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Carbon Pricing in Nordic Countries

Julien Grosjean, Olivier Cuny, Christian Gianella, Pauline Reyl

- Nordic countries (i.e. Denmark, Finland, Iceland, Norway and Sweden) introduced carbon neutrality targets at a very early stage and made the decision long ago to raise their national carbon price levels in order to expedite the greenhouse gas (GHG) emission reduction process (see Chart on cover page).

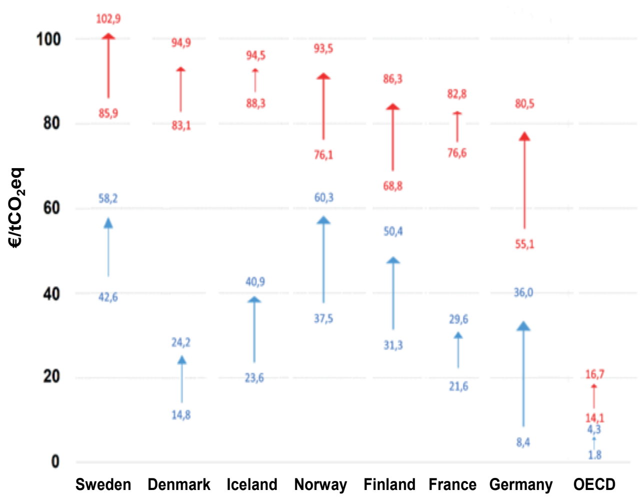
- High levels of explicit carbon pricing have had a significant impact in these countries. Carbon taxes have been a major factor in cutting CO_2 emissions since the early 1990s, particularly in the heating and transport sectors, with Sweden acting as the trailblazer.

- Just like the Alain Quinet report in France, several Nordic countries have estimated the carbon price required to achieve their climate targets and then, as in Denmark and Norway, have decided, in order to bridge the carbon pricing gap needed to achieve their climate objectives, to significantly raise their respective national nominal carbon tax rates in 2022 and impose double carbon pricing (carbon tax and European carbon allowances) on certain industries, thereby standing out from other European countries.

- Concurrently, support measures were implemented to safeguard household purchasing power together with target subsidies and partial tax exemptions for certain industrial sectors. These measures helped to ensure the acceptance of carbon pricing.

- Potential fossil fuel substitutes have also been promoted in industry, prompting the development of strategic industrial sectors such as low-carbon steel. Bioenergy (biomass-fuelled heating networks, black liquor) and electrification (electrical industrial processes, electrolysers, electric vehicles, heat pumps) have therefore established a foothold as a result of the increase in carbon prices. In 2023, far-reaching government support on an unprecedented scale was proposed for carbon capture and storage, most notably in Norway and Denmark. This proposal was made with a view to forming a Nordic hub that would play a pioneering role across the globe and could be used to reduce carbon emissions produced by certain industrial activities in the EU.

Average effective and explicit carbon prices applied by Nordic countries



→ Average net effective carbon rate* in 2018 (bottom of arrows) versus in 2021 (top of arrows)

→ Average explicit carbon price** in 2018 (bottom of arrows) versus in 2021 (top of arrows)

* Average net effective carbon rate: sum of tradeable emission permits, carbon taxes and fuel excise taxes, minus the amount of fossil fuel subsidies.

** Average explicit carbon price: sum of tradeable emission permits and carbon taxes.

Source: OECD (2023).

1. High and increasing levels of carbon pricing

1.1 The trailblazing role of Nordic countries in explicit carbon pricing since 1990

With regard to government policies, GHG emission pricing can be carried out explicitly, for example by introducing a national carbon tax or by adjusting the price of carbon allowances in emissions trading systems (ETSs). The total explicit carbon price is the sum of emission allowance prices and carbon tax. Set up in 2005, the EU ETS applies to the GHG emissions[1] produced by certain facilities in the heavy industry sector and electricity and heat generation sectors, and by airlines and shipping companies in the European Union, Norway, Iceland and Liechtenstein. The ETS covers nearly 40% of the EU's GHG emissions. The average EU ETS allowance price, stable at around €25/tCO_2eq in 2019-2020, soared to up to €100/tCO_2eq in 2021-2022 due to the ETS reform introduced under the EU Green Deal.[2] The price then slightly dropped in 2023 to an average of €84/tCO_2eq. This price change has for the most part driven the increase in explicit carbon prices in Nordic countries (see Chart on cover page).

As for the other component of explicit carbon pricing – national carbon tax – Nordic countries were the first in the world to impose an explicitly Pigouvian carbon tax,[3] introduced in 1990 in Finland, 1991 in Sweden and Norway, and 1992 in Denmark. The gradual increase in this rate over the last 30 years is the reason behind the record nominal carbon tax rates currently in force in the Nordic area, some of the highest in the world (€122/tCO_2 in Sweden, €90/tCO_2 in Norway). With regard to the tax base, most Nordic countries do not directly tax CO_2 emissions but rather apply the tax rate to a physical unit of fuel (e.g. litres for petrol) based on its fossil carbon content (with the rate considerably varying depending on the fuel type and the sectors of use).

In Finland, the base was broadened to cover emissions produced over the entire life cycle of the fuel (e.g. those emitted when producing the fuel, during transport). The nominal carbon tax rate in Finland (€77/tCO_2 for transport, €53/tCO_2 for heating) would therefore be nearly €95/tCO_2 if it were set, as in Sweden, on the narrower base of fossil carbon content in fuels used for consumption. Following in France's footsteps, Iceland, Denmark and Norway broadened the scope of carbon tax to include fluorocarbons that emit GHGs. The hike in carbon tax rates in Nordic countries and the scrapping of exemptions have therefore also played a noteworthy role in the increase in explicit carbon prices, with the rise in ETS carbon allowance prices.

Most Nordic countries stand out on the European stage for their decision to implement double carbon pricing (ETS and national carbon tax) in certain industrial sectors falling under the ETS Directive, with a view to quickening the pace of decarbonisation. For example, Norway taxes the carbon emissions of the aviation and oil and gas production sectors at a rate of €56/tCO_2 and €63/tCO_2 respectively. The total explicit carbon price for these sectors (excluding free ETS allowances) is thus nearly €150/tCO_2. Finland also enforces this double pricing for thermal power plants (district heating networks, industrial cogeneration). In most of the rest of Europe, the industries falling within the scope of the ETS are fully exempt from carbon tax.

1.2 Some of the highest net effective carbon rates in the world

To determine an accurate estimate of the tax initiatives carried out by states to combat climate change, the OECD has set out the average net effective carbon rate.[4] This composite indicator is the sum of explicit carbon prices (i.e. ETS carbon allowance prices[5] – including free allowances – and carbon tax) and implicit carbon prices relating to energy excise taxes on fuels such as the energy tax, including reduced rates and exemptions. In accordance with the EU's energy taxation directive, Nordic countries tax fuels based on their energy density (by means of the energy tax) and their impact on climate change (by means of the carbon tax). Nordic countries introduced this dual format of taxes on fuels in the 1990s. The average net effective carbon rate also includes "negative" carbon prices relating to fossil fuel subsidies. VAT, an excise

(1) CO_2 emissions, but also N_2O emissions for certain chemical sectors and perfluorocarbon (PFC) emissions in the aluminium industry.
(2) Ministry for the Ecological Transition and Regional Cohesion (2024), "Marchés du carbone - SEQE" (in French only).
(3) A Pigouvian tax, named after the British economist Arthur Pigou, is a tax imposed on economic operators whose activities generate negative externalities for society. The tax is designed to internalise the social cost of economic activities, such as in cases of pollution.
(4) OECD (2022), "Pricing Greenhouse Gas Emissions: Turning Climate Targets into Climate Action".
(5) The carbon allowances allocated free of charge are not deducted from the total of the effective carbon rate.

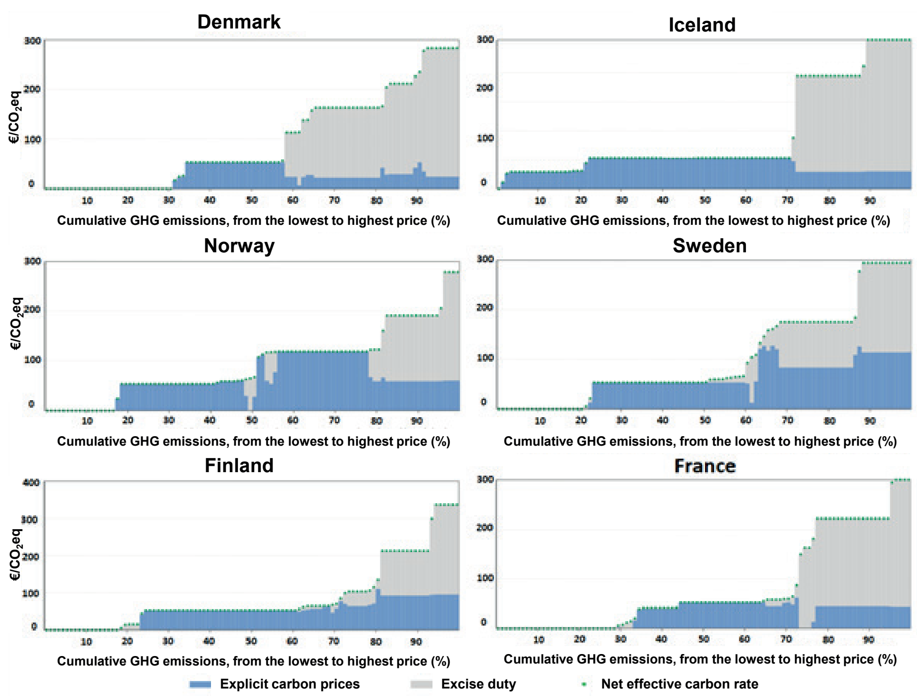
tax on value and not physical units, is excluded from the model. Net effective carbon rates can be used to effectively compare the climate tax policy initiatives implemented by countries based on a common metric.[6]

The net effective carbon rates of Nordic countries (see Chart on cover page and Chart 1) are currently some of the highest in the world. In 2021, the average net effective carbon rate was nearly €100/tCO_2eq[7] for the five Nordic countries. Chart 1 also underscores how, in Sweden and Norway in particular, explicit prices are a major factor in the total effective carbon rate. In 2021, over 40% of emissions in Norway, Denmark and Sweden were subject to a net effective carbon rate of more than €100/tCO_2eq.

At a sectoral level, the net effective carbon rate applied to the industrial and building heating sectors is vastly higher in Nordic countries than most other countries, but the rate applied to the transport sector is close to the European average. The average net effective carbon rate applied to industry is two times higher than the European average as a result of double carbon pricing (ETS and national carbon tax) and high energy taxes. It totalled €99/tCO_2eq in Denmark and €83/tCO_2eq in Norway, compared to the EU average of €45/tCO_2eq.[8]

In the building heating sector, the average effective carbon rate for Nordic countries is three times higher than the European average, with levels as high as €203/tCO_2eq in Sweden and €188/tCO_2eq in Denmark. The main reason for this is the high energy tax rates for heating introduced by Nordic countries, in conjunction with high carbon tax rates. As for road transport, Nordic countries impose effective tax that is relatively close to the European average of €200/tCO_2eq,[9] since high carbon taxes on road fuels are offset by lower energy taxes, established to prevent the risk of windfall effects at borders.

Chart 1: Breakdown of the net effective carbon rates in Nordic countries in 2021



Source: OECD (2023).

(6) B. Dequied (2020), "La tarification du carbone est-elle alignée avec nos objectifs climatiques ?" (in French only), CGDD (Sustainable Development Agency).

(7) These rates would be even higher if the OECD recognised emissions produced from bioenergy as zero like the methodology used for the official GHG inventories of the United Nations Framework Convention on Climate Change (UNFCCC) or that for the ELFE (energy taxation estimate) model in France, developed by the French General Commission for Sustainable Development (CGDD) to establish the effective carbon rate by linking tax data with energy consumption data. As bioenergy has the greatest share in Nordic country energy mixes and is not subject to carbon or energy taxes, the net effective carbon rate is heavily reduced if their emissions are recognised under total national emissions.

(8) OECD data (2023).

(9) OECD data (2023).

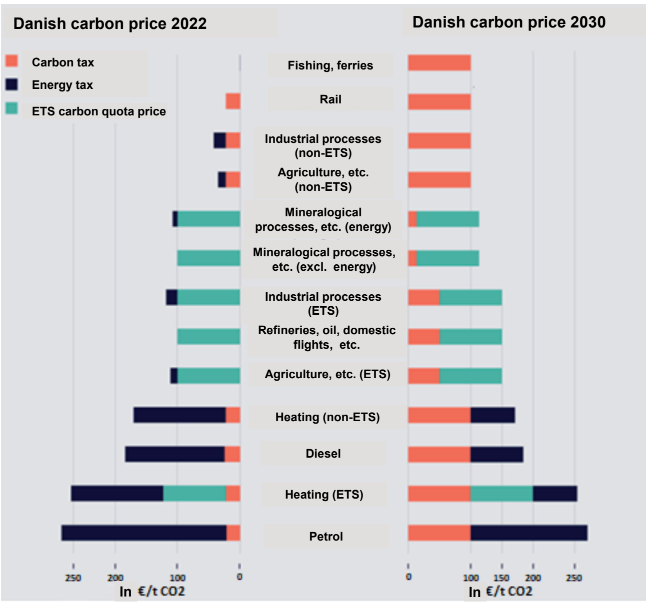
1.3 National carbon budgets require further increases in carbon pricing

Many kinds of economic tools (taxes, subsidies, etc.) and regulatory measures (standards on capital goods emissions, building emissions, etc.) are employed to cut GHG emissions to achieve national carbon neutrality targets. One such tool is carbon pricing, which has become the measure of choice in Nordic countries to align the activities of economic operators with the government's climate targets. In France, the Quinet report[10] estimated the value of climate action (or the shadow carbon price),[11] i.e. the value of GHG emission reduction initiatives for society that help achieve the 2050 carbon neutrality goal, to be €250/tCO_2 for 2030. Several Nordic governments, particularly Denmark and Norway, have recently conducted a similar assessment. They have also estimated the difference between the current carbon price and the carbon price required to comply with the national carbon budget (known as the carbon pricing gap), and subsequently raised their carbon pricing as a result to ensure that the national climate target was attained using this tool (see Chart 2).

In that respect, these countries have just set themselves on an unprecedented trajectory for rising carbon prices. In 2022, Denmark, which had in the past usually relied heavily on energy taxes, announced a wide-reaching reform of the carbon tax structure to cut its GHG emissions by 70% by 2030 compared to 1990. The carbon pricing implemented by Denmark will be more homogenised between industries within the ETS scope and those that are not covered by the ETS (see Chart 2). The carbon tax for non-ETS scope industries will be raised to €47/tCO_2 in 2025 and then €100/tCO_2 in 2030. For industrial sectors within the ETS scope, the carbon tax rate will be raised from €10/tCO_2 to €50/tCO_2 between 2025 and 2030, resulting in an explicit carbon price of over €150/tCO_2 for certain industries, as the Danish Ministry of Finance estimates that the ETS allowance price will float around €100/tCO_2 in 2030. Lower double carbon pricing will be applied to certain industries such as cement factories.

For its part, Norway announced an increase in its carbon pricing – the highest in all the Nordic countries – with a view to cutting its emissions by 55% by 2030. The nominal carbon tax rate is expected to increase to €200/tCO_2 by 2030[12] for the non-ETS sectors, breaking the European record level set by Sweden. Norway therefore raised this rate of 21% on 1 January 2023, bringing the tax to €90/tCO_2eq,[13] following an initial 30% increase in 2022.

Chart 2: Denmark's carbon tax reform



Source: Danish Ministry of Finance (2022).

Note: The reform announced concerns the structure of contributions rather than their total level. The Danish Ministry of Finance assumes that the price of an ETS allowance will be €100/tCO_2 in 2030.

(10) France Stratégie, Rapport Quinet (2019), "La valeur de l'action pour le climat" (in French only).
(11) The shadow carbon price is the government-determined value of actions that can prevent one tonne of CO_2 equivalent from being emitted.
(12) 2,400 NOK/tCO2 (2024).
(13) 952 NOK/tCO2 (2023).

2. A major impact on CO_2 emission levels

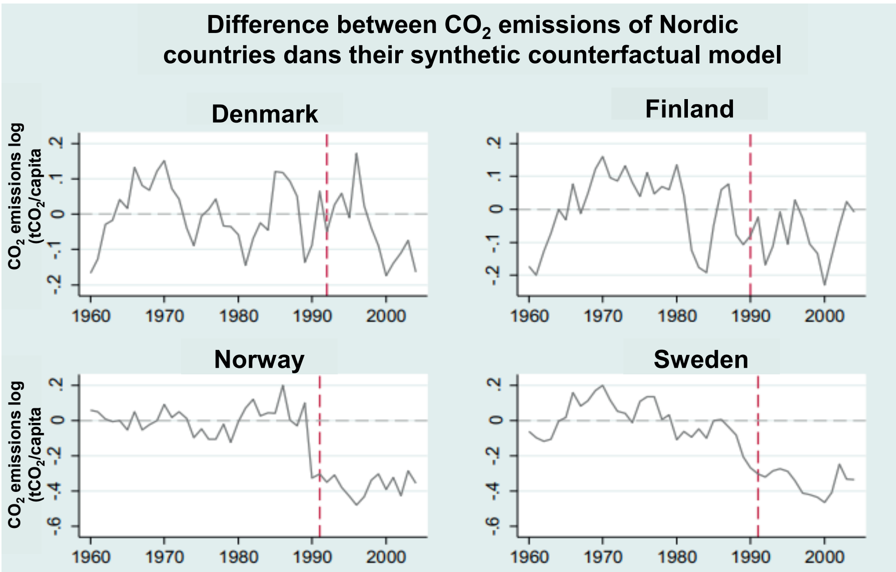
2.1 Significant carbon pricing has effectively decarbonised Nordic economies

The pace of decarbonisation in Nordic economies is brisk.[14] The energy transition – the shift from an energy system centred around fossil fuels to a low-carbon energy system – is almost complete in most Nordic countries. Iceland, Norway, Sweden and Finland are currently the four countries leading the transition in Europe. The share of low-carbon energy in final energy consumption stands at approximately 80% on average, compared to the 23% share of renewables in the EU in 2022.[15] Thanks to the additional low-carbon energy generated by nuclear power, Sweden currently emits the least GHG emissions per capita in the EU (0.4 tCO_2 per capita).[16]

Carbon pricing has been a major factor in achieving these excellent results, corroborated by numerous research papers on the topic[17] which retrospectively confirm that imposing a tax on carbon by raising fossil fuel prices is an effective decarbonisation measure.[18,19] As carbon taxes were introduced at an early stage, their effectiveness in climate action terms has been studied more in Nordic countries than in other European countries.

Estimates of the impact of carbon taxes in Nordic countries have recently been calculated by applying the synthetic control method.[20,21,22] This method can assess the impact of a public policy in isolation by comparing the results obtained by a given country (in this case, reduced CO_2 emissions in a Nordic country that has introduced a carbon tax) to those of a synthetic counterfactual model (the equivalent of a Nordic country that does not apply a carbon tax, constructed using a weighted average of a panel of OECD countries selected for their similar characteristics to the given country).

Chart 3: Synthetic control model (SCM) of the impact of carbon taxes by Nordic countries on GHG emissions



Source: S. Fernando (2019), World Bank.

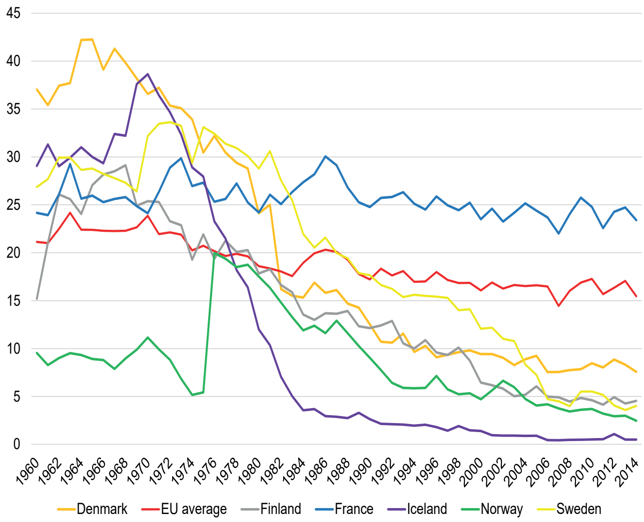
(14) J. Grosjean and E. Duédal (2021), "Climate Strategies in the Nordic Countries", *Trésor-Economics*, No. 185.
(15) Eurostat (2023). Renewable energy refers to any energy generated using Earth's natural resources, such as sunlight, wind, water (waterways, tides and waves), the heat of the Earth's surface and biomass.
(16) EEA (2022).
(17) A. Köppl and M. Schratzenstaller (2022), "Carbon taxation: A review of the empirical literature", *Journal of Economic Surveys*, Wiley.
(18) L. Rabier et al. (2023), "Interim Report – The economic challenges of the net zero transition", Directorate General of the Treasury.
(19) I. Parry (2019), "Carbon-pricing strategies could hold the key to meeting the world's climate stabilization goals", *IMF Finance & Development*.
(20) S.F. Fernando (2019), "The Environmental Effectiveness of Carbon Taxes: A comparative Case Study of the Nordic Experience", *World Bank Working Papers Series*, pp. 349.
(21) J.J. Andersson (2019), "Carbon Taxes and CO_2 Emissions: Sweden as a Case Study", *American Economic Journal*.
(22) T.K. Mideksa (2021), "Pricing for a Cooler Planet: An Empirical Analysis of the Effect of Taxing Carbon", *CESifo Working Papers*.

The results confirm that carbon tax has played an undeniable role in cutting GHG emissions in Nordic countries, namely Norway and Sweden, that impose a high rate, as illustrated in Chart 3. Over the period studied (1990-2004, preceding the entry into force of the ETS in 2005), the carbon tax in Denmark and Finland was nearly half that of Sweden and Norway.[23] This gulf seems to be the reason why studies were unable to identify a significant impact on emissions in the former two countries.[24] The considerably varying impact of the tax among Nordic countries is said to also be attributed to specific tax benefits (especially reduced taxes for certain industries, for instance for the biggest CO_2 emitters in Denmark) and, generally, to lower effective carbon rates in Denmark and Finland. Aggregated over the 1990-2004 period, carbon taxes in Nordic countries were said to have enabled a maximum cumulative reduction of 52 tCO_2 per capita in Norway, nearly double the country's current annual emissions according to Fernando's model.

2.2 A particularly sharp impact on heating

The most exhaustive literature review on carbon pricing was authored by Döbbeling-Hildebrant.[25] The impact of carbon tax, followed by double carbon pricing introduced with the ETS, was probably greatest on the building heating sector. In Sweden, residential building emissions have been cut by almost 80% since 1990,[26] thanks to the enforcement of the carbon tax that has made bioenergy (biomass/fuelwood) a more competitive option over fossil fuels for district heating network supply, and to the carbon tax exemption for bioenergy.[27] As a result, between 1990 and 1995, carbon tax has double the share of bioenergy in the heating network, cutting the network's GHG emissions by nearly 1.5 $MtCO_2$ per year (i.e. 2.5% of total national emissions).[28] Denmark and Finland also have a greener heating network thanks to bioenergy (replacing coal, oil and gas).[29] Greening the district heating network has helped to decarbonise the building sector in Nordic countries (see Chart 4).

Chart 4: CO_2 emissions from residential buildings



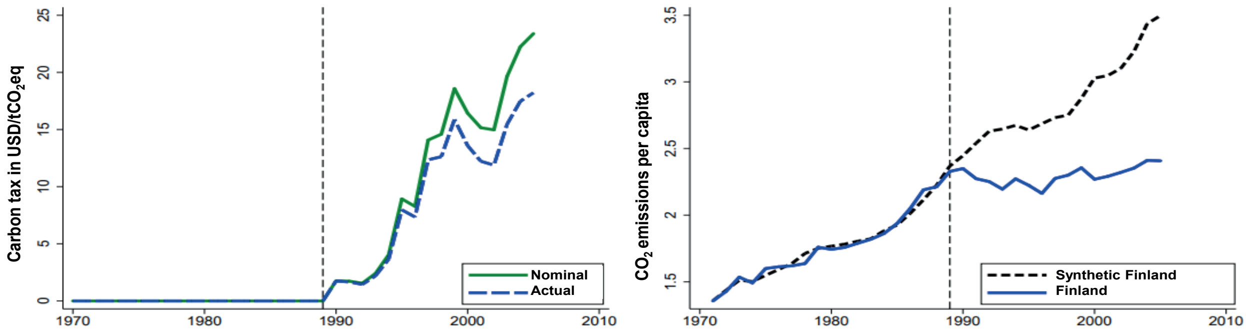
Source: World Bank (2022).

2.3 An acceleration in decarbonisation of transport

As the synthetic control models have illustrated, carbon tax had a major impact on transport sector emissions in Sweden and Finland.[30] Sweden's carbon tax, based on carbon fossil content of road fuels (€0.22/litre on diesel and €0.25/litre on petrol in 2023), is purported to have cut transport emissions by 9.4% between 1990 and 2005 compared to the emissions pathway of a "synthetic Sweden" constructed by Andersson (2019) using the emissions data recorded in 14 similar countries where no carbon tax was implemented. The models developed by Mideksa (2021) for Finland similarly show that the country's carbon tax has had a major impact on the transport sector (see Chart 5), where it has reportedly cut emissions by 27% in the period from 1990 to 2003.

(23) T. Haugland et al. (1993) "A comparison of carbon taxes in selected OECD countries", *OECD Environment Monograph* No. 78.
(24) S.F. Fernando (2019), op. cit.
(25) N. Döbbeling-Hildebrant et al. (2024), "Systematic review and meta-analysis of ex-post evaluations on the effectiveness of carbon pricing", *Nature Communications*.
(26) S. Akerfeldt et al. (2011), "CO_2 Taxation in Sweden: 20 Years of Experience and Looking Ahead", Swedish government.
(27) F. Bohlin (1998), "The Swedish carbon dioxide tax: effects on biofuel use and carbon dioxide emissions", *Elsevier, Biomass and Bionergy*, vol. 15, pp. 283-291.
(28) T. Haugland et al. (1993), op. cit.
(29) J. Grosjean (2021), "Les stratégies des pays nordiques en matière de rénovation énergétique des logements" (in French only), *Annales des Mines*, Réalités industrielles.
(30) J.J. Andersson (2019) and T.K. Mideksa (2021), op. cit.

Chart 5: Impact of carbon tax on Finnish transport emissions



A) Carbon tax in Finland **B) Co_2 emissions from Finnish transport**

Source: CESifo/T.K. Mideksa (2021).

2.4 The impact of carbon tax on industry emissions

Thanks to carbon tax, GHG emissions in industry have been significantly reduced in Norway,[31] Denmark[32],[33] and Sweden.[34,35] The regression analyses conducted by Brännlund et al., based on sets of energy cost statements provided by industry firms and their actual emissions, reveal that Sweden's industry cut its emissions by 10% over the 1991-2004 period, while increasing production by 35%, particularly as a result of the carbon tax. With regard to Denmark, Bjørner and Jenssen estimated that the imposition of carbon tax on the country's industry, combined with energy retrofitting subsidies, has led to a major reduction in emissions particularly due to improved energy efficiency. They estimated the price elasticity of energy demand to be –0.44 for the years subsequent to the introduction of the tax.

3. Support measures introduced to bolster the acceptability and efficiency of carbon pricing

3.1 Measures for businesses

The push-pull strategy[36] was adopted in Nordic countries for government decarbonisation policies with a view to subsidising decarbonisation solutions (the "pull" element) while also increasing the effective carbon rate (the "push" element). This strategy has been key in maintaining industry's competitiveness.

Considerable tax exemptions have in particular encouraged bioenergy uptake and the electrification of industrial processes. Reduced rates for carbon taxes on bioenergies (on the pretext that they do not contain fossil carbon) and energy taxes have made them more competitive than fossil fuels in certain industries, just as for heating networks. Waste wood (branches, treetops, etc.) and black liquor (detergent residue from paper manufacturing) have in this respect contributed to the decarbonisation of industry. Reduced rates applied to bioenergy constitute a considerable tax expenditure, the equivalent of nearly 0.1% of Swedish GDP[37] in the 2010s. The electrification of the production process was also buttressed by a tax measure. In Finland, the tax on electricity in industry was brought down to the European minimum (€0.5/MWh). In Sweden, a full five-year exemption from this tax was even granted to electricity-intensive industries committed to carrying out

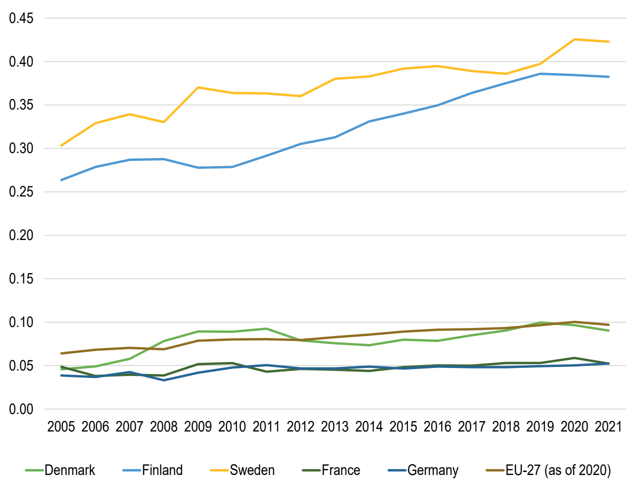
(31) B. Larsen and R. Nesbakken (1997), "Norwegian Emissions of CO_2 1987-1994, A Study of Some Effects of the CO_2 Tax", *Environmental and Resource Economics*.
(32) T. Bjørner and H. Jensen (2002), "Energy taxes, voluntary agreements and investment subsidies – a micro-panel analysis of the effect on Danish industrial companies' energy demand", Elsevier, *Resource and Energy Economics,* Vol. 24, pp. 229-249.
(33) M. Hajek et al. (2019), "Analysis of carbon tax efficiency in energy industries of selected EU countries", Elsevier, *Energy Policy,* Vol. 134.
(34) R. Brännlund et al. (2014), "Carbon intensity in production and the effects of climate policy – Evidence from Swedish industry", Elsevier, *Energy Policy*, Vol. 67, pp. 844-857.
(35) M. Andersen (2004), "Vikings and virtues: a decade of CO_2 taxation", *Climate Policy*.
(36) C. Allaux (2012), "The Decision-Making Process and Eco-Behavior: The Impact of Environmental Public Policies", *Revue française d'administration publique*, No. 144 (in French only).
(37) Sweden's National Accounts (2015) (in Swedish only).

energy retrofitting under the Programme for Improving Energy Efficiency in Energy Intensive Industries (PFE).[38]

In addition to tax exemptions, direct subsidies to finance decarbonisation equipment were rolled out on a large scale. Denmark's green tax reform was for example introduced together with a large green fund (€7.2bn, 2.1% of GDP) to support industry in particular. In Sweden, a string of subsidy programmes (Klimatklivet, Industriklivet, etc.) were launched in the 2010s in compliance with EU rules on State aid. These programmes have notably co-funded flagship projects such as CemZero (low-carbon cement which uses electric plasma instead of coal in its manufacture) and Hybrit (manufacture of low-carbon steel by replacing the coking coal used in blast furnaces with green hydrogen produced from low-carbon electrolysers).[39] These projects are expected to cut national emissions by 5% and 10% respectively.

Generally speaking, all these tools (carbon pricing, targeted support in the form of tax exemptions and subsidies, etc.) have triggered a sharp reduction in the share of fossil fuels in Nordic country energy consumption. The share of renewables in Sweden's and Finland's industrial energy mix has risen by over 12 percentage points between 2005 and 2021, while it has hovered at around 5% in Germany and France (see Chart 6).

Chart 6: Share of renewables in industrial final energy consumption



Source: Eurostat (2023).

More targeted tax benefits were also set up as an exception to the principle of uniform carbon pricing. For example, natural gas used in Norway's industry and falling within the ETS scope (excluding the oil and gas production industry) is subject to heavily reduced carbon tax rates (just €2.9/tCO_2 for most of these industries, or even a zero rate for a number of chemical industries). In Denmark, the increase in carbon pricing went hand in hand with exemptions for sectors most vulnerable to international competition. Denmark's double carbon pricing (ETS and carbon tax) is therefore very low for ore processing so as to prevent the closure of cement factories which are nevertheless responsible for 5% of national emissions. Starting in the early 1990s, Sweden and Finland granted partial exemptions from energy tax to the industrial sector. Many of these exemptions were scrapped over time, in step with the OECD's recommendations. In total, according to the available ex post empirical assessments, after the mid-2000s when the ETS price was low, carbon pricing in Nordic countries did not significantly hinder competitiveness in certain industries, in which the additional costs were offset by exemptions and tax benefits.[40]

3.2 Support for carbon capture and storage

An increase in carbon pricing was recently introduced alongside an unprecedented government support strategy for carbon capture and storage (CCS) with a view to providing additional industrial support for decarbonisation and, at the same time, developing strategic industrial expertise for years to come. Carbon pricing helped to prompt many Nordic industrial firms to capture and store CO_2,[41] since under EU regulations a company within the ETS scope is not required to surrender ETS allowances for emissions when they are stored in accordance with a stringent procedure. The price differential between carbon pricing and the CCS cost determines whether businesses take up CCS or not.

(38) Swedish Energy Agency – Programme for Improving Energy Efficiency in Energy Intensive Industries (PFE) (2005).
(39) Report of the High Level Commission on Carbon Pricing and Competitiveness (2019), Carbon Pricing Leadership Coalition.
(40) OECD (2019), "Carbon pricing and competitiveness: are they at odds?", Environment, *Working Paper* No. 152.
(41) OECD (2019), "How carbon taxation can help deploy CCS in natural gas production".

Norway has invested in CCS for quite some time: since 1996 – the year when subsidies for CCS projects were first launched – Norway has stored over 30 $MtCO_2$ (nearly as much as national annual emissions) in Mongstad,[42] Sleipner and Snøhvit (saline aquifers). Drawing on the country's vast experience in drilling for oil and gas in the North Sea, the Norwegian government has expressed its intention, since 2015, to form a cross-border industrial sector by means of the major Longship pilot project. It hopes to do this by relying on the Northern Lights joint venture, formed by major oil companies, for the transport of CO_2 via pipeline and its storage 2,600 metres below the seabed. The Øygarden site, to the north of Bergen, is scheduled to be operational by late 2024 and roughly 15% of national emissions could be stored there every year from 2026 (with a total storage capacity equivalent to three times the annual national emissions). Nearly 70% of the total investment of €2.7bn (0.5% of GDP) was funded by the government,[43] with the total cost of CCS estimated to total between €85 and €130/tCO_2.[44]

Following in Norway's footsteps, Denmark has opened three CCS tenders this year totalling €4.7bn for between now and 2025 (1.2% of GDP). The goal is to store 10% of national emissions by 2030[45] and turn Denmark into a European hub for CCS. As in Norway, the total CCS cost (capture, liquefaction, transport, storage) is estimated to total between €80 and €155/tCO_2,[46] making this solution almost competitive compared to the average ETS allowance price in 2023 (€84/tCO_2eq). Denmark's CCS potential is estimated to be over 500 times greater than national emissions.[47]

Box 1: Iceland's project to store CO_2 in basaltic rocks

In Iceland, the Carbfix project, launched in 2006 by energy company Reykjavik Energy, the French National Centre for Scientific Research (CNRS), the University of Iceland and Columbia University, cheaply turns CO_2 into volcanic rock. The initial goal was to store hydrogen sulphide (H_2S) produced by the Hellisheidi geothermal power plant. However, testing also showed that CO_2 produced by the power plant, captured using solvents once it has exited the flues and then dissolved in water, could also be mineralised to become volcanic rock when the resulting solvent is injected underground. This mineralisation process should reduce CO_2 migration risks compared to conventional CCS sites that inject CO_2 into aquifers or former oil and gas reservoirs. The project organisers announced that the objective is to store 1 billion tonnes of CO_2 by 2030 (i.e. more than three times greater than France's annual emissions), but currently only 100,000 tonnes of CO_2 has been stored since 2014.

While the low cost of this storage solution – roughly €20/tCO_2 – may seem appealing, the considerable cost of transporting CO_2 to Iceland also has to be factored in. Since the Parliament of Iceland has adopted the European Carbon Capture and Storage Directive (2009/31/EC), EU industries within the ETS scope could therefore decide to store a portion of the CO_2 they produce using this solution in order to cut their emissions. To meet the demand, a CCS terminal is slated to be built and operational by 2026 under the Coda Terminal project, boasting an annual storage capacity of 3 $MtCO_2$ by 2031. A third of this project's cost is subsidised by the EU's Innovation Fund, which is in turn funded by a portion of the revenues from the auctioning of ETS allowances.[a]

a. Carbfix (2022).

(42) Norwegian Petroleum (2023), "Carbon Capture and Storage".
(43) Government of Norway (2021), "Questions and answers about the Longship project".
(44) The Ministry of Climate and Environment of Norway (2023), "Industriell karbonfjerning - potensial, kostnader og mulige virkemidler" (in Norwegian only).
(45) Danish Ministry of Climate, Energy and Utilities (2022), "Status on CCS in Denmark".
(46) Dansk Affaldsforening (2020), "CO_2-fangst fra danske affaldsenergianlaeg" (in Danish only).
(47) TotalEnergies (2023), "Carbon Capture and Storage".

CCS policies face the issue that the biogenic CO_2 emissions[48] produced by industries within the ETS scope are recognised as zero, meaning that their low rates do not act as an incentive for carbon storage. As a result, Nordic countries are left with no choice but to subsidise the capture and storage of biogenic CO_2 (BioCCS) from, for example, biomass-fuelled plants. In light of this, Norway and Denmark are exploring avenues for a specific government support scheme for BioCCS.[49] Sweden plans to support BioCCS by offering considerable subsidies (0.7% of cumulative GDP by 2045)[50] and is expecting to roll out an auction scheme: industrial firms with BioCCS projects will determine how much CO_2 it will store and the estimated cost, and only the firms stating the most competitive costs will be eligible to receive the government support (which also factors in the costs of transport to international storage sites), estimated to total between €95 and €170/tCO_2[51] for 15 years. The winning companies will be required to sell their "negative emissions" in auctions on a dedicated market, and the level of support will be adjusted depending on the final purchase price paid by third parties, in accordance with EU rules on State aid.

3.3 Measures for households

Together with the increase in carbon pricing, tax adjustments were introduced to safeguard household purchasing power. In Sweden for example, as part of the major green tax reform rolled out in the early 2000s, the entirety of the carbon price increase was neutralised from a tax standpoint with a simultaneous labour tax cut under a "green tax shift".[52] The additional cost of the green transition for energy distributors was also reduced in the electricity bills of Swedish end users with a cut in consumption taxes. The green transition in Nordic countries was therefore led in large part by energy distributors. These distributors reacted to the government's tax rulings by relying on greener energy sources. Examples include district heating – which is now generated for the most part by bioenergy – and road fuels, with a Swedish fuel biodiesel content of 40% in 2023. At the same time, this greening has not had any major downstream economic impacts on households and companies thanks to tax offsetting.

In a similar case, Denmark's ongoing tax reform plans for carbon tax increases for non-industrial sectors (transport, heating, etc.) to be largely neutralised by an energy tax cut so as not to be detrimental to purchasing power (see Chart 2). Despite the average household tax burden being scarcely affected, carbon tax is a more effective means of reducing GHG emissions than energy tax as it equalises the marginal cost of abatement across fuels (Baranzini).[53]

In Norway, for sectors not within the ETS scope, most of the hike in carbon tax on motor fuels has been offset: half of the increase has been counterbalanced by cutting the motor fuel tax relating to road use, and the remainder through tax adjustment on vehicle insurance.

These various measures have ensured that carbon pricing, despite its high rate, is accepted in Nordic countries. In addition, carbon taxes in this region are only ever so slightly regressive – given the countries' low level of inequality with a relatively low Gini coefficient[54] in the early 1990s – which has helped them gain acceptance.[55] More recently, the debate over the acceptability of additional carbon pricing seems to have been rekindled in certain Nordic countries. An OECD survey from 2022[56] has revealed that support for a carbon tax with lump-sum transfers is now relatively low in Denmark (45%, the lowest acceptability rate after Germany out of the 12 high-income countries analysed).

(48) Biogenic carbon is the carbon stored by plants through photosynthesis from CO_2 in the atmosphere. This CO_2, for example, is released when waste wood is burnt in cogeneration plants.
(49) Norwegian Ministry of Climate and Environment (2023) (in Norwegian only).
(50) Swedish Ministry of Climate and Enterprise (2022) (in Swedish only).
(51) Swedish Energy Agency (2021), "Förslag på utforming av ett stödsystem för bio-CCS" (in Swedish only).
(52) J. Grosjean and E. Duédal (2021), "Climate Strategies in the Nordic Countries", *Tresor-Economics*, No. 185.
(53) A. Baranzini and Z. Zhang (2004), "What do we know about carbon tax? An inquiry into their impacts on competitiveness and distribution of income", Elsevier, *Energy Policy*, vol. 32, pp. 507-518.
(54) The Gini coefficient is a synthetic indicator that captures the level of inequality (income, salaries, etc.).
(55) T. Sterner et al. (2021), "Understanding the resistance to carbon taxes", Resources for the Future, *Working Paper* 21-18.
(56) A. Dechezleprêtre et al. (2022), "Fighting climate change: International attitudes toward climate policies", *OECD Economics Department Working Papers*, No. 1714 – see p. 62, Figure A4.

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Publication manager:
Dorothée Rouzet

Editor in chief:
Jean-Luc Schneider
(01 44 87 18 51)
tresor-eco@dgtresor.gouv.fr

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