030, except Sweden in 2030 for which we assume 0.28. Then, we evaluate the RHS of (A3.1.2) with MFBioSh set according to the numbers in columns (1) and (2) of Table 3.1. This reveals DieselBioSh for each country in 2020 (column 3) and the targets for 2030 (column 4).

A3.2. Calculating the EV share of the car fleet

In forming the entries for Denmark and Finland in the first column of Table 3.3 we deduced the EV shares for 2030 in their passenger car fleets by comparing the explicit EV targets with estimates of the total sizes of their passenger car fleets.

For Norway, Sweden and Iceland, we deduced EV shares for 2030 in their passenger car fleets from assumptions concerning EV shares in annual sales of passenger cars from 2020 to 2030.

To make the link for these three countries between annual EV sales and the EV share in the stock of passenger cars in 2030, we started by assuming that the total stock of cars (internal combustion and EV) at the beginning of year t, S(t), is given by:

$$S(t) = \sum_{\tau=0}^{L} N(t-\tau) * Z(\tau) \quad \text{for t= 2020, 2021, …} \quad \text{(A3.2.1)}$$

where

N(t-τ) is new cars purchased in year t-τ. For convenience, we assume that all purchases take place at the start of the year.
S(t) refers to the stock at the start of year t.
L is the maximum life of a car, assumed to be 20 years.
Z(τ) is the survival fraction for cars of age τ. The values we have adopted are contained in Table A3.2.1. We assume that all cars purchased in the current year and each of the previous 4 years are still on the road (survive). Of the cars purchased 5 years earlier, 93.75 per cent survive to the current year, etc. The survival rates in Table A3.2.1 imply an average road life for cars of 12.5 years.

For Norway, Sweden and Iceland, we assume that car sales grew at 2 per cent a year from the start of 2000 to the start of 2020 and that this growth rate continues to the start of 2030.

We adopt an equation similar to (A3.2.1) for the stock of EVs:

$$SEV(t) = \sum_{\tau=0}^{L} NEV(t-\tau) * Z(\tau) \quad \text{for t= 2020, 2021, …} \quad \text{(A3.2.2)}$$

where

NEV(t-τ) is new EV cars purchased at the start of year t-τ; and
SEV(t) is the stock of EVs at the start of year t.

Table A3.2.1. Longevity of passenger vehicles

Age (years)	Survival fraction, $Z(\tau)$	Age (years)	Survival fraction, $Z(\tau)$
20	0	9	0.6875
19	0.0625	8	0.75
18	0.125	7	0.8125
17	0.1875	6	0.875
16	0.25	5	0.9375
15	0.3125	4	1
14	0.375	3	1
13	0.4375	2	1
12	0.5	1	1
11	0.5625	0	1
10	0.625		
		Average life	12.5 years

We assume that there are no EV purchases before 2016. At the start of each of the years 2016, 2017, 2018, 2019 and 2020, we assumed that NEV(t) is 1/5th of the EV stock in existence at the start of 2020. Thus, we chose NEV(t) for these 5 years for Norway to imply an EV stock in 2020 of 22.1 per cent (see Table 3.3) of Norway's total passenger fleet. For Sweden and Iceland, we chose the NEV(t)s for 2016-2020 to imply EV stocks in 2020 of 6.2 and 4.6 per cent of their total passenger fleets.

Finally, we assume that the EV policy in Norway is implemented by setting the EV fraction of sales for each year from 2021 onwards at 70 percent (see Table 3.3). For both Sweden and Iceland, we assume 60 per cent. Given these percentages, and the assumed paths for total sales, we can calculate the future paths for EV sales according to:

$$\mathrm{NEV}(t) = \mathrm{F\_EV}(t) * \mathrm{N}(t) \quad \text{for t= 2021, …} \qquad \text{(A3.2.3)}$$

where

F_EV(t) is the annual target share for EV sales.

We then apply (A3.2.1) and (A3.2.2) to calculate total stocks of passenger vehicles in 2030, S(2030), and EV stocks in 2030, SEV(2030). These calculations give the EV policy shares shown in Table 3.3: 62.2 per cent for Norway; 48.1 per cent for Sweden; and 47.4 per cent for Iceland.

4. THE EFFECTS OF NORDIC GREENHOUSE POLICIES: PERCENTAGE DEVIATIONS FROM NO-POLICY BASELINE

This section presents simulation results for the effects on the Nordic economies of the greenhouse policy shocks described in section 3 (summarized at the start of section 3).

For the most part, the results are expressed as percentage deviations in 2030 from the no-policy baseline described in section 2. For example, the first result in Table 4.1 means that real household consumption in DK in 2030 is 1.321 per cent less with the greenhouse policies than it would be without the policies.

In presenting the results, we start with macro effects at the national level. Then we go to industry output effects at the national level. This is followed by labour-market effects at the national and regional levels. Next, we look at effects on the costs of living for households classified by urban/intermediate/rural and income decile in the Nordic countries. Finally, we calculate the contribution of the Nordic policies to greenhouse abatement.

4.1. Macro effects at the national level

Table 4.1 shows results for national macro variables. The big picture is that the greenhouse policies described in section 3 will have moderate macroeconomic costs for the Nordic countries. On account of these policies: their real GDPs 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 [=100*(1.215*(1-0.131)-1)] between 2019 and 2030 rather than by 21.5 per cent (see the baseline growth projections in Table 2.1)

As will become apparent in the detailed explanation, the results in Table 4.1 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 doesn't affect the results for industry outputs and other real variables.
- aggregate investment in each Nordic country during the period from 2019 to the start of 2030 is not affected by greenhouse policies. This 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. Thus, we assume that business confidence in 2030 is determined independently of greenhouse policies. In combination 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. Thus, we assume that the costs of greenhouse policies are shared equally between the public and private sectors.

With these assumptions in mind, we explain these results in Table 4.1 starting with the real GDP deviations in row 7.

Real GDP deviations (row 7, Table 4.1)

The real GDP results can be understood via the stylized equation:

$$\text{real GDP} = F\left(NR, K, L, Tech, Eff\right) \tag{4.1}$$

Table 4.1. Macro effects (%) in 2030 of greenhouse policies in Nordic countries

		DK	FI	SE	NO	IS
1	Real h'hold cons (C)	-1.32	-1.27	-1.51	-1.14	-0.59
2	Real investment (I)	0.11	-0.06	-0.05	0.21	0.00
3	Real gov cons (G)	-1.32	-1.26	-1.43	-0.93	-0.59
4	Real GNE (combination of C, I, G)	-1.01	-1.00	-1.13	-0.74	-0.49
5	Export volumes (X)	-1.2	-2.66	-2.75	-2.61	0.63
6	Import volumes (M)	-1.36	-2.83	-2.34	-1.23	0.06
7	Real GDP	-0.73	-1.16	-1.31	-1.22	-0.18
8	Aggregate employment	0.00	0.00	0.00	0.00	0.00
9	Ave real wage	-0.76	-2.15	-2.64	-0.68	-0.70
10	Aggregate cap stock	-0.65	-0.10	0.00	0.00	0.00
11	GDP price index	-0.81	-0.02	-0.00	-0.19	-0.59
12	Private consumption price (CPI)	-0.20	0.06	0.16	-0.45	-0.18
13	Export price index	-0.40	1.52	1.74	1.86	-0.18
14	Import price index	0.93	0.67	0.31	0.34	0.39
15	Population	0.00	0.00	0.00	0.00	0.00
16	Welfare	-0.99	-0.72	-0.91	-0.38	-0.29

Sim C18_p22 may 20, 2023

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 optimize the aggregate value of production. Using this stylized framework, Table 4.2 decomposes the real GDP deviations from row 7 of Table 4.1 into four parts. Labour (L) is omitted from this decomposition because we assume that the greenhouse policies have no effect on aggregate employment in 2030, see row 87 of Table 4.1. The decomposition in Table 4.2 quantifies the other four driving effects:

- ***reduced oil production*** (reduced use of natural resources). This is important for Norway (NO) and to a lesser extent Denmark (DK). It doesn't affect the other 3 countries.
- ***capital loss***. This arises from early scrapping of coal-fired electricity generation capacity. The main effect is for Denmark. By 2019, the other Nordic countries had very little coal-generated electricity and consequently their real GDP in 2030 is barely affected by our assumption of a 90% phase out of remaining capacity.
- ***deterioration in production technology***. This arises from our assumption that the movement towards bio-diesel increases the cost of providing motor fuels. This 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. This happens in the current simulation because households switch from petroleum and coal products (very highly taxed) to electricity (taxed at lower rates than petroleum).

Table 4.2. Decomposition of GDP effects: percentage contributions

	Natural resource use (oil)	Capital loss (coal)	Production efficiency (Petrol prods)	Dead-weight losses (switch to electricity)	Real GDP
DK	-0.24	-0.21	-0.02	-0.25	-0.73
FI	0.00	-0.02	-0.80	-0.35	-1.16
SE	0.00	0.03	-0.91	-0.42	-1.31
NO	-0.45	-0.01	-0.38	-0.39	-1.22
IS	0.00	0.01	0.00	-0.19	-0.18

Using Table 4.2, we can see that the real GDP loss for IS is small because: IS doesn't produce oil and suffers no reduction in its use of natural resources;

- IS doesn't produce coal-fired electricity and suffers no capital loss[7];
- IS produces very little motor fuel and consequently suffers almost no deterioration in economy-wide production technology; and
- households in IS have a relatively low budget share for petroleum products so that the switch towards electricity causes a relatively small efficiency loss.

By contrast, SE has a relatively large GDP loss because SE makes a large switch to biofuels [see columns (1) and (2) of Table 3.1] which is reflected in Table 4.2 by a large entry in the production-efficiency column.

Real private and public consumption (rows 1 and 2, Table 4.1)

Real private and public consumption fall relative to real GDP in four of the Nordic countries. The exception is NO. In our simulation, we assume that the value of private consumption in each region moves with the value of the region's GDP. Consequently, the value of private consumption in each nation moves approximately with the value of the national GDP. In real terms, private consumption at the national level falls relative to GDP in four Nordic countries because in these countries the price of private consumption rises relative to the price of GDP (rows 11 and 12, Table 4.1). Public consumption is assumed to move with private consumption in real terms in each region and this relationship is approximately maintained at the national level. Thus, real public consumption at the national level falls relative to real GDP for the four countries. For NO, the price of private consumption falls relative to the price of GDP. Consequently, for NO real national public and private consumption rise relative to real GDP.

A key determinant of movements in the price of private consumption relative to the price of GDP is the terms of trade (the movement in export prices relative to import prices, rows 13 and 14). 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. This is because GNE includes imports, but not exports, whereas GDP includes exports but not imports. Within GNE, the price deflator for private consumption rises in all countries

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[7] Table 4.2 shows a tiny capital contributions for IS, SE and NO despite capital deviations of zero row 10, Table 4.1. This is a numerical quirk explained by differences between the baseline and policy runs in the capital shares in GDP.

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 DK and IS are 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 DK and IS import a lot of petroleum products relative to their exports of these products. Thus, both these countries suffer a terms of trade decline. This, 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.

FI, SE and NO (particularly NO) 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, for FI and SE 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 NO, 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 4.1)

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 for all countries except NO because we use consumer prices (rather than the GDP prices) to deflate nominal wages.

Welfare (rows 16, Table 4.1)

In calculating changes in welfare, we include changes in most components of household consumption. But we leave out the increase in electricity consumption and the reduction in motor-fuel consumption associated with the uptake of electric cars. We also leave out the increase in expenditure on electrical equipment associated with the installation of household charging stations. The reduction in expenditure on motor fuels dominates the increase in expenditures on electricity and charging stations. Thus, leaving out 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 through an example. If expenditure on electrical equipment needs to increase by 25 per cent because of 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 technicalities of calculating welfare changes are in Appendix A4.

GDP deflator (row 11, Table 4.1)

The movements in price deflators for GDP are negative, indicating that the Nordic greenhouse policies cause real devaluation. (Recall that we assume no movement in nominal exchange rates, second dot point in section 4.1.) The starting point for understanding this feature of the results is the equation:

$$\text{real GDP} - \text{ real GNE} = \text{X} - \text{M} \tag{4.2}$$

that is, 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 NO. However, we assume that the movements in investment are small, implying an increase in investment to real GDP in all Nordic countries. . This is sufficient to convert the declines in consumption relative to GDP for FI and SE into increases in real GNE relative to real GDP. Thus for FI and SE, together with NO, we must have a decrease in X-M. For DK and IS, X-M must increase, reflecting reductions in real GNE relative to real GDP.

For DK, there is a direct negative effect on exports via international reduction in demand for Danish oil. Nevertheless, X-M must increase. This is facilitated by real devaluation, that is a reduction in the Danish price level (price of GDP, row 11, Table 4.1) relative to that of the rest of the world. For IS, there is little direct negative effect on exports. The small real devaluation necessary to increase X-M stimulates exports. Although imports become more expensive, there is a small positive effect on M (row 6). This arises from high use of imported inputs by export-oriented industries.

For SE and NO there are direct negative effects on exports. For NO this is via contraction in demand for oil. For SE, 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 SE's exports. These direct negatives for NO and SE's exports are sufficient to require a reduction in 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 NO and SE, row 11).

For FI, the export-to-import ratio rises slightly (rows 5 and 6). This is contrary to expectation, because we know that X-M must fall. Closer inspection of our results reveals that X – M does indeed fall. It turns out that for FI, X is sufficiently greater than M that a 2.66 per cent reduction in X (row 5) outweighs a 2.83 per cent reduction in M (row 6), that is

$$\Delta(\text{X} - \text{M}) = -0.0266 * \text{X} + 0.0283 * \text{M} < 0 \tag{4.3}$$

Similarly to SE, there is a direct negative impact on FI'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 (FI's GDP deflator falls by only 0.02 per cent), FI's real imports fall by 2.83 per cent, reflecting the reduction in economic activity and the import intensity of FI's motor-fuels industry. It happens that a 2.83 reduction in imports in combination with the direct negative export effects is sufficient to generate the required decrease in X-M, with almost no real exchange rate movement.

4.2. Industry effects at the national level

Table 4.3 shows the effects in 2030 of the Nordic greenhouse policies on industry outputs at the national level. For some industries, the results in Table 4.3 flow directly from special treatments in the formulation of the policy shocks. For other industries, the results come mainly via macro effects. In this subsection, we provide explanations for a selection of industries.

These explanations are divided into two parts. First we deal with industries for which the results are directly related to the greenhouse policy shocks. Then we deal with a group of industries for which the results flow mainly from changes in the macro economy.

Industries with special treatments in the shocks representing Nordic greenhouse policies

1. Crops

This industry is stimulated in DK as an input to the production of motor fuels. The negative results for FI, SE and IS are caused by loss of international competitiveness related to increased costs of petroleum products that are used intensively as an input to crop production. Crop production in NO 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 NO becomes relatively cheap.

3. Forestry & logging

This industry is strongly stimulated in FI, SE and NO by use as an input to the production of motor fuels. We also assume that forestry and logging provides the bio-input for motor fuels in IS. This is unimportant because IS does not produce significant amounts of motor fuels. Forestry and logging is stimulated in DK by trade effects.

3. Coal

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

6. Oil

Production is reduced in all producing countries through reduced demand in the creation of motor fuels. This is significant in NO.

Under our assumption that greenhouse policies barely affect aggregate capital for each country at the start of 2030, the contraction of NO's oil industry (a capital intensive industry) releases considerably more capital than labour to be absorbed by other NO industries. This leads to a small reduction in NO 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.

7. Gas

Production is stimulated in DK, FI and NO via stimulation of ElecGas, see discussion of industries 29 to 33.

Table 4.3. Effects on industry* output (%) in 2030 of Nordic greenhouse policies

	DK	FI	SE	NO	IS
1 Crops	0.77	-3.65	-6.12	1.21	-3.86
2 Livestock	0.42	-0.34	-0.25	0.58	-1.34
3 ForestryLogs	8.30	27.29	61.55	96.02	0.48
4 FishingAqua	*NA*	-0.55	-5.02	1.24	-1.92
5 Coal	*-78.87*	-58.02	-11.92	-14.19	*NA*
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	-1.23	0.93	1.29
9 FoodBevTob	0.31	-0.52	-0.59	0.53	-0.97
10 Textiles	1.32	-0.93	-3.93	1.70	0.87
11 Apparel	0.49	-0.22	-3.85	1.20	-0.62
12 LeatherPrd	0.45	-0.39	-4.11	0.54	-0.08
13 WoodProds	4.10	-4.79	-6.63	-1.13	0.82
14 PaperProds	2.40	-3.35	-5.27	0.83	0.33
15 PetrolCoalP	-5.51	-22.26	-37.58	-17.11	*NA*
16 ChemicalPrd	17.18	-7.83	-15.90	-0.25	6.69
17 Pharmaceutic	2.14	-1.41	-1.05	-0.32	-1.15
18 RubberPlas	3.11	-0.10	-0.85	0.54	0.75
19 NonMetMinPrd	1.76	0.06	-1.88	-0.23	1.12
20 FeMetals	6.91	0.58	-2.71	4.33	2.50
21 NonFeMetals	2.61	-1.22	-0.24	3.04	4.13
22 FabriMetals	1.27	0.07	0.39	2.48	-0.19
23 Computer &optics	0.80	0.21	0.99	0.74	-0.28
24 ElectricEqp	2.00	1.59	1.36	3.90	3.09
25 MachineNEC	0.80	0.43	0.54	1.23	-0.53
26 MotorVehicle	0.52	0.42	0.54	0.79	-0.74
27 OthTransEqp	1.11	1.30	-0.05	1.79	-0.69
28 FurnitRepair	0.59	-0.58	-0.09	0.14	-0.56
29 ElecCoal	-88.72	-87.90	*NA*	*NA*	*NA*
30 ElecGas	65.51	4.42	-18.48	12.04	*NA*
31 ElecOther	102.94	-38.50	-24.82	18.32	*NA*
32 ElecHydro	*NA*	15.82	4.31	4.19	1.98
33 ElecNuc	*NA*	14.83	3.12	*NA*	*NA*
34 ElecDist	2.73	0.69	0.69	3.39	1.98
35 GasSupDist	1.17	*NA*	-3.62	4.99	*NA*
36 Water	-0.03	-0.73	-0.66	-0.09	-0.14
37 Construction	0.16	-0.23	-0.18	0.22	0.01
38 Wholesale & retail	0.50	-0.49	-0.63	0.18	-0.13
39 AccomFood	-1.06	-0.49	-0.58	-0.35	-0.31
40 LandTransprt	0.96	-0.67	-1.08	0.25	-0.32
41 WaterTrnsprt	-0.80	-3.16	-6.09	-0.78	0.75
42 AirTransport	0.38	-0.08	-0.28	-0.25	-0.11
43 Warehousing	0.52	-0.59	-0.95	0.42	0.16
44 Communication	0.17	-0.27	-0.13	0.44	-0.12
45 Finance	0.42	-0.12	-0.01	0.24	-0.17
46 InsurPension	0.85	-0.06	0.35	0.52	-0.38
47 RentLease	-0.21	-0.53	-0.49	0.25	-0.04
48 OthBusSrv	0.43	-0.08	0.16	0.62	-0.06
49 Recreation &per serv	-0.36	-0.35	-0.52	0.19	0.00
50 PubAdm & defence	-1.14	-1.16	-1.31	-0.73	-0.49
51 Education	-0.49	-0.72	-0.79	-0.36	-0.31
52 Health &social serv	-1.28	-1.07	-1.22	-0.71	-0.47
53 Services of dwellings	-1.23	-1.37	-1.33	-0.12	-0.41
Absorption of electricity**	0.55	0.78	0.68	3.27	1.98

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 made a few aggregations. For example our industry 1, Crops, is an aggregation of the first 8 GTAP industries. We have also disaggregated the GTAP electricity generation industry into 5 generating industries (our industries 29-34).

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

13. Wood prods

This industry contracts in FI, SE and NO because of cost increases caused by the diversion of raw materials (forestry and logging) into motor fuels. In DK the industry gains competitive advantage and expands.

15. Petroleum & coal products

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

24. Electrical equipment

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

29 to 33. Electricity generating industries

In DK, ElecCoal is phased out and replaced by ElecGas and ElecOther. ElecOther is a heterogeneous collection that includes solar, wind and oil-based capacity. ElecticHydro and ElectricNuc don't operate in DK.

In FI, ElecCoal is replaced mainly by ElecNuc. There are also minor contributions from ElecHydro and ElecGas. In FI, 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.

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

Like SE, NO has no ElecCoal. NO relies heavily on ElecHydro, with minor contributions from ElecGas and ElecOther. Both ElecGas and ElecOther (which doesn't have a significant oil input) become cheap in NO relative to the comparable products in the other Nordic countries. This enables NO to expand its exports, which were already significant in 2019.

IS relies entirely on ElecHydro (includes thermal). Expansion of output must match expansion in IS's absorption of electricity.

As shown in the last row of Table 4.3, absorption of electricity increases in all the Nordic countries reflecting the increase in the use of electric vehicles.

Industries for which macro and trade effects dominate

16. Chemical products

This is a trade-exposed industry with considerable exports from all Nordic countries. In DK and IS, the industry benefits from real devaluation. In FI, SE and NO, the benefits of real devaluation are offset by increases in the price of petroleum and coal products. The chemical products industry in FI, SE and NO is much more intensive in its use of petroleum and coal products than it is in DK and IS.

9-28 excluding 15 & 16. Other trade-exposed manufacturing industries

Table 4.3 shows 90 results for these industries, 18 industries by 5 Nordic countries. 36 of these results are negative and 54 are positive.

The industries in this group are heavily trade exposed, 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 for DK (see row 11 in Table 4.1). For DK real devaluation is dominant. All the industries in this group of 18 show a positive result for DK in Table 4.3. For FI, SE and NO, real devaluation is moderate, leaving a mixture of positive and negative results for these 18 trade-exposed industries.

For IS, real devaluation measured by the reduction in the price deflator for GDP is almost as great as for DK (0.59 per cent compared with 0.81 per cent, row 11 in Table 4.1). Yet, for IS, 10 of the 18 industries in this trade-exposed group exhibit negative output deviations. The explanation is that some of IS's export industries such as non-ferrous metals are heavily dependent on imported inputs. This limits the ability of real devaluation to stimulate exports and improve the trade balance. It is also true that a major export for IS is food to the Nordic countries and the rest of Europe. The reduction in private consumption in these countries inhibits IS exports.

38 to 53. Public and private sector service industries

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

For example, industries 43 to 48 in NO have small positive output deviations. All of these industries have non-negligible export sales, typically 5 to 10 per cent. The competitiveness of these industries in NO is enhanced relative to competitors in other Nordic countries leading to export expansion and NO's small positive output deviations. The competiveness effect for these industries in NO arises from the reduction in the cost of using capital relative to the cost of using labour, explained in our discussion of industry 15, oil. According to our database, industries 43 to 48 in NO are considerably more capital intensive than the corresponding industries in the other Nordic countries, and gain significant cost advantage from NO's reduction in the cost of using capital.

4.3. Labour-market effects

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

Industry employment results are generated directly by Nordic-TERM at the sub-national regional level and then aggregated to the national level. Employment results follow in a predictable way from industry output results such as those described at the national level in subsection 4.2. Then the occupational results flow 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, education requirement and age composition of employment in each occupation. Details of the theory and data used in generating labour-market effects are in RM2, available at ###Carlos to post on line somewhere #.

Because 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 smoothed by their spread across occupations.

Employment by industry

Table 4.4 shows greenhouse-related deviations in employment by industry for the Nordic countries. In most cases, the employment deviation in Table 4.4 is similar to the output deviation in Table 4.3, but there are exceptions.

Output of petroleum and coal products (industry 15) falls sharply in all producing countries but employment rises. This follows from the "technological deterioration" that we introduced to account for the cost increase for motor fuels caused by the switch towards bio-diesel. With this switch, 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. This can be seen in the coal results for FI and NO. In FI, coal (includes peat) output falls by 58.02 per cent and coal employment falls by 74.26 per cent. In NO, 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 Tables 4.3 and 4.4 stay in line. This 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 FI and SE. In both cases, output contracts but employment increases. We traced these strange results to the effects of aggregation across NUTS2 regions within FI and SE. 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.

Employment by occupation

The first two panels of Table 4.5 show growth in employment between 2019 and 2030 by selected occupations in the baseline and policy runs. The policy-induced deviations in employment by occupation in 2030 are in the bottom panel.

The bottom panel 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 4.4, employment falls in most consumption-oriented industries such as Health & social services (ind 52).

Table 4.4. Effects on industry employment (%) in 2030 of greenhouse policies in Nordic countries

	DK	FI	SE	NO	IS
1 Crops	0.85	-3.80	-6.28	1.31	-4.38
2 Livestock	0.43	0.02	0.18	0.57	-1.52
3 ForestryLogs	9.51	32.72	74.94	121.70	0.63
4 FishingAqua	-0.86	0.13	-7.94	2.11	-3.37
5 Coal	*NA*	-74.26	-23.06	-31.10	*NA*
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	-0.46	1.06	1.57
9 FoodBevTob	0.26	-0.02	-0.04	0.40	-0.82
10 Textiles	1.27	-0.55	-3.49	1.59	0.98
11 Apparel	0.45	0.23	-3.31	1.03	-0.45
12 LeatherPrd	0.42	0.09	-4.04	0.37	0.03
13 WoodProds	4.06	-4.44	-6.11	-1.23	0.89
14 PaperProds	2.35	-2.83	-4.69	0.72	0.49
15 PetrolCoalP	5.70	70.23	118.24	3.51	*NA*
16 ChemicalPrd	17.08	-7.16	-15.13	-0.46	6.84
17 Pharmaceutic	2.07	-0.58	-0.06	-0.57	-0.99
18 RubberPlas	3.05	0.34	-0.25	0.43	0.86
19 NonMetMinPrd	1.72	0.46	-1.38	-0.35	1.18
20 FeMetals	6.88	0.93	-2.20	4.19	2.60
21 NonFeMetals	2.58	-0.59	0.26	2.89	4.25
22 FabriMetals	1.23	0.42	0.86	2.39	-0.14
23 Computer &optics	0.75	0.80	1.70	0.59	-0.20
24 ElectricEqp	1.95	2.11	1.98	3.77	3.19
25 MachineNEC	0.75	0.90	1.13	1.12	-0.43
26 MotorVehicle	0.46	0.78	1.18	0.69	-0.64
27 OthTransEqp	1.07	1.58	0.61	1.75	-0.66
28 FurnitRepair	0.55	-0.08	0.49	0.05	-0.45
29 ElecCoal	-85.82	-81.36	*NA*	*NA*	*NA*
30 ElecGas	65.38	5.42	-17.67	11.83	*NA*
31 ElecOther	103.34	9.96	19.06	18.03	*NA*
32 ElecHydro	*NA*	16.73	5.29	3.99	2.11
33 ElecNuc	*NA*	15.85	4.24	*NA*	*NA*
34 ElecDist	2.61	1.53	1.65	3.13	2.12
35 GasSupDist	1.03	*NA*	-2.82	4.74	*NA*
36 Water	-0.08	-0.39	-0.32	-0.19	-0.07
37 Construction	0.13	0.13	0.26	0.10	0.06
38 Wholesale & retail	0.46	-0.04	-0.13	0.09	-0.03
39 AccomFood	-1.10	-0.15	-0.21	-0.41	-0.23
40 LandTransprt	0.92	-0.29	-0.54	0.10	-0.26
41 WaterTrnsprt	-0.88	-2.73	-5.66	-0.92	0.78
42 AirTransport	0.34	0.51	0.2	-0.31	0.03
43 Warehousing	0.46	-0.03	-0.19	0.24	0.25
44 Communication	0.12	0.30	0.51	0.28	0.02
45 Finance	0.36	0.26	0.57	0.00	-0.04
46 InsurPension	0.83	0.53	1.07	0.34	-0.25
47 RentLease	-0.32	0.29	0.43	0.02	0.14
48 OthBusSrv	0.38	0.35	0.64	0.50	0.06
49 Recreation &per serv	-0.42	0.10	0.03	0.05	0.09
50 PubAdm & defence	-1.17	-0.86	-1.01	-0.83	-0.44
51 Education	-0.51	-0.57	-0.65	-0.41	-0.28
52 Health &social serv	-1.30	-0.92	-1.08	-0.75	-0.44
53 Services of dwellings	-1.36	-0.26	-0.13	-0.42	-0.22

For Printing occupations, there is a mixed picture in the bottom panel of Table 4.5: positive for DK, NO and IS, and negative for FI and SE. The main employing industry for this occupation is Paper products (ind 14). Paper products has positive employment results for DK, NO and IS in Table 4.4, and negative results for FI and SE.

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. This reflects stimulation of employment opportunities in Electrical equipment (ind 24), Construction (ind 37), a variety of manufacturing industries, and motor fuels (recall that employment in motor fuels expands with the adoption of biodiesel). With the exception of IS, employment opportunities increase for Agricultural, forestry and fishing labourers reflecting the expansion of industries providing bio-materials to motor fuels.

Employment by wage-band, age and education

Tables 4.6 to 4.8 are set out in a similar manner to Table 4.5.

The first two panels of Table 4.6 show growth in employment between 2019 and 2030 by wage band in the baseline and policy runs. Wage bands refer to hourly wage rates in 2019: less than 25 Euro per hour; 25 to 40 Euro per hours, etc.

The policy-induced deviations in employment by wage band in 2030 are in the bottom panel of Table 4.6. The deviation results are small, less than 1 per cent in all cases. They show no clear pattern. In DK and IS, the simulated greenhouse policies have small negative effects on employment in the lowest wage band and positive effects on employment on the other bands.

In SE the effects are slightly positive in low-wage bands and negative in high-wage bands. In FI and NO there are mixed pictures.

Overall, Table 4.6 indicates that greenhouse policies have a negligible impact on the distribution of jobs across wage bands.

Tables 4.7 and 4.8 show that greenhouse policies have a negligible impact on the distribution of jobs across age and education requirements.

Employment by region

The first two rows for each Nordic country in Table 4.9 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: recall from section 4.1 that we assume that greenhouse policies do not affect aggregate national employment in 2030.

All of the regional deviations are less than 1 per cent in absolute terms. The largest positive deviations are 0.37 per cent for SE31 (Norra Mellansverige) and 0.36 per cent for NO03 (Sør-Østlandet). The largest negative deviation is -0.94 per cent for FI20 (Åland),

As explained in section 2.6, regional results can be analyzed 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

Table 4.5. Total growth in employment (%) between 2019 and 2030 by selected occupation

No-policy baseline	DK	FI	SE	NO	IS
4 Hospitality & retail manager	1.1	-0.1	5.4	7.8	3.9
5 Scient & engineer professional	-3.8	-4.5	-0.1	3.8	-0.8
6 Health professional	4.3	4.7	9.8	9.8	7.7
19 Other clerk	-1.5	-1.4	0.9	6.1	0.9
22 Personal care worker	4.9	5.1	10.2	9.7	6.8
27 Metal machine trade	-9.4	-8.8	-3.8	1.2	-3.7
28 Printing	-9.2	-5.5	-1.0	-1.0	-0.5
29 Electrical trade	-5.6	-7.4	-2.4	0.5	-3.4
34 Cleaners & helpers	0.5	-0.7	3.8	6.5	7.4
35 Agr, forest, fishing labourer	-16.6	-13.9	-14.8	-7.3	-8.0
37 Food prep assistant	4.0	4.9	9.5	8.9	1.8

Policy	DK	FI	SE	NO	IS
4 Hospitality & retail manager	1.3	-0.3	5.4	7.8	3.9
5 Scient & engineer professional	-3.6	-4.2	0.2	3.9	-0.5
6 Health professional	3.2	3.9	8.8	9.0	7.3
19 Other clerk	-1.3	-1.4	1.2	6.1	0.9
22 Personal care worker	3.8	4.3	9.2	9.0	6.4
27 Metal machine trade	-8.4	-8.5	-3.6	1.9	-3.1
28 Printing	-7.7	-7.3	-3.5	-0.5	-0.4
29 Electrical trade	-5.3	-6.9	-2.2	0.7	-2.8
34 Cleaners & helpers	0.4	-0.7	3.9	6.7	7.2
35 Agr, forest, fishing labourer	-15.9	-6.0	7.2	-0.6	-9.2
37 Food prep assistant	3.2	4.7	9.3	8.6	2.0

% deviations, 2030	DK	FI	SE	NO	IS
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	-0.9	-0.7	-0.4
19 Other clerk	0.2	0.0	0.2	0.0	0.0
22 Personal care worker	-1.1	-0.8	-0.9	-0.7	-0.4
27 Metal machine trade	1.1	0.4	0.3	0.7	0.6
28 Printing	1.6	-1.9	-2.6	0.4	0.1
29 Electrical trade	0.3	0.5	0.3	0.3	0.6
34 Cleaners & helpers	-0.1	0.1	0.1	0.1	-0.2
35 Agr, forest, fishing labourer	0.8	9.2	25.9	7.2	-1.3
37 Food prep assistant	-0.7	-0.2	-0.2	-0.3	0.2

Table 4.6. Total growth in employment (%) between 2019 and 2030 by wage-band (euro per hour)

No-policy baseline	DK	FI	SE	NO	IS
0_25	1.6	-1.6	3.3	6.2	3.2
25_40	-1.9	-2.5	2.0	6.0	2.2
40_55	-2.9	-1.2	0.7	4.6	1.3
55_70	-2.5	-5.3	1.0	2.7	-0.2
70_85	-4.2	-4.2	2.2	2.0	-1.3
85_100	-5.7	-5.1	1.8	4.0	-1.2
100_plus	-3.6	-5.8	0.2	6.1	-2.8

Policy	DK	FI	SE	NO	IS
0_25	1.4	-1.6	3.3	6.2	3.1
25_40	-1.9	-2.4	2.2	5.7	2.2
40_55	-2.7	-1.3	0.7	4.6	1.5
55_70	-2.2	-5.0	1.4	2.7	0.2
70_85	-3.4	-4.4	2.2	1.9	-1.0
85_100	-5.1	-5.5	2.1	3.7	-1.2
100_plus	-3.0	-5.4	-0.2	5.7	-2.1

% deviations, 2030	DK	FI	SE	NO	IS
0_25	-0.3	0.0	0.0	0.0	-0.1
25_40	0.1	0.1	0.2	-0.2	0.0
40_55	0.2	-0.2	0.0	0.0	0.2
55_70	0.3	0.3	0.3	0.0	0.4
70_85	0.8	-0.3	0.0	-0.1	0.3
85_100	0.7	-0.5	0.2	-0.2	0.0
100_plus	0.5	0.4	-0.4	-0.3	0.8

Table 4.7. Total growth in employment (%) between 2019 and 2030 by age

No-policy baseline	DK	FI	SE	NO	IS
A14-19	0.5	-0.8	4.4	6.4	3.9
A20-29	-0.2	-1.5	3.0	6.1	3.3
A30-39	-1.0	-1.9	3.1	5.7	2.3
A40-49	-1.6	-1.9	2.9	5.5	2.2
A50-59	-1.7	-1.7	2.8	5.4	2.4
A60-	-1.1	-1.3	3.6	5.7	2.3

Policy	DK	FI	SE	NO	IS
A14-19	0.5	-0.9	4.2	6.4	3.8
A20-29	-0.3	-1.5	3.0	6.1	3.2
A30-39	-1.1	-1.9	3.0	5.7	2.3
A40-49	-1.5	-1.9	2.9	5.5	2.2
A50-59	-1.7	-1.6	2.8	5.4	2.3
A60-	-1.2	-1.3	3.6	5.7	2.3

% deviations, 2030	DK	FI	SE	NO	IS
A14-19	0.0	-0.1	-0.1	0.0	-0.1
A20-29	-0.1	0.0	0.0	-0.0	-0.1
A30-39	-0.1	0.0	-0.1	0.0	0.0
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 4.8. Total growth in employment (%) between 2019 and 2030 by education level

No-policy baseline	DK	FI	SE	NO	IS
Basic	-1.6	-2.7	2.2	5.4	3.2
Secondary	-1.8	-2.4	1.9	4.6	0.6
Tertiary, 4years	0.2	-1.0	4.7	7.0	3.3
Tertiary, greater than 4 years	-0.3	-0.3	8.6	6.6	3.8

Policy	DK	FI	SE	NO	IS
Basic	-1.4	-2.8	2.0	5.5	3.2
Secondary	-1.7	-2.2	2.2	4.9	0.7
Tertiary, 4years	-0.1	-1.2	4.4	6.7	3.2
Tertiary, greater than 4 years	-0.5	-0.6	7.9	6.4	3.6

% deviations, 2030	DK	FI	SE	NO	IS
Basic	0.3	0.0	-0.2	0.0	-0.1
Secondary	0.1	0.2	0.3	0.3	0.1
Tertiary, 4years	-0.2	-0.2	-0.3	-0.3	-0.1
Tertiary, greater than 4 years	-0.2	-0.2	-0.7	-0.2	-0.1

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.

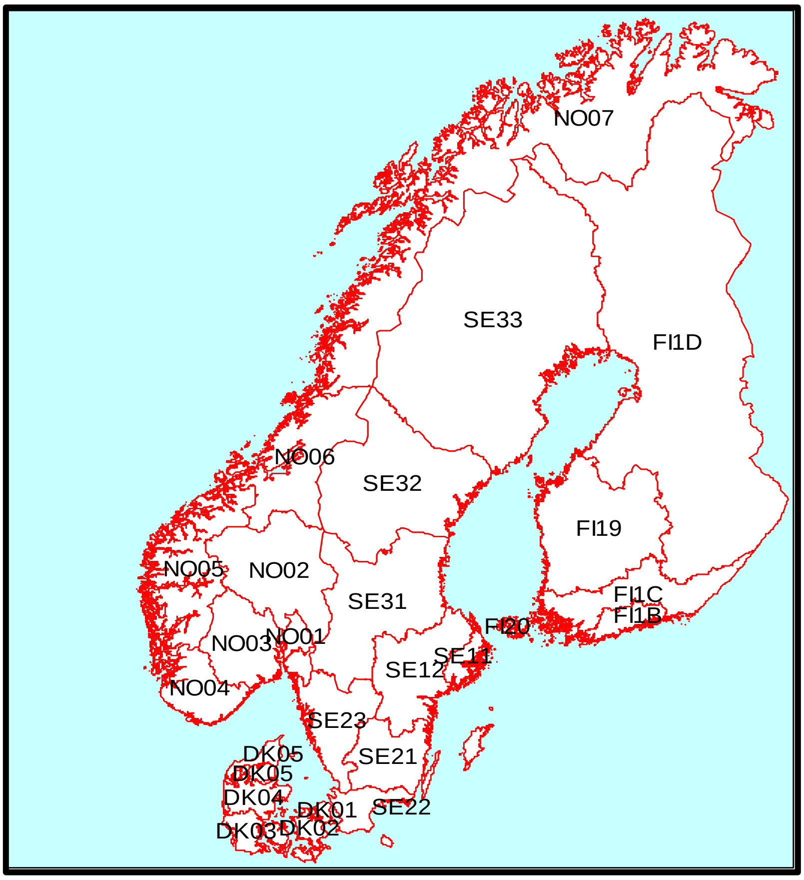
The industry-mix and industry-growth effects generated by greenhouse policies are positive for SE31. With regard to industry mix, SE31 benefits from having above-average shares of its employment in Forestry and logging (ind 3) and Petroleum and coal products (ind 15). The Nordic greenhouse policies generate large increases in employment in both of these industries (74.94 per cent and 118.24 per cent, SE column in Table 4.4). Wood products and Paper products (inds 13 and 14) have negative employment outcomes for SE in Table 4.4 (-6.11 per cent and -4.69 per cent). These negatives mainly reflect contraction of exports caused by cost increases flowing from the Forestry and logging industry. However, the Wood products and Paper products industries in SE31 have low reliance on exports. Consequently they suffer less from export contraction than these industries in SE as a whole. This gives SE31 a positive industry-growth effect.

For NO03, both the industry-mix and industry-growth effects are positive. NO03 benefits from having almost no oil (ind 6) in its employment mix. Oil is a significant employer in Norway and as can be seen from Table 4.4, employment in the industry at the national level falls sharply (-20.77 per cent). The region also benefits from an over representation in its employment mix of Electrical equipment (ind 24). NO03's positive industry-growth effect is explained mainly by relatively strong consumption demand for local products associated with its positive industry-mix effect.

For FI20, the industry-mix and industry-growth effects generated by greenhouse policies are negative. The main contributor to the industry-mix effect is Electric coal (ind 29) which is over-represented in FI20 and suffers a sharp contraction in employment at the national level (-81.36 per cent, Table 4.4). The negative industry-growth effect follows from damped consumption demand associated with FI's negative industry-mix effect.

Table 4.9. Total growth in employment between 2019 and 2030 by NUTS2 region

	Denmark	DK01	DK02	DK03	DK04	DK05			
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	FI19	FI1B	FI1C	FI1D	FI20			
base	-1.98	-2.26	-1.46	-2.08	-2.27	-3.36			
policy	-1.98	-2.06	-1.54	-1.95	-2.51	-4.27			
deviation	0	0.20	-0.08	0.13	-0.25	-0.94			
	Sweden	SE11	SE12	SE21	SE22	SE23	SE31	SE32	SE33
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
deviation	0	0.19	-0.04	0.18	-0.05	-0.37	0.37	-0.09	-0.13
	Norway	NO01	NO02	NO03	NO04	NO05	NO06	NO07	
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	
	Iceland								
base	2.20								
policy	2.20								
deviation	0								



DK01	Hovedstaden
DK02	Sjælland
DK03	Syddanmark
DK04	Midtjylland
DK05	Nordjylland
FI19	West Finland
FI1B	Helsinki-Uusimaa
FI1C	South Finland
FI1D	North and East Finland
FI20	Åland
NO01	Oslo og Akershus
NO02	Hedmark og Oppland
NO03	Sør-Østlandet
NO04	Agder og RogÅland
NO05	Vestlandet
NO06	Trøndelag
NO07	Nord-Norge
SE11	Stockholm
SE12	Östra Mellansverige
SE21	Småland med öarna
SE22	Sydsverige
SE23	Västsverige
SE31	Norra Mellansverige
SE32	Mellersta Norrland
SE33	Övre Norrlan

The baseline forecasts in Table 4.9 show variation in employment growth across regions in each Nordic country. For example, in DK05 baseline employment falls by 2.01 per cent between 2019 and 2030 whereas in DK01 it falls by 0.80 per cent. One question that we can answer from the information in Table 4.9 is: do greenhouse policies help to smooth out regional differences in growth rates for employment or do they accentuate the differences. The example of FI20 (Åland) suggests accentuation: FI20 has the lowest baseline growth rate of all the Nordic NUTS2 regions (-3.36 per cent) and the most negative greenhouse-induced deviation (-0.94 per cent). However, accentuation isn't generally true. By counting up positives and negatives in Table 4.9 we find that over the 25 Nordic NUTS2 regions, there are only 10 cases of accentuation. These 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 smoothing. These 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.

4.4. Cost of living effects for different types of households

Table 4.10 and Charts 4.1a-c 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 4.10 are in RM3, available at #Carlos to post on line somewhere #. Results are given for only three of the Nordic countries because we found no suitable data for identifying expenditure by household type for NO and IS.

The main price movement in our simulations is for motor fuels. For households in DK and FI, the Nordic greenhouse policies that we simulate increase the price of motor fuels by about 11 per cent and for SE, the price increase is about 38 per cent.[8] As can be seen from Table 4.11, rural households generally devote a higher share of their total expenditure to motor fuels than is the case for intermediate households, and intermediate households generally devote a higher share than is the case for urban households. Thus, in Table 4.10 and Charts 4.1a-c, we see that rural households suffer cost-of-living increases from greenhouse policies that are greater than those that for intermediate households, who in turn suffer cost-of-living increases that are greater than those for urban households.

Looking along the rows of Table 4.10, or going from low deciles to high deciles in Charts 4.1a to c, we see no clear patterns. In most of the nine graphs in Charts 4.1a to c, there is little or nothing to suggest either and 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.

[8] These price increases are a little higher than those shown in column (9) of Table 3.1. They are the final price increases, taking account of increases in the prices of inputs such as crops and forestry products, whereas those in Table 3.1 are first-round effects.

Table 4.10. Effects in 2030 of Nordic greenhouse policies on costs of living for households classified by location and income: percentage deviations relative to national CPI (D01 is lowest decile, D10 is highest decile)

% 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
Intermediate	-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
Intermediate	-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
Intermediate	-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 4.11. Baseline percentages in 2030 of household expenditures devoted to Motor fuels: households classified by location and income decile (D01 is lowest decile, D10 is highest decile)

	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
Intermediate	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
Intermediate	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
Intermediate	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 consistency in the movement of the cost-of-living results as we move between deciles is explained by the lack of consistency in Table 4.11 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. This was to be expected. For DK and FI they reflect 11 per cent increases in an item worth between 0.55 and 5.12 per cent of household budgets. For SE the cost-of-living effects are more significant: a 38 per cent increases in an item worth between 1.71 and 7.85 per cent of household budgets. Nevertheless, even for SE the results indicate that our simulated greenhouse policies are unlikely to cause important relative cost-of-living disadvantage to any broadly identified group of households.

Chart 4.1a. Cost-of-living effects (%) from Table 4.10: Denmark

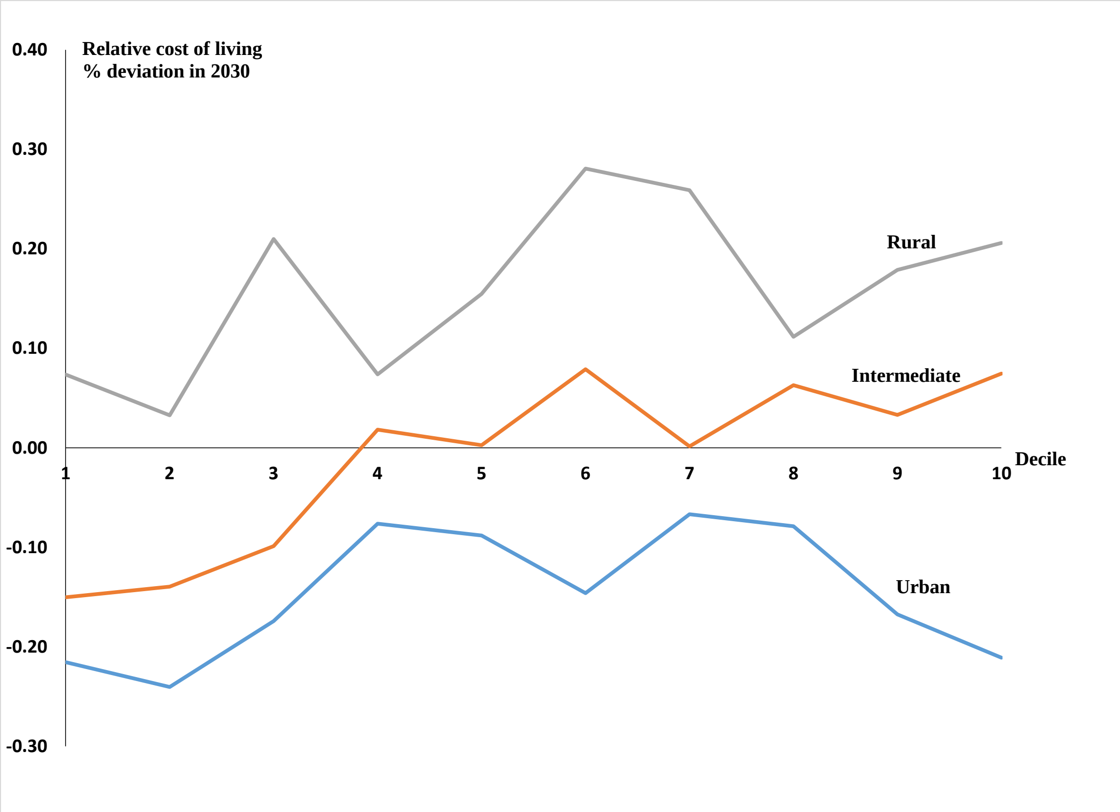


Chart 4.1b. Cost-of-living effects (%) from Table 4.10: Finland

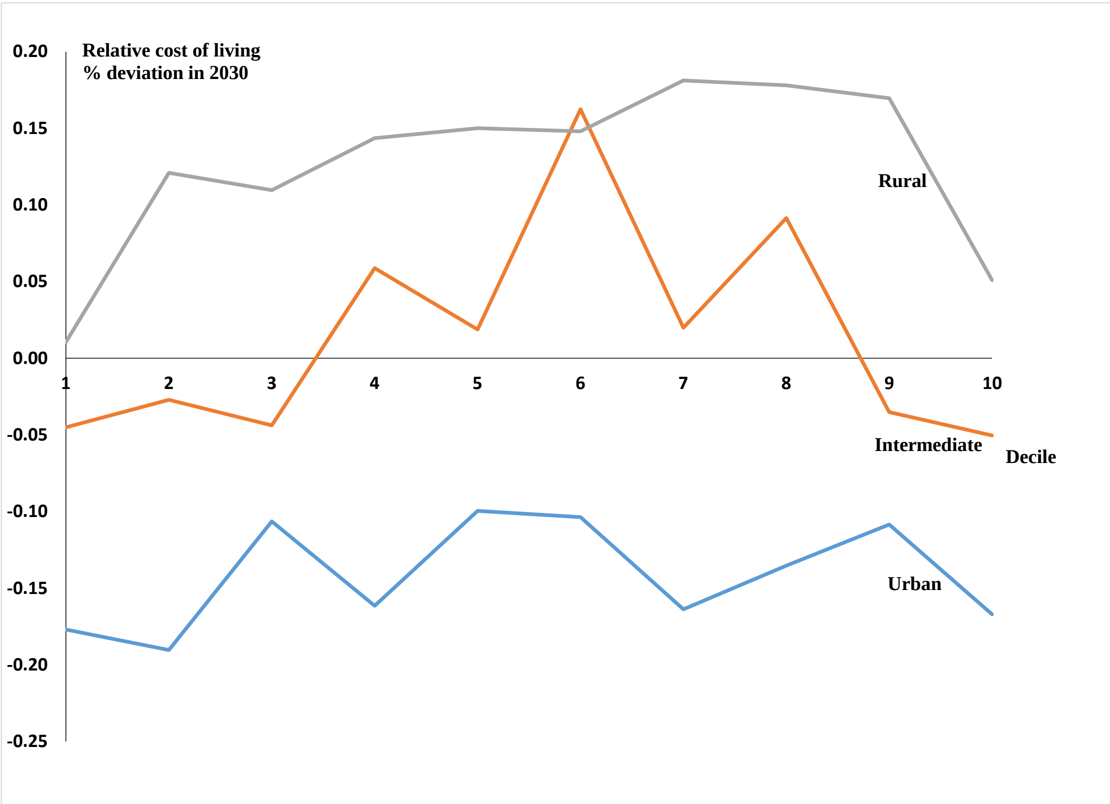
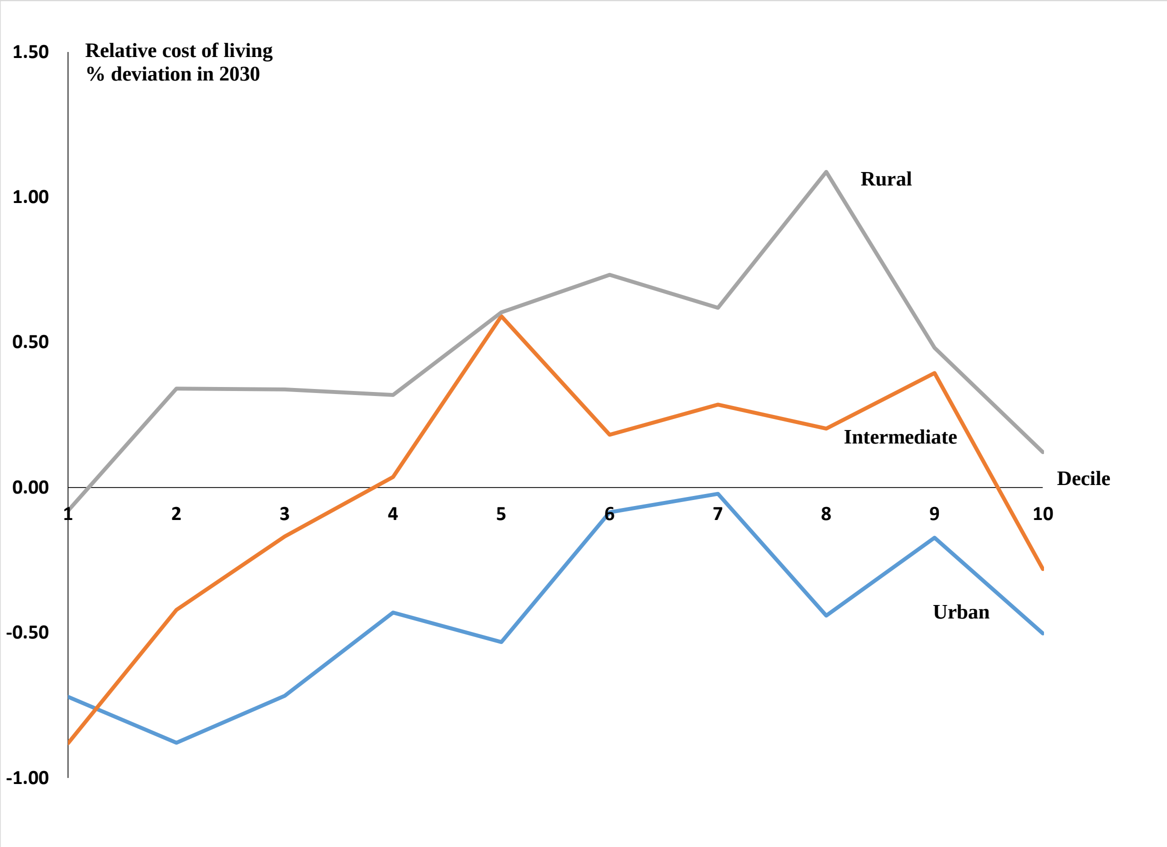


Chart 4.1c. Cost-of-living effects (%) from Table 4.10: Sweden



4.5. CO2eq emission effects

Table 4.12a is the same as Table 2.6b: it shows baseline (no policy) CO2eq emissions in 2030. Table 4.12b shows emissions in 2030 with greenhouse policies. Tables 4.12c&d show differences and percentage differences between Tables 4.12a&b.

Looking at Tables 4.12c&d we see that our simulated policies generate significant reductions in emissions from combustion of coal in DK, FI and SE. In DK and FI, the phase-out of coal-fired electricity is the major contributor. In SE, the main factors are reduction in the use of coal per unit of output in petroleum & coal products, and reduction in the output of petroleum & coal products.

The simulated policies generate increased emissions from combustion of gas in DK, FI and NO. This is explained by increased in output of gas-fired electricity (ind 30, Table 4.3). In SE, gas-fired electricity contracts leading to reduced emissions from combustion of gas. In IS there is almost no use of gas.

In all countries, Tables 4.12c&d show reductions in emissions from combustion of petroleum & coal products. This is explained by two factors: increased bio-shares in 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.

Table 4.12a. CO2 eq. emissions (Kt) for 2030 without new policies: baseline

	DK	FI	SE	NO	IS
Combustion of					
Coal	3819	16660	9751	4649	781
Gas	6963	4831	2240	15664	0
PetrolCoalPrds	22684	21796	29873	18206	1145
Activity in					
Forestry & land	2893	-13590	-36736	-16436	9020
Other	15729	15535	19438	19746	3364
Total (net)*	52089	45232	24565	41830	14310
Total (gross)**	49196	58822	61301	58266	5290

Table 4.12b. CO2 eq. emissions (Kt) for 2030 with greenhouse policies

	DK	FI	SE	NO	IS
Combustion of					
Coal	749	5773	4847	4575	801
Gas	7917	6764	2083	16002	0
PetrolCoalPrds	21435	15282	12542	14400	1039
Activity in					
Forestry & land	2893	-13590	-36736	-16436	9020
Other	15788	14908	17847	19078	3390
Total (net)*	48782	29138	583	37620	14251
Total (gross)**	45889	42727	37319	54056	5231

Table 4.12c. Policy-induced change in CO2 eq. emissions in 2030

	DK	FI	SE	NO	IS
Combustion of					
Coal	-3070	-10888	-4903	-74	20
Gas	954	1934	-157	338	0
PetrolCoalPrds	-1249	-6514	-17331	-3806	-105
Activity in					
Forestry & land	0	0	0	0	0
Other	59	-627	-1591	-668	26
Total (net)*	-3306	-16095	-23982	-4210	-59
Total (gross)**	-3306	-16095	-23982	-4210	-59

Table 4.12d. Policy-induced percentage change in CO2 eq. emissions in 2030

	DK	FI	SE	NO	IS
Combustion of					
Coal	-80.4	-65.4	-50.3	-1.6	2.5
Gas	13.7	40.0	-7.0	2.2	1.7
PetrolCoalPrds	-5.5	-29.9	-58.0	-20.9	-9.2
Activity in					
Forestry & land	0.0	0.0	0.0	0.0	0.0
Other	0.4	-4.0	-8.2	-3.4	0.8
Total (net)*	-6.3	-35.6	-97.6	-10.1	-0.4
Total (gross)**	-6.7	-27.4	-39.1	-7.2	-1.1

* Includes forestry and land use

** Excludes 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 DK is the expansion of the output of crops (ind1, Table 4.3) which generates emissions through soil disturbance. For FI, SE and NO, the contraction in the output of petroleum & coal products reduces activity-based emissions from this industry. In IS, expansion of ferrous and non-ferrous metals (inds 20 & 21, Table 4.3) increases activity-based emissions from these industries.

The first two rows of Table 4.13 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 the baseline growth projections for gross CO2eq emissions from Table 2.7. Row 5 extracts from Table 4.12d estimated policy-induced percentage reductions in gross emissions. Row 6 gives the emission indexes with the simulated policies, calculated by applying percentages in row 5 to the indexes in row 4. Row 6 can be compared with row 7 which shows emission targets. These are either official targets for 2030 or interpolated from targets announced for later dates. Comparison of rows 6 and 7 indicates that achievement of the 2030 targets for DK, FI, NO and IS will require policies beyond those that we have examined. For SE, implementation of their ambitious bio-fuel targets will take them below their 2030 greenhouse target.

Appendix A4. Measuring the welfare effect of the greenhouse policies

Households choose their consumption vector in year t to maximize utility subject to budget constraint. Their utility function takes the form:

$$U = U\left(\frac{X_1}{B_1}, ..., \frac{X_n}{B_n}\right) \qquad \text{(A4.1)}$$

where

X_i is household consumption of commodity i; and

B_i is a preference variable. Increases in B_i mean that a given level of consumption of i generates less utility.

The parameters of the U function vary across household types, but for simplicity, in (A4.1) we suppress the subscripts that identify household type.

In our simulations, we use movements in the B_is to capture the effects of increased expenditure by households on electrical equipment and electricity and reduced expenditure on petroleum products associated with the uptake of EVs. But we don't want EV-related changes in expenditure levels (changes in X_is) to generate utility. For example, if expenditure on electrical equipment needs to increase by 25 per cent because of the installation of charging stations, then a 25 per cent increase in $X_{ElecEquip}$ should generate no additional utility. Apart from a second-order problem, we meet this requirement in (A4.1) with $B_{ElecEquip}$ moving from 1 in baseline to 1.25 in policy. The second-order problem is that the $B_{ElecEquip}$ value of 1.25 should not be applied the movements in $X_{ElecEquip}$ that reflect adjustments in consumption of electrical equipment apart from the required charging stations. However, this is a second-order effect that is ignored in our computations.

Table 4.13. Gross[1] CO2eq emissions: baseline; policy; and targets

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

1. This table does not include emissions from forestry and land use. This measure of emissions is referred to as gross. .

* Source: Eurostat (env_air_gge), available at
http://appsso.eurostat.ec.europa.eu/nui/show.do?lang=en&dataset=env_air_gge

** Source: European Environmental Agency, GHG_Projections_2021_xlsx –including pivot chart, available at
https://www.eea.europa.eu/data-and-maps/data/greenhouse-gas-emission-projections-for-8

In percentage change form, (A4.1) can be written as

$$u = \sum_i S_i * (x_i - b_i) \qquad \text{(A4.2)}$$

where

u, x_i and b_i are percentage deviations in the variables denoted by the corresponding uppercase symbols; and

S_i is the elasticity of U with respect to X_i/B_i defined by

$$S_i = U_i * \frac{X_i/B_i}{U} \quad , \qquad \text{(A4.3)}$$

In (A4.3), U_i is is the derivative of U with respect to its i^{th} argument.

With households choosing X_i, i = 1, …, n, to maximize U defined by (A4.1) subject to their budget (Y) constraint:

$$Y = \sum_i P_i * X_i \quad , \qquad \text{(A4.4)}$$

we have

$$\frac{\partial U}{\partial X_i} = \Lambda * P_i \qquad i = 1, \ldots, n, \qquad \text{(A4.5)}$$

where Λ is the Lagrangian multiplier in the constrained optimization problem.

The derivative on the LHS of (A4.5) can be written as:

$$\frac{\partial U}{\partial X_i} = U_i * \frac{1}{B_i} \qquad i = 1, \ldots, n, \qquad \text{(A4.6)}$$

Now substituting into (A4.3) from (A4.6) and (A4.5) we obtain:

$$S_i = \frac{P_i * X_i}{U / \Lambda} \quad , \qquad (A4.7)$$

We assume that utility units are defined so that U/Λ is equal to the baseline value of Y. Thus, we can interpret S_i as a budget share.

We measure the welfare effect of policy changes for households of type r by the effect on their utility per capita given by:

$$\text{welfare}(r) = u(r) - \text{pop}(r) \qquad (A4.8)$$

Combining (A4.8) and (A4.2) and instating an r argument to identify households by nation gives

$$\text{welfare}(r) = c(r) - \text{pop}(r) - \sum_i S_i(r) * b_i(r) \qquad (A4.9)$$

where

c(r) is the percentage deviation in aggregate consumption of households in country r.

The last term on the RHS of (A4.9) explains the difference between the consumption results in row 1 of Table 4.1 and the welfare results in row 15.

5. CONCLUSION

In this report, we have 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 effects of completing the phase-out of coal as a fuel for electricity.

As shown in Table 4.13, with the exception of Sweden, these policies alone will not be sufficient to achieve Nordic greenhouse targets for 2030. Nevertheless, for two reasons our results support an optimistic conclusion.

First, the policies we have looked at will cause significant reductions in greenhouse emissions at moderate macroeconomic cost. This is indicated in the first three rows of Table 5.1. The percentage emission reductions are between 6 times and 30 times greater than the percentage GDP losses. NO and IS have the worst ratios. Greenhouse policies have a relatively large negative effect on NO's GDP (see Table 4.1) and a relatively small effect on its gross emissions (Table 4.12d). The GDP effect for NO is exacerbated by reduction in the use of oil resources (Table 4.2). 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 bio-fuel share of motor fuels (Table 3.1). For IS, the policies have little effect on greenhouse emissions while at the same time causing a GDP-reducing substitution of lightly-taxed electricity for more heavily-taxed motor fuels.

The second reason for giving the results an optimistic interpretation is illustrated by the lower panel of Table 5.1. It implies that significant reductions in emissions can be achieved with very little structural disruption.

In DK, the percentage deviation in employment in 2030, in the worst-affected occupation out of the 39 in our model, is -1.13 per cent. This is the result for Personal care workers in the bottom panel of Table 4.5. An adjustment of this size would not require employed workers to lose their jobs. It doesn't mean that 1.13 per cent of DK's Personal care workers are fired in

Table 5.1. Policy-induced percentage deviations in 2030 for selected variables

		DK	FI	SE	NO	IS
Table 4.12d	Total (gross) emissions	-6.72	-27.36	-39.12	-7.23	-1.12
Table 4.1	Real GDP	-0.73	-1.16	-1.31	-1.22	-0.18
	Ratio: % emission reduction to % GDP loss	*9*	*24*	*30*	*6*	*6*
	Worst results for:					
Tables 4.5*	Employment by **occupation**	-1.13	-1.93	-2.59	-0.69	-1.31
Table 4.6	Employment by **wage band**	-0.28	-0.48	-0.36	-0.24	-0.10
Table 4.7	Employment by **age group**	-0.10	-0.05	-0.11	-0.01	-0.09
Table 4.8	Employment by **educational requirement**	-0.25	-0.22	-0.71	-0.25	-0.14
Tables 4.9	Employment by **NUTS2 region**	-0.17	-0.94	-0.37	-0.49	0.00
Table 4.10	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 4.5.

2030. From the top two panels of Table 4.5 we see that it means employment of Personal care workers will grow between 2019 and 2030 by 3.8 per cent in policy rather than 4.9 per cent in baseline.

In NO, the worst affected occupation is Health professional, with a negative deviation of 0.69 per cent. This occupation has strong baseline growth in NO. Adoption of greenhouse policies means that its employment growth will be slightly lower than it otherwise would have been.

In FI and SE, the worst-affected occupation is Printing, with negative deviations of 1.93 and 2.59 per cent. In both countries, employment in this occupation is falling in the baseline (top panel of Table 4.5). Consequently, greenhouse policies could exacerbate a potential adjustment problem, particularly in FI. However, even with the negative greenhouse contribution it seems likely that the decline in employment opportunities for Printing workers over 11 years would be handled by natural attrition.

For IS, the story is similar to that for FI and SE. The occupation worst affected by greenhouse policies is Agriculture, forestry & fishing labourer, with a deviation of -1.31 per cent. This occupation has declining employment in the baseline. Again, it seems likely that even with the negative greenhouse contribution the decline in employment opportunities for IS's Agriculture, forestry & fishing labourers would be handled by natural attrition.

Looking at the other dimensions of employment (wage band, age, education and region), we see in Table 5.1 that the policy-induced deviations for the worst-affected groups are negligible, less than 1 per cent in absolute terms in all cases.

Large policy-induced negative employment deviations can be found among our industry results (Table 4.4). However, from an adjustment point of view, we think that the occupational and sub-national regional results are of prime relevance. That the greenhouse policies do not generate any large negative employment deviations in these two dimensions is reassuring. It means these policies are unlikely to cause skill or locational mis-matches in Nordic labour markets.

The final row of results in Table 5.1 shows the policy-induced cost-of-living increases relative to the national average for the worst affected group of households in DK, FI and SE. In all cases, the worst affected households are rural 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.